IN PARTNERSHIP WITH PLYMOUTH UNIVERSITY

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Module Code: PUSL3122	Module Name: HCI, Computer Graphics, and Visualisation
Coursework Title: Project Report	
Deadline Date: 25th of May 2023	Member of staff responsible for coursework: Dr. Alaa Alkhafaji
Programme: BSc (Hons) Software Engineering	
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Group work: please list all names of all participants formally associated with this work and state whether the work was undertaken alone or as part of a team. Please note you may be required to identify individual responsibility for component parts.

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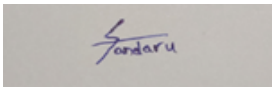
Randeera Withanage	10749185

We confirm that we have read and understood the Plymouth University regulations relating to Assessment Offences and that we are aware of the possible penalties for any breach of these regulations. We confirm that this is the independent work of the group.

Signed on behalf of the group: 

Individual assignment: ***I confirm that I have read and understood the Plymouth University regulations relating to Assessment Offences and that I am aware of the possible penalties for any breach of these regulations. I confirm that this is my own independent work.***
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Use of translation software: failure to declare that translation software or a similar writing aid has been used will be treated as an assessment offence.
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SHAPELAND

(SHAPE LEARNING APPLICATION FOR PRIMARY SCHOOL CHILDREN)

PUSL3122 HCI, Computer Graphics, and Visualisation .
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Chapter 01 – Introduction

The increasing ubiquity of computing implies that applications are being utilized in diverse contexts by a vast user base. Consequently, the design and development of novel user interfaces must consider complex user profiles, interaction contexts, and multimodal information. The foundation of user interfaces lies in two relatively new fields: Human-Computer Interaction (HCI) and Computer Graphics. However, the integration of HCI and Computer Graphics is crucial in creating effective and visually appealing user interfaces. HCI principles and methods inform the design process by considering user needs, cognitive abilities, and interaction patterns. Computer Graphics techniques contribute to the visual presentation of information, enhancing the user experience and facilitating efficient communication of complex data. The convergence of HCI and Computer Graphics facilitates the development of user interfaces that not only deliver functional capabilities but also engage users through visually captivating and interactive designs. Therefore, integration of HCI and Computer Graphics in education is essential to equip children with the knowledge and skills necessary to design and develop user interfaces that meet the evolving needs of users in various domains. By emphasizing the importance of these fields in academic curricula, educators can prepare future professionals to tackle the challenges of creating user-centric and visually appealing computer applications. (Hascoët, 2015)

Nevertheless, this document presents the development of an educational application designed for primary school children to, with a primary objective on facilitating their understanding of shapes both 2D and 3D. The application aims to provide a comprehensive learning experience, integrating principles from HCI and computer graphics to create an intuitive and engaging user interface. By incorporating HCI principles, the application endeavours to establish an interface that is both user-friendly and accessible to children. The design process emphasizes the importance of user-cantered approaches, considering the cognitive and developmental abilities of primary school children. HCI principles such as simplicity, consistency, and feedback mechanisms are employed to ensure an intuitive and seamless user experience throughout the application. Furthermore, by leveraging the power of computer graphics techniques, the application brings shapes to life in both 2D and 3D representations. Accurate rendering of dimensions, colours, and shading provides a realistic visual experience, aiding children in developing a deeper understanding of shape properties and spatial relationships.

Development Source Code - https://github.com/Plymouth-University/main-coursework-phoenix

Chapter 02 – Background

The development of ShapeLand application for primary school children to learn about shapes in 2D and 3D formats addresses the need for interactive and engaging tools that enhance the learning experience. This application provides a comprehensive platform for children to explore, visualize, and manipulate different shapes, enabling them to grasp fundamental concepts of geometry and spatial reasoning. The application caters to primary school children, typically aged 4 to 6, who are at a crucial stage of cognitive development and are acquiring foundational knowledge geometry. At this stage, it is important to foster a positive and enjoyable learning environment to promote active participation and retention of information. Traditionally, learning about shapes in classrooms has often relied on static textbooks and limited visual aids. The lack of hands-on experiences and interactive elements can hinder children's understanding and engagement with the subject matter. This ShapeLand application seeks to bridge this gap by providing dynamic and interactive tools that allow children to create, visualize, and manipulate shapes in both 2D and 3D formats.

The application aims to offer an array of features that enable children to not only understand the properties of shapes but also actively participate in their creation and modification. Users can create new shapes by inputting dimensions and witness their visual representation in real-time. The application supports 2D visualization, allowing children to examine shapes on a flat surface, and 3D visualization, offering a more immersive experience. This application incorporates functionalities such as scaling, shading, and colour customization, enabling children to experiment and personalize their shapes. ShapeLand includes a shape matching feature, where users are presented with incomplete pictures and are required to correctly place the corresponding shapes to complete the full picture. Additionally, it includes a 3D space feature where children can observe galaxy, earth, mars, and moon in 3D. Those engaging activities promote visual perception and shape recognition skills among primary school children.

Chapter 03 – Data Gathering

In the process of developing the ShapeLand application, various techniques were utilized to gather data. These techniques were carefully chosen to ensure a comprehensive and reliable collection of relevant information. The main techniques that utilized in this study as follows:

Extensive research was conducted to gather relevant information and insights on shape learning in primary school education. This research involved studying research papers, academic journals and educational resources related to shape geometry and pedagogical approaches. In there, primary goal was to gain a comprehensive understanding of established teaching methodologies, learning objectives, and effective strategies for engaging primary school students.

To gather data for the development of the educational application, a survey was conducted in selected primary schools in Colombo, Gampaha and Kalutara districts. The purpose of the survey was to collect valuable insights and feedback from primary school teachers. It consisted of structured and open-ended questions that focused on topics such as current shape learning practices, challenges faced, preferences for educational technology, and desired features in a shape learning application. The questions were carefully crafted to ensure clarity and encourage meaningful responses. (Appendix 1)

User feedbacks played a crucial role in gathering data during the development of the application. Prototype versions of the application were tested with primary school children in controlled settings. Observations and interviews were conducted to gather feedback on usability, engagement, and the effectiveness of different features. This iterative process allowed for continuous improvement of the application based on user experiences and suggestions.

Chapter 04 – Design

4.1 – Story Board

The following scenario unfolds within a classroom, featuring a teacher and a group of students engaged in a collaborative discussion. The primary objective of this interaction revolves around the students' collective endeavor to ascertain the shape corresponding to a particular name they have in mind. However, the teacher assumes the role of an instructor, imparting precise and accurate knowledge regarding the designated shape to the students' utilizing activities.

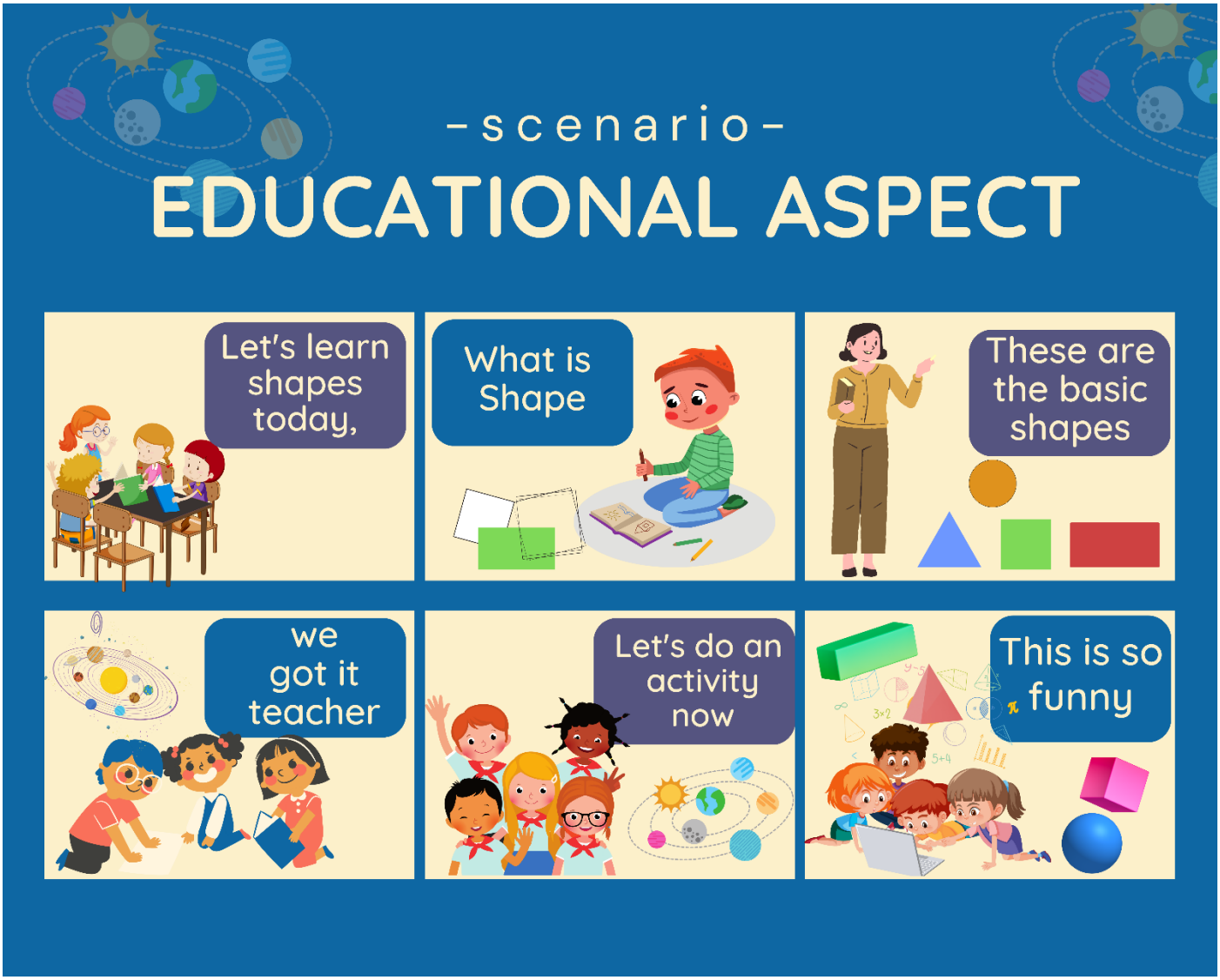

Figure 1: Story Board

4.2 – Low-Fidelity

The initial design iteration of ShapeLand involved creating low-fidelity prototypes using sketches. These rough sketches outlined the basic layout, placement of elements, and overall structure of the application. Since these low-fidelity prototypes provide a quick and cost-effective way to visualize the app's concept it has been utilized.

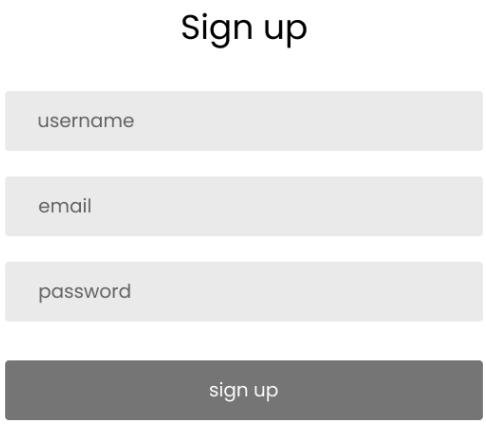

Figure 2: LF-Sign Up

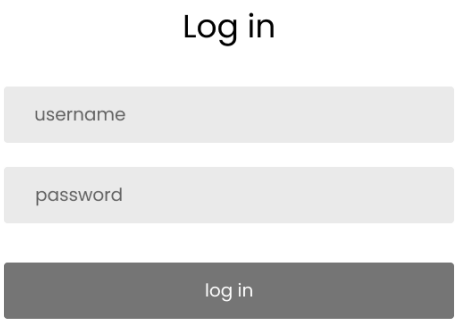

Figure 3: LF-Login

Figure 4: LF-Settings Customization

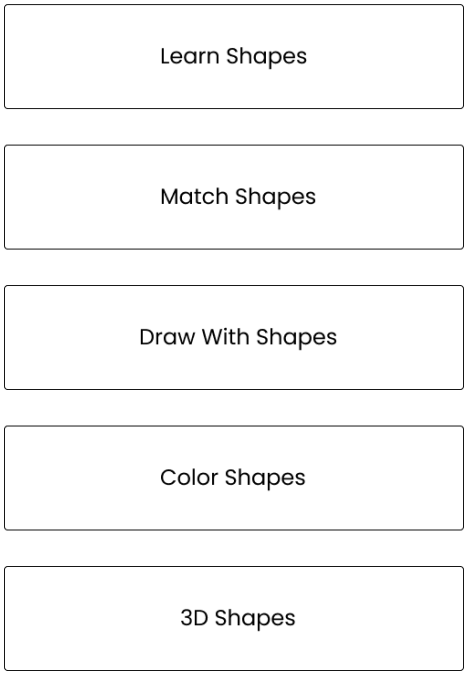

Figure 5: LF-Dashboard

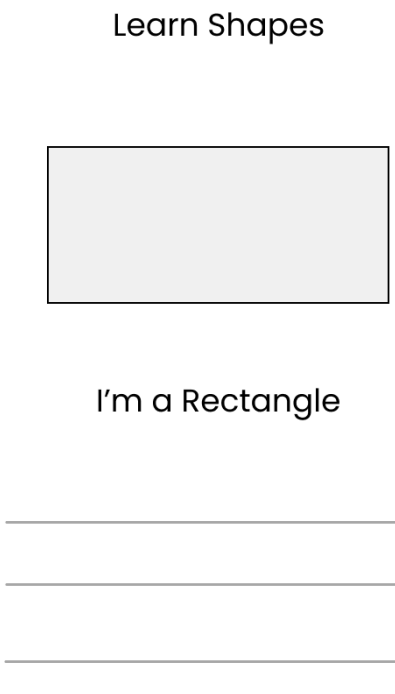

Figure 6: LF-Learn Shapes

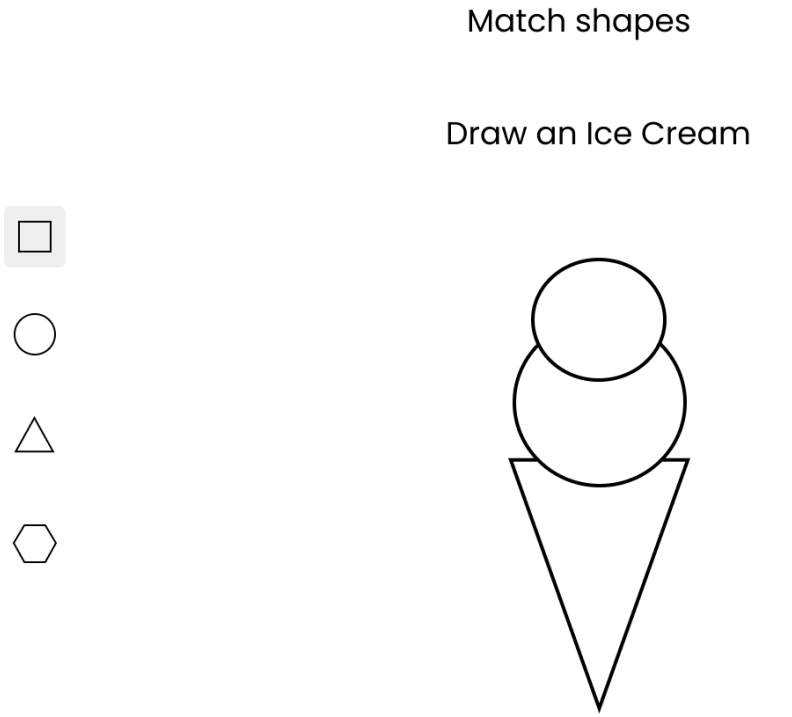

Figure 7: LF-Match Shapes (Ice Cream)

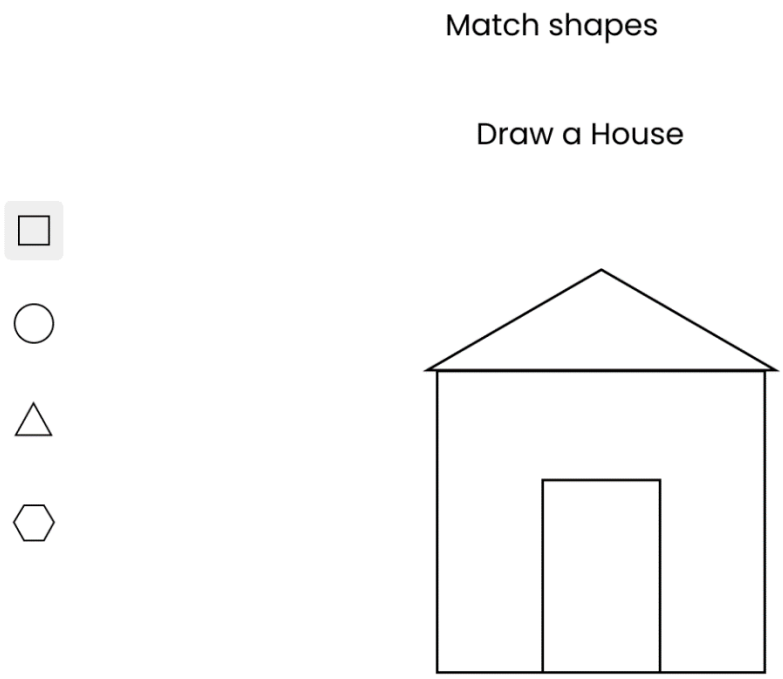

Figure 8: LF-Match Shapes (House)

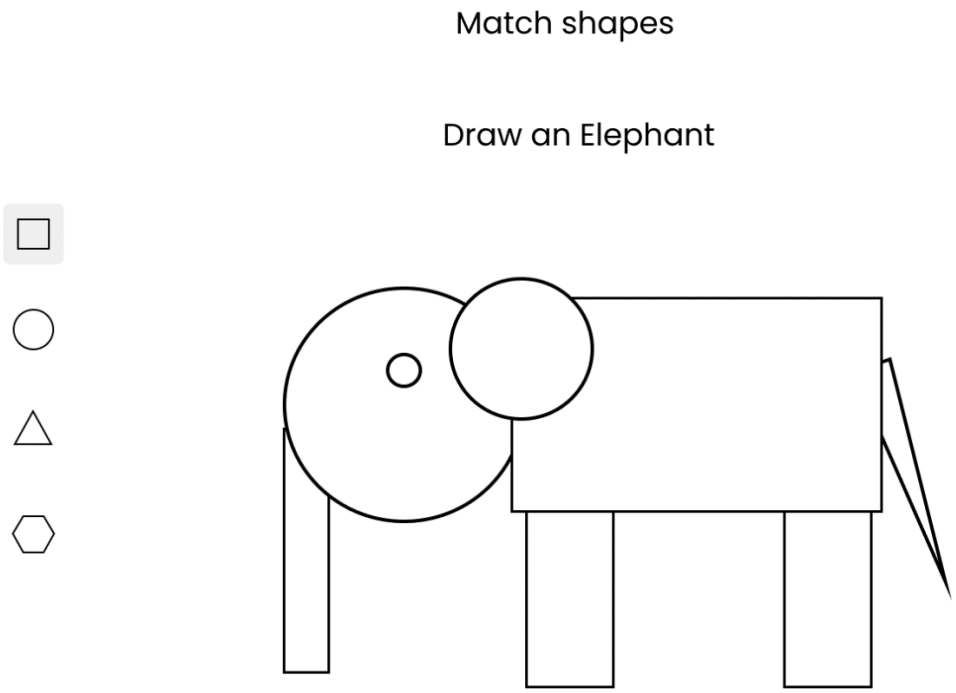

Figure 9: LF-Match Shapes (Elephant)

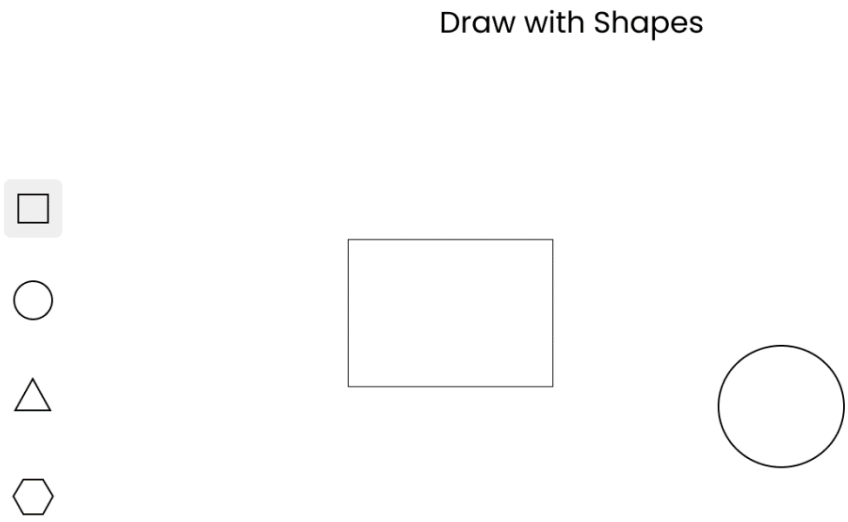

Figure 10: LF-Draw with Shapes

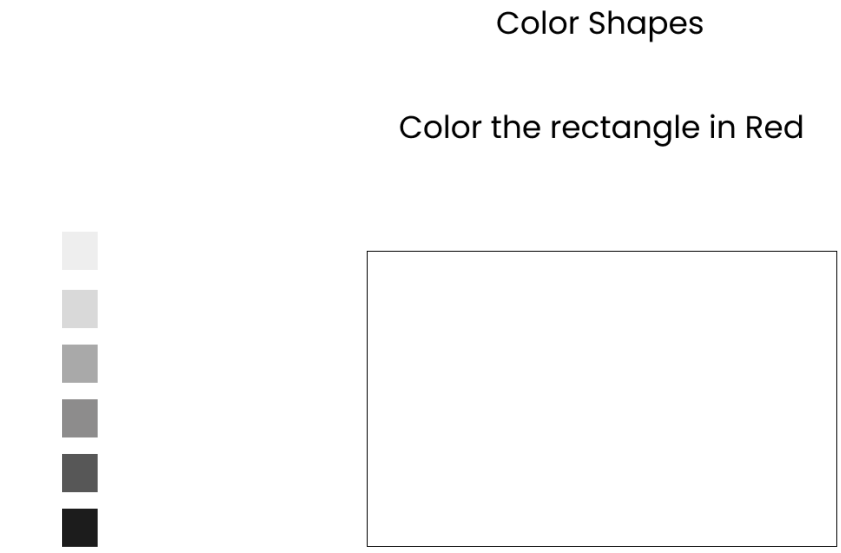

Figure 11: LF-Colour Shapes

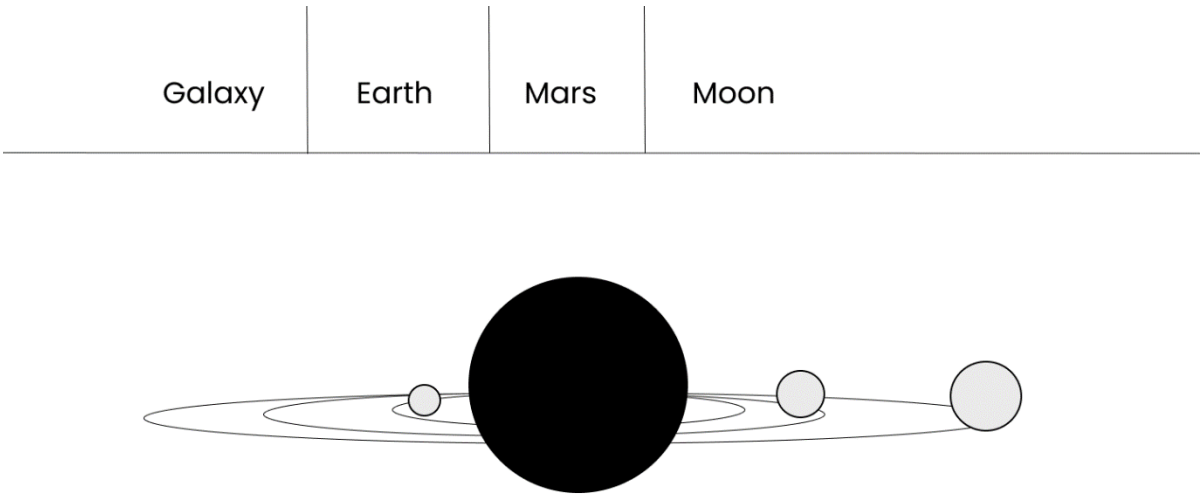

Figure 12: LF-3D Space

4.3 – High-Fidelity

The design process progressed to the creation of a high-fidelity prototype using Figma. The main objective of designing a high-fidelity prototype is to replicate the app's interface and interactions with a higher level of detail and visual fidelity. It incorporated realistic colors, typography, and interactive elements to simulate the user experience more accurately. These prototypes were utilized for comprehensive usability testing evaluations to gather information.

4.3.1 – Sign Up

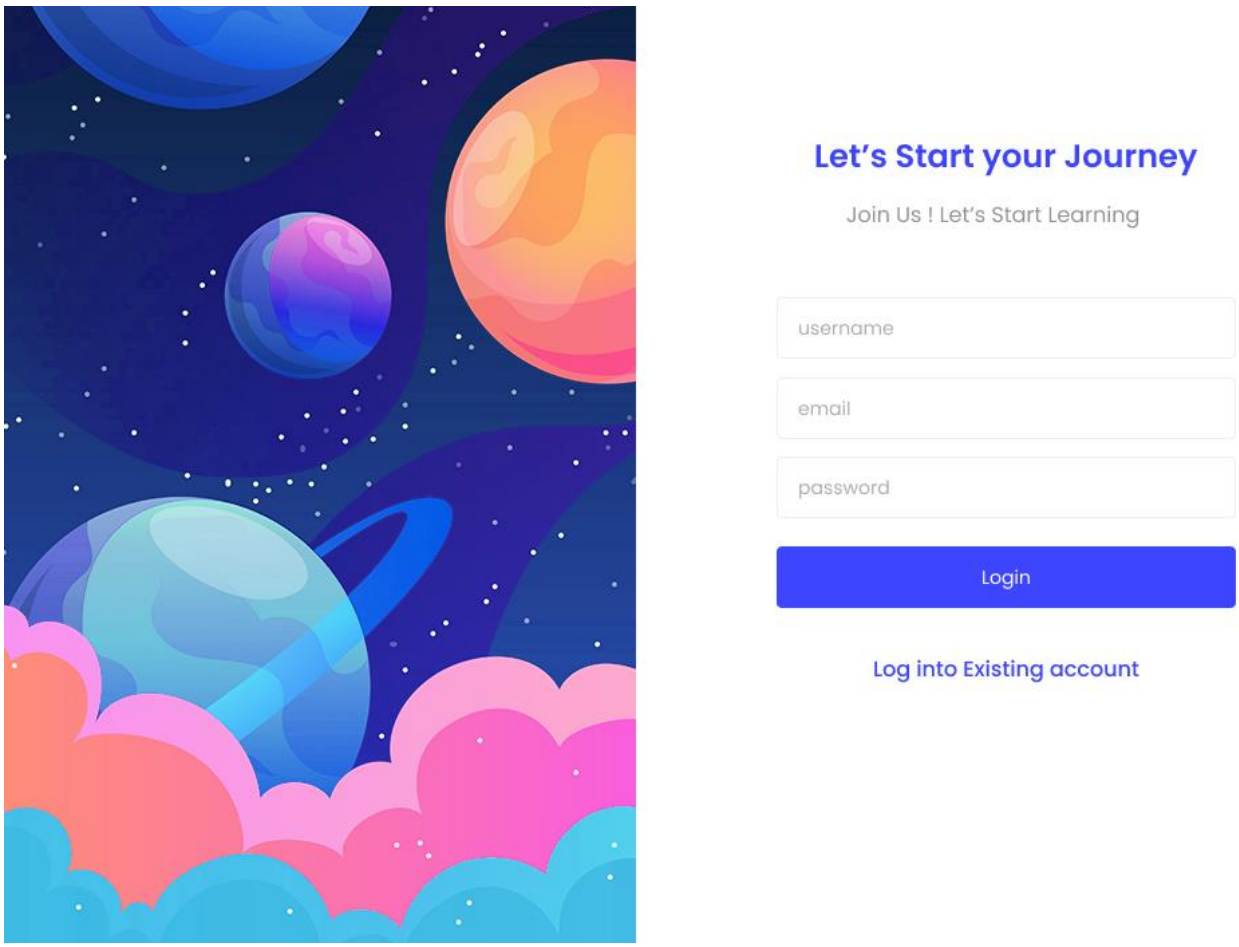

Figure 13: HF-Sign Up

4.3.2 – Login

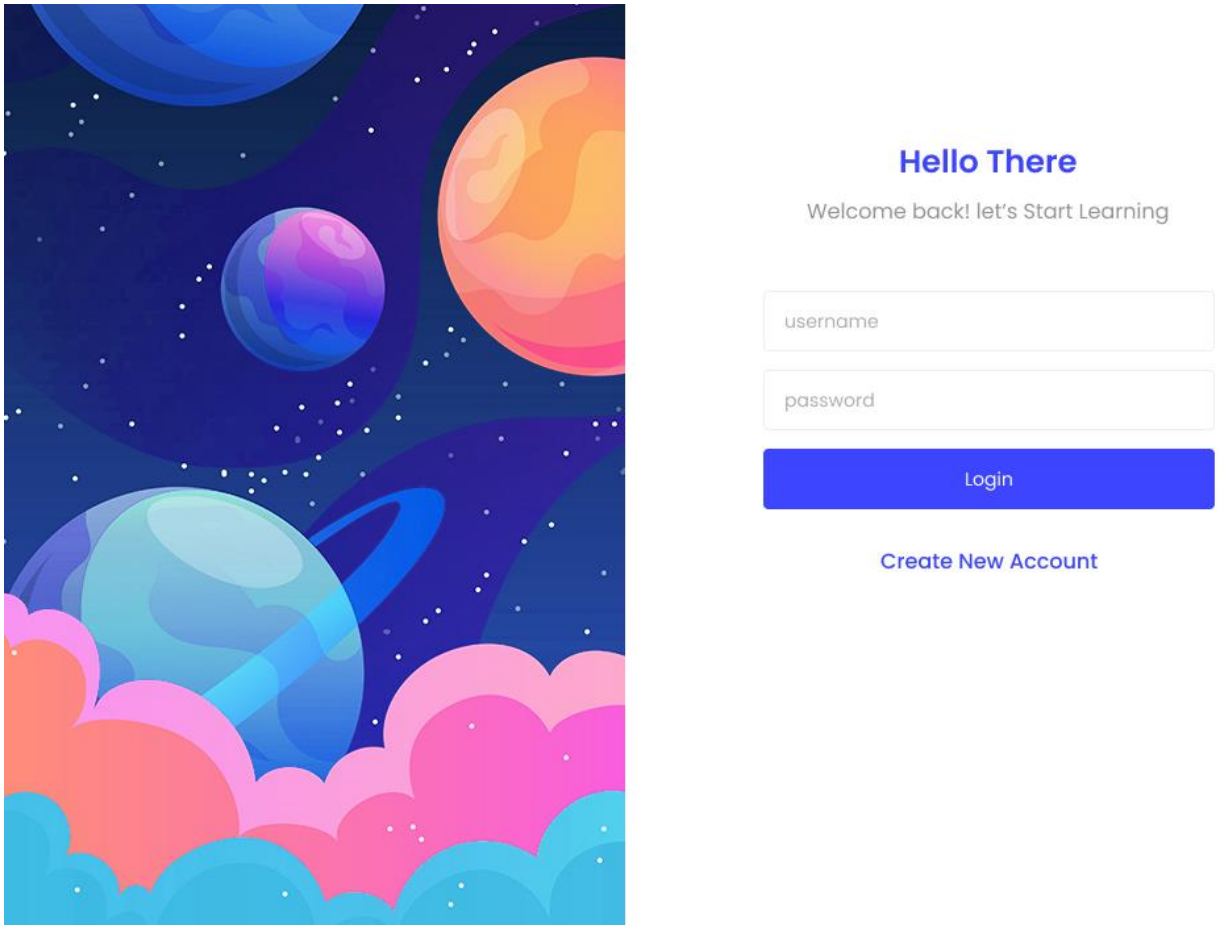

Figure 14: HF-Login

4.3.3 – Settings Customization

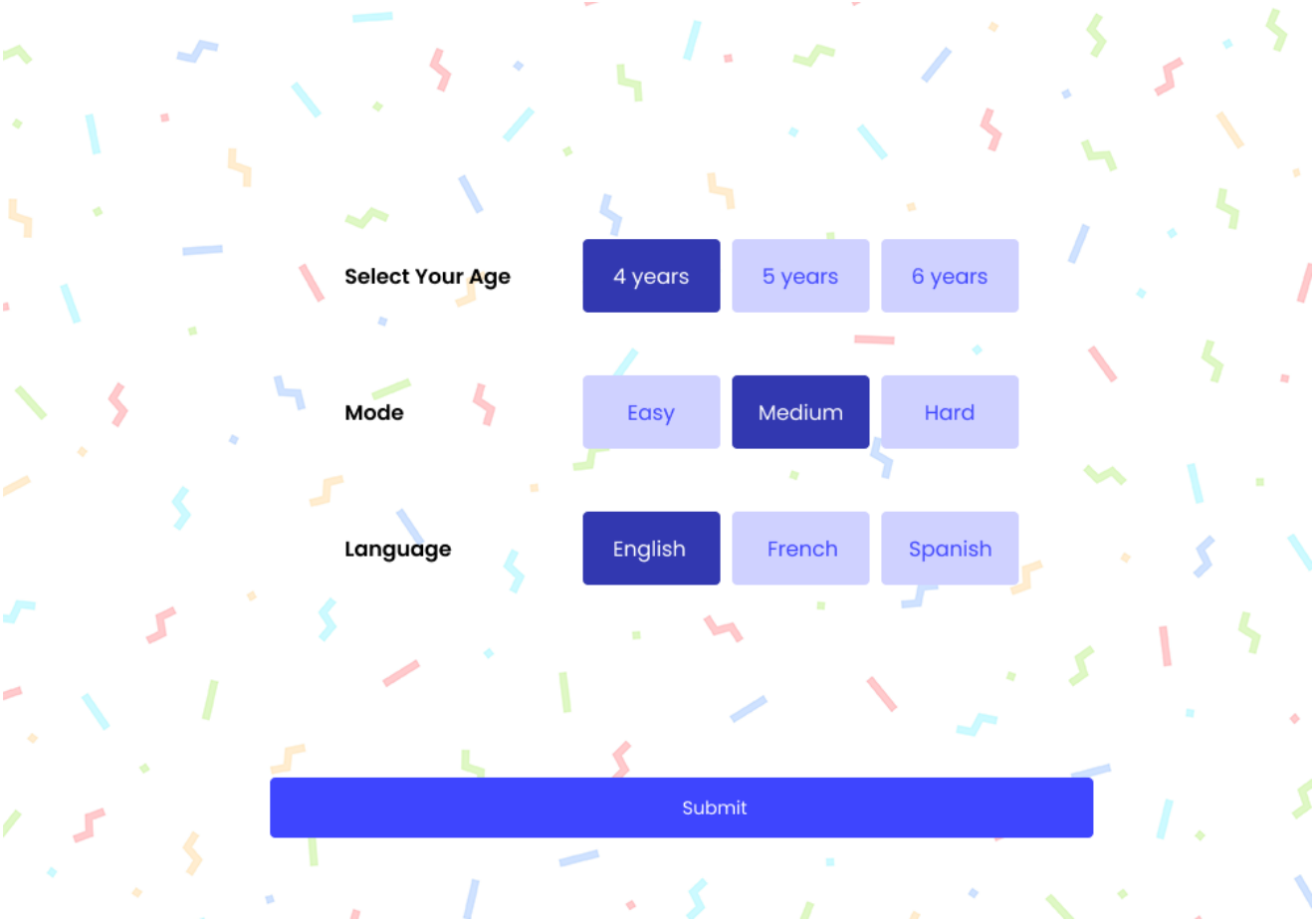

Figure 15: HF-Settings Customization

4.3.4 – Dashboard

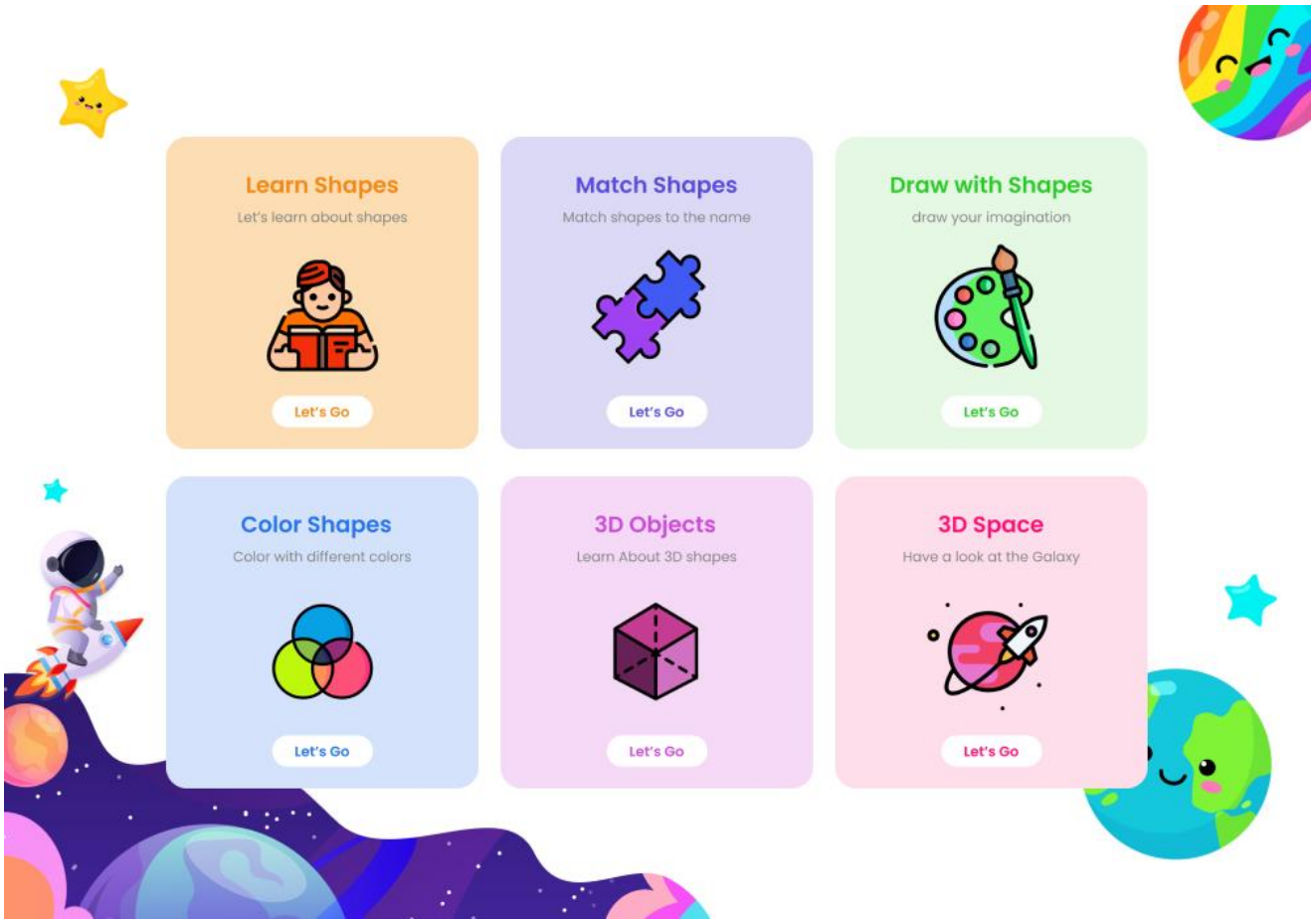

Figure 16: HF-Dashboard

4.3.5 – Learn Shapes

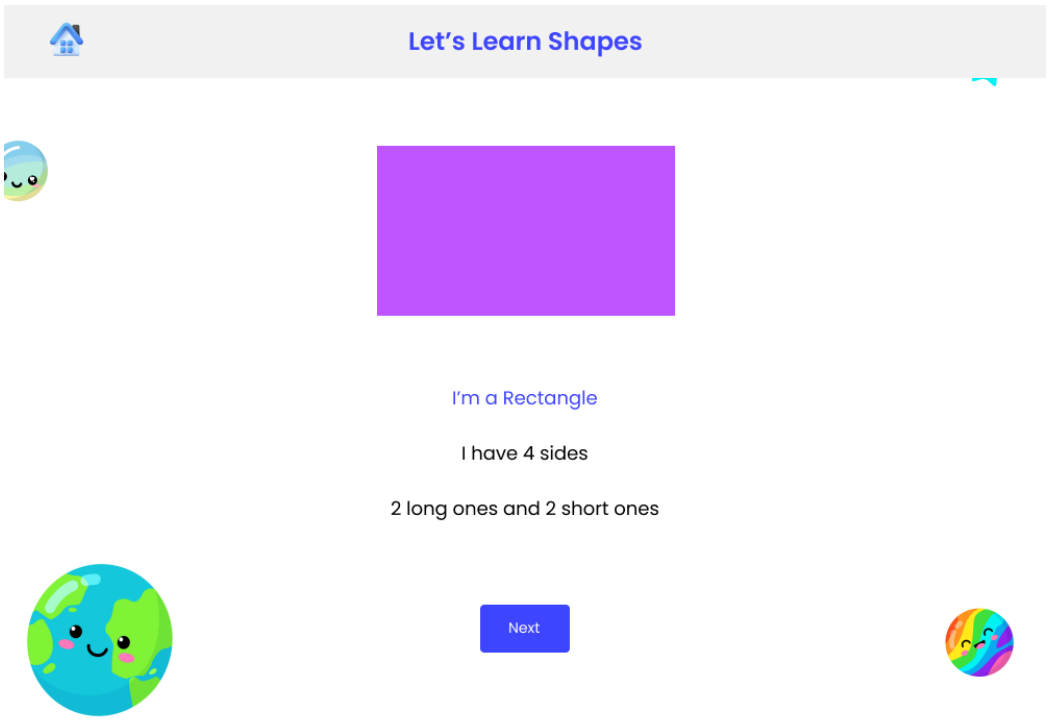

Figure 17: HF-Learn Shapes (Rectangle)

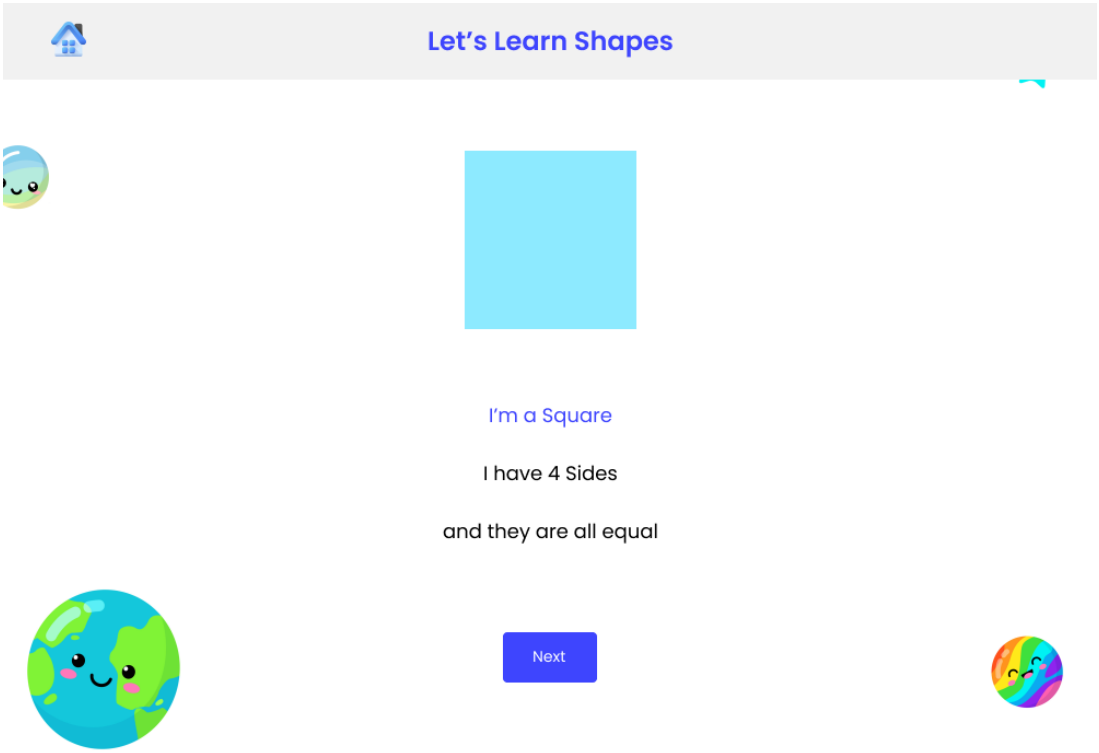

Figure 18: HF-Learn Shapes (Square)

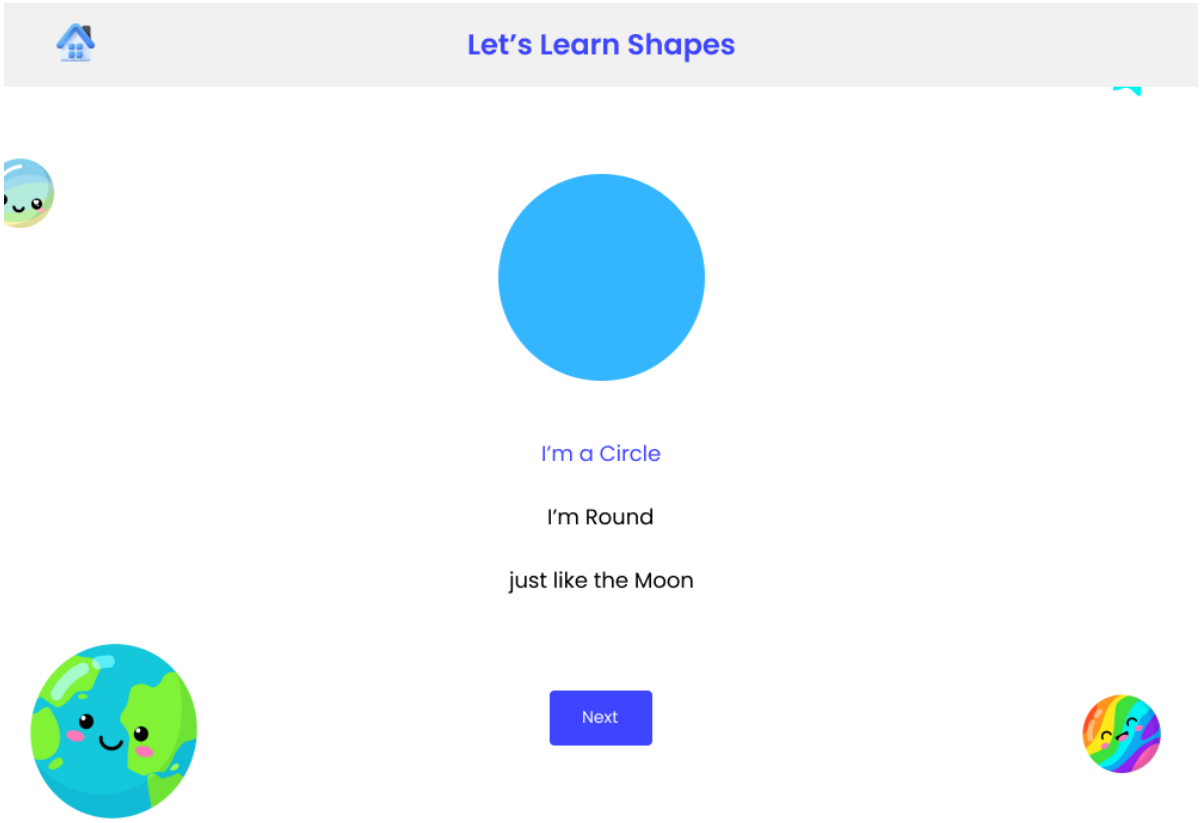

Figure 19: HF-Learn Shapes (Circle)

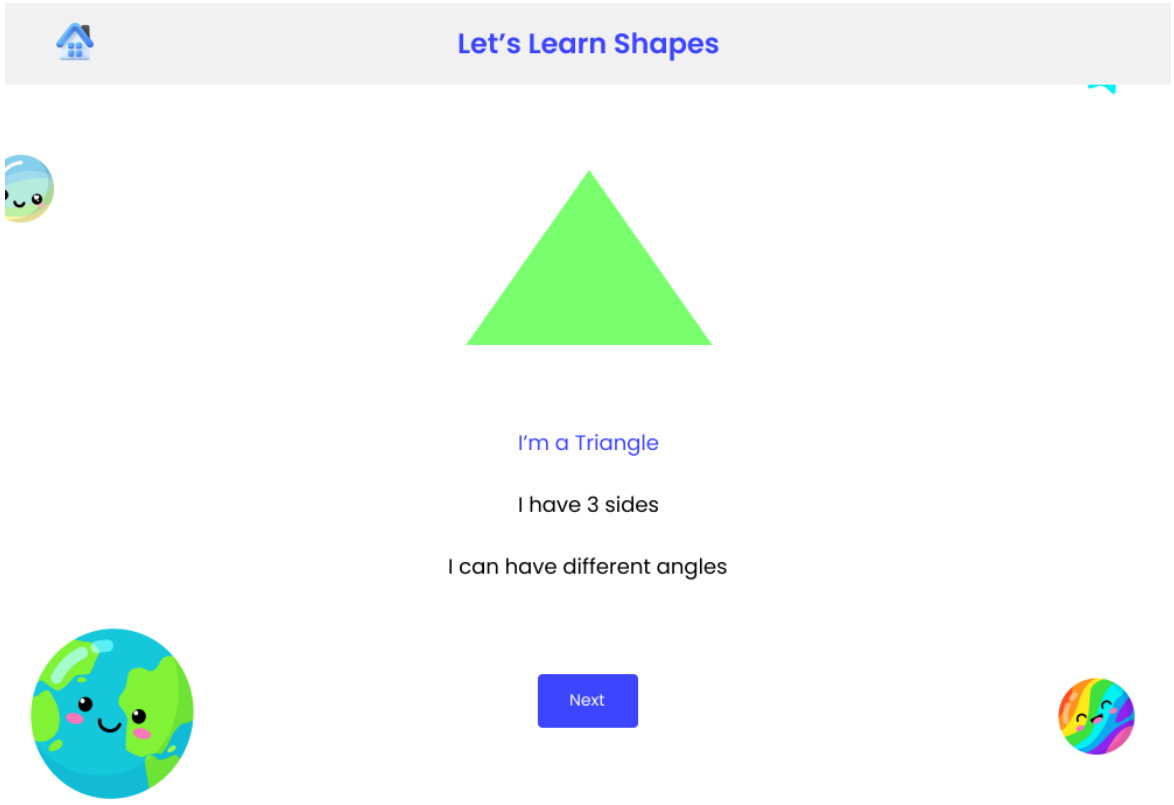

Figure 20: HF-Learn Shapes (Triangle)

4.3.6 – Match Shapes

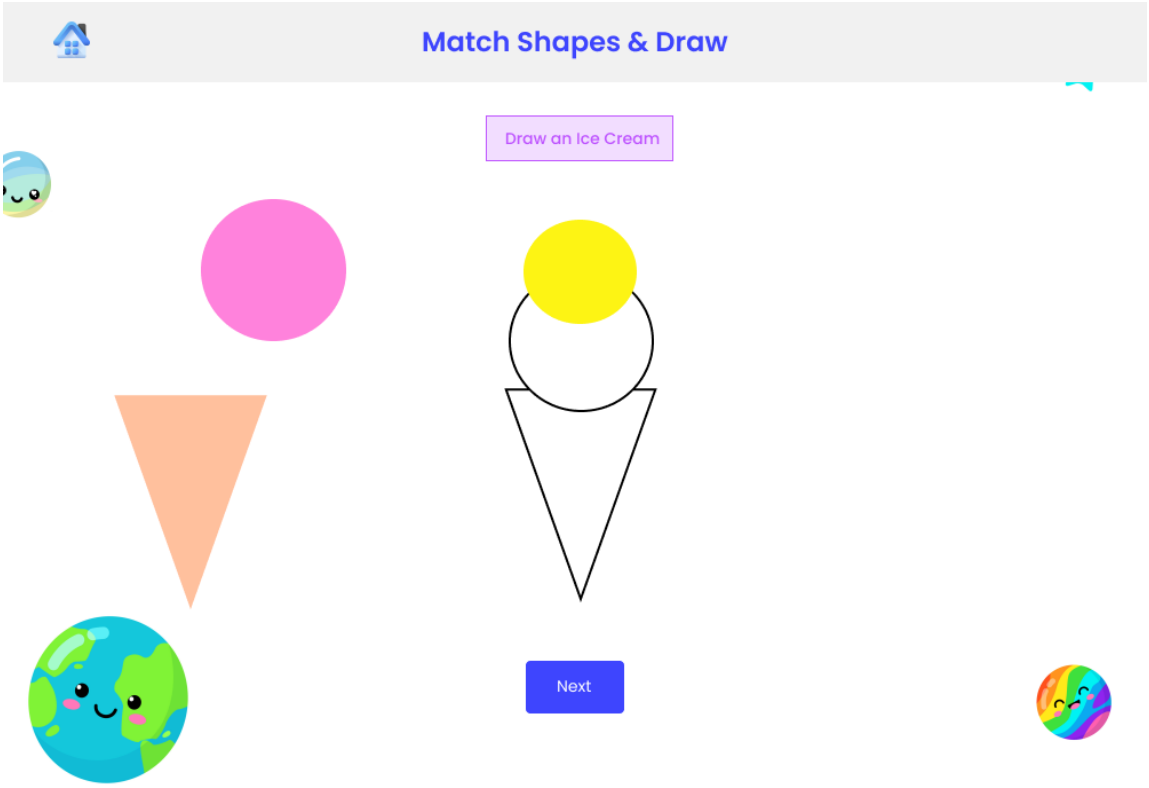

Figure 21: HF-Match Shapes (Ice Cream)

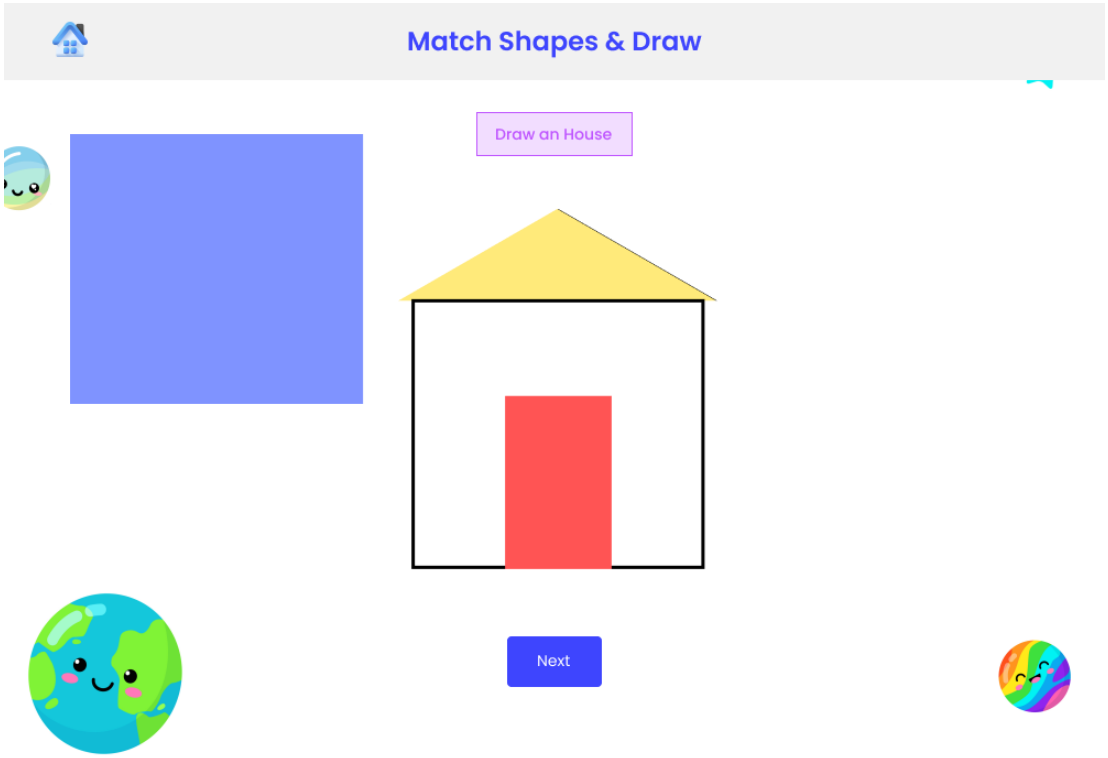

Figure 22: HF-Match Shapes (House)

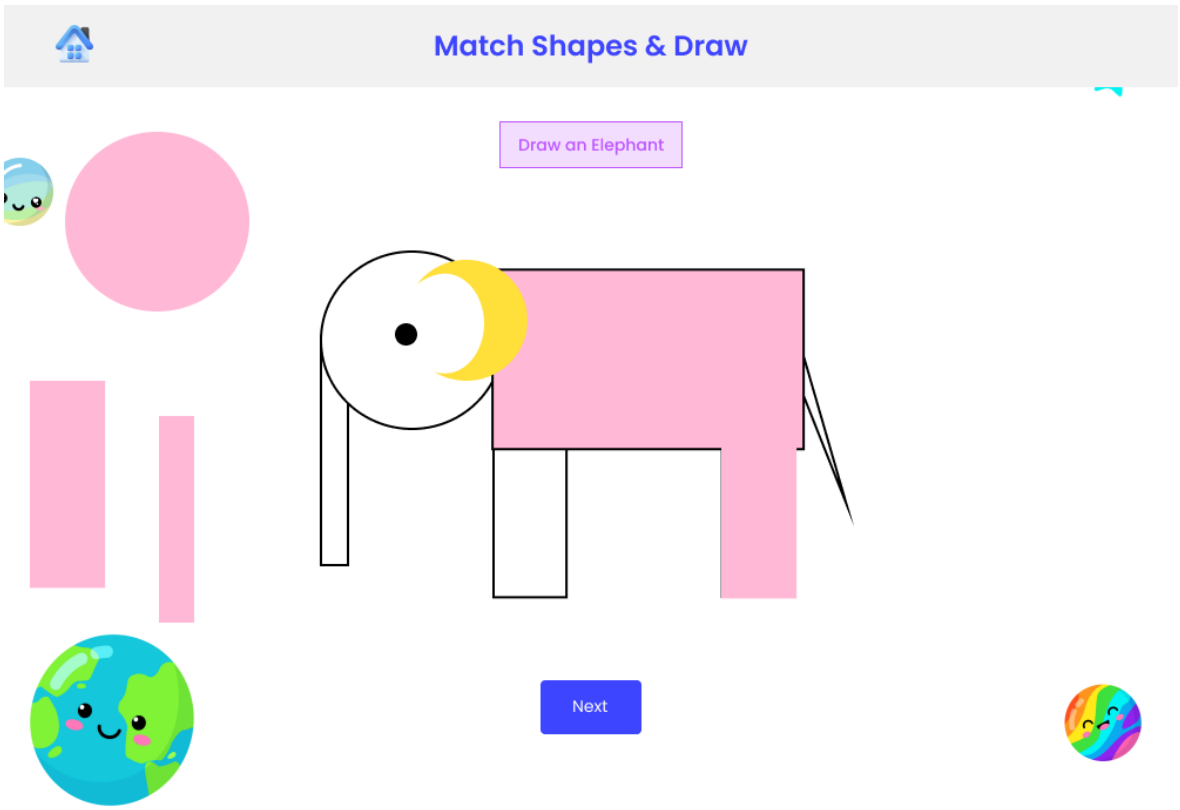

Figure 23: HF-Match Shapes (Elephant)

4.3.7 – Draw with Shapes

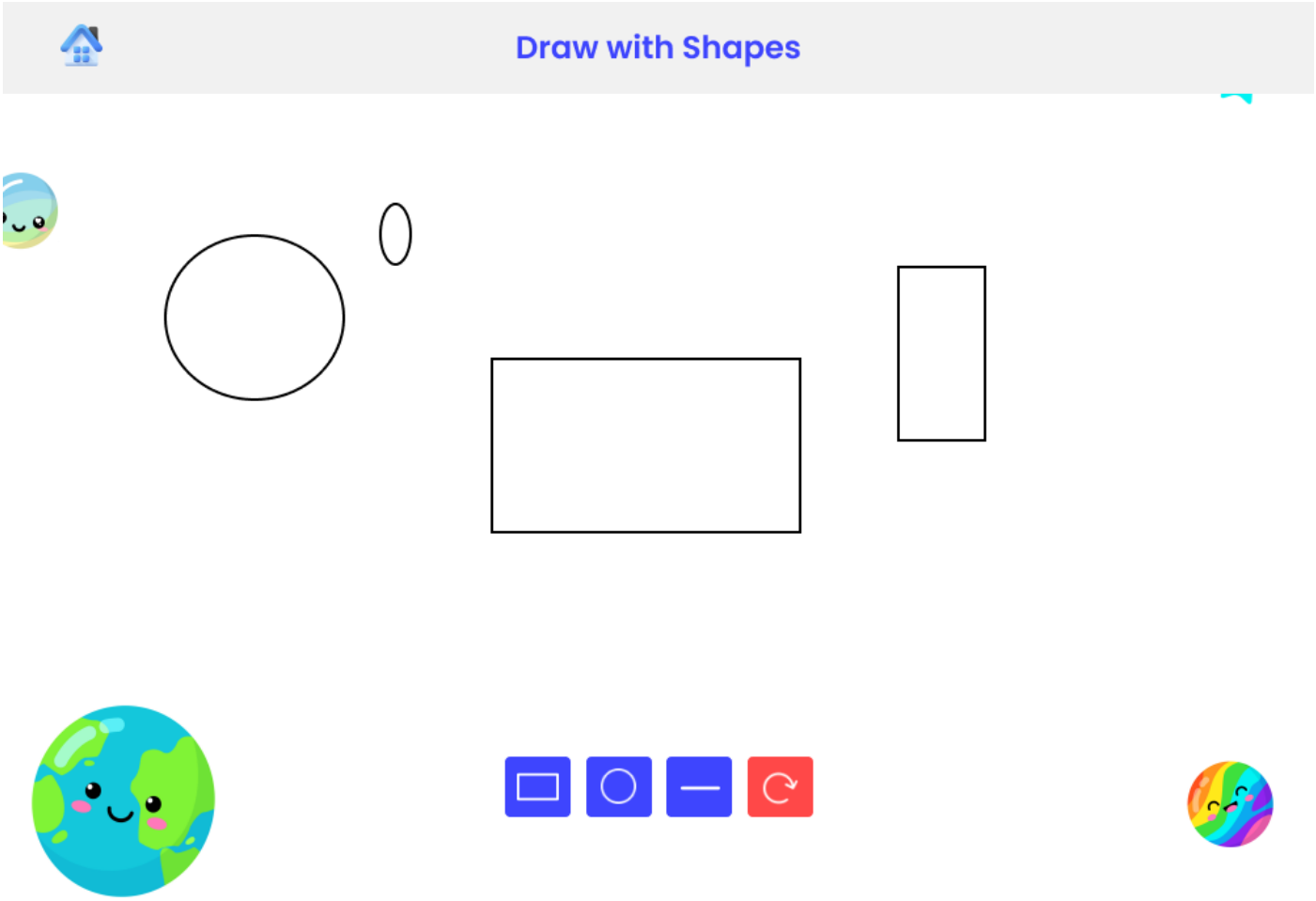

Figure 24: HF-Draw with Shapes

4.3.8 – Color Shapes

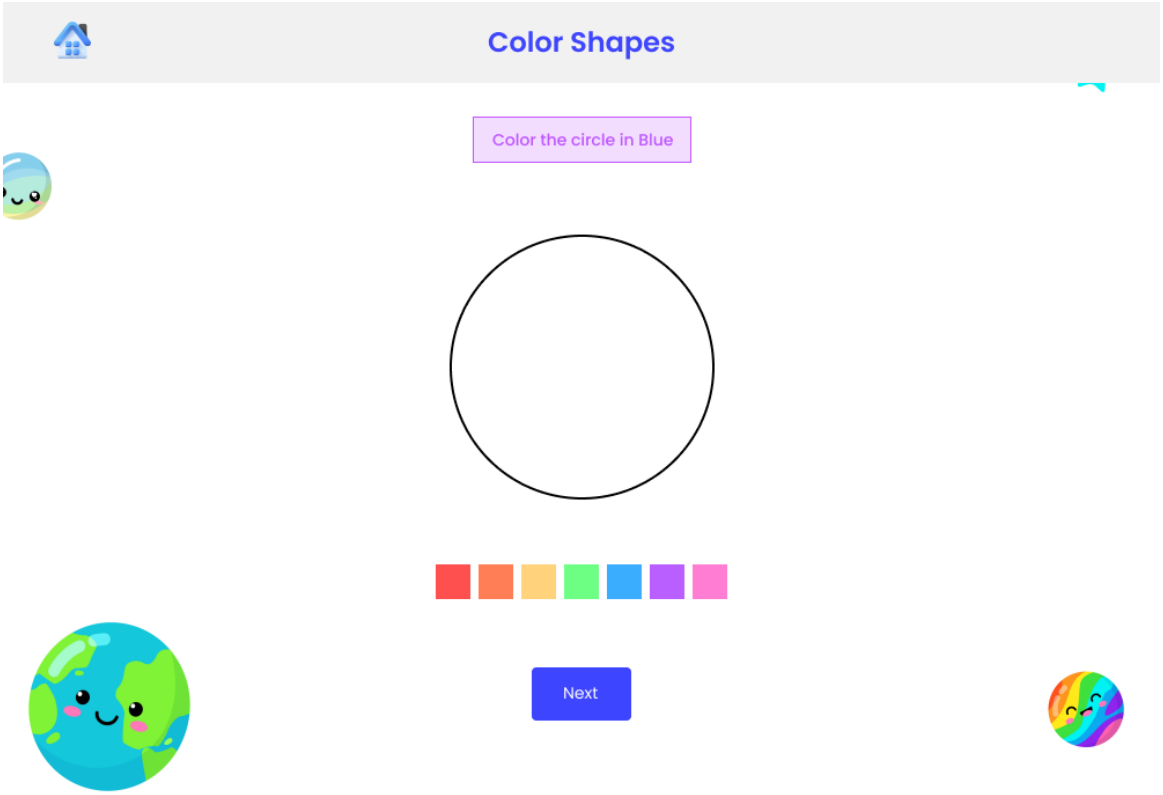

Figure 25: HF-Colour Shapes (Circle)

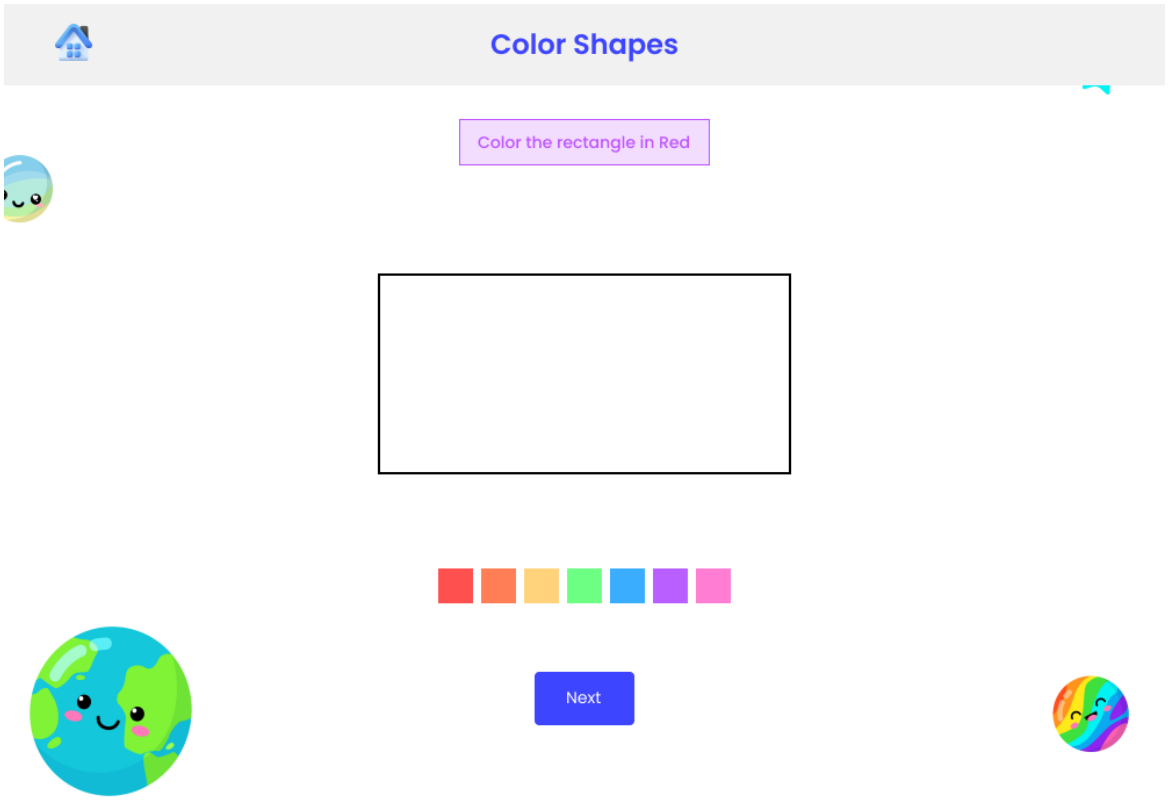

Figure 26: HF-Colour Shapes (Rectangle)

4.3.9 – 3D Objects

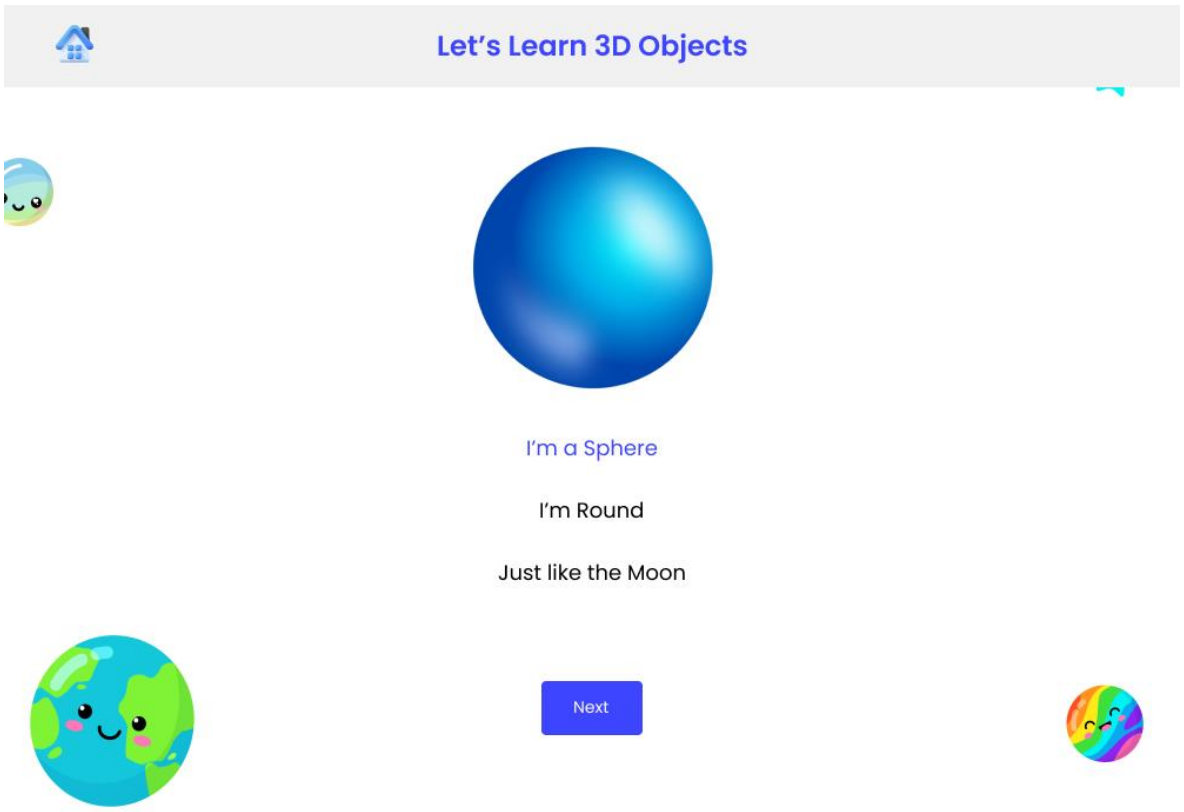

Figure 27: HF-3D Objects (Sphere)

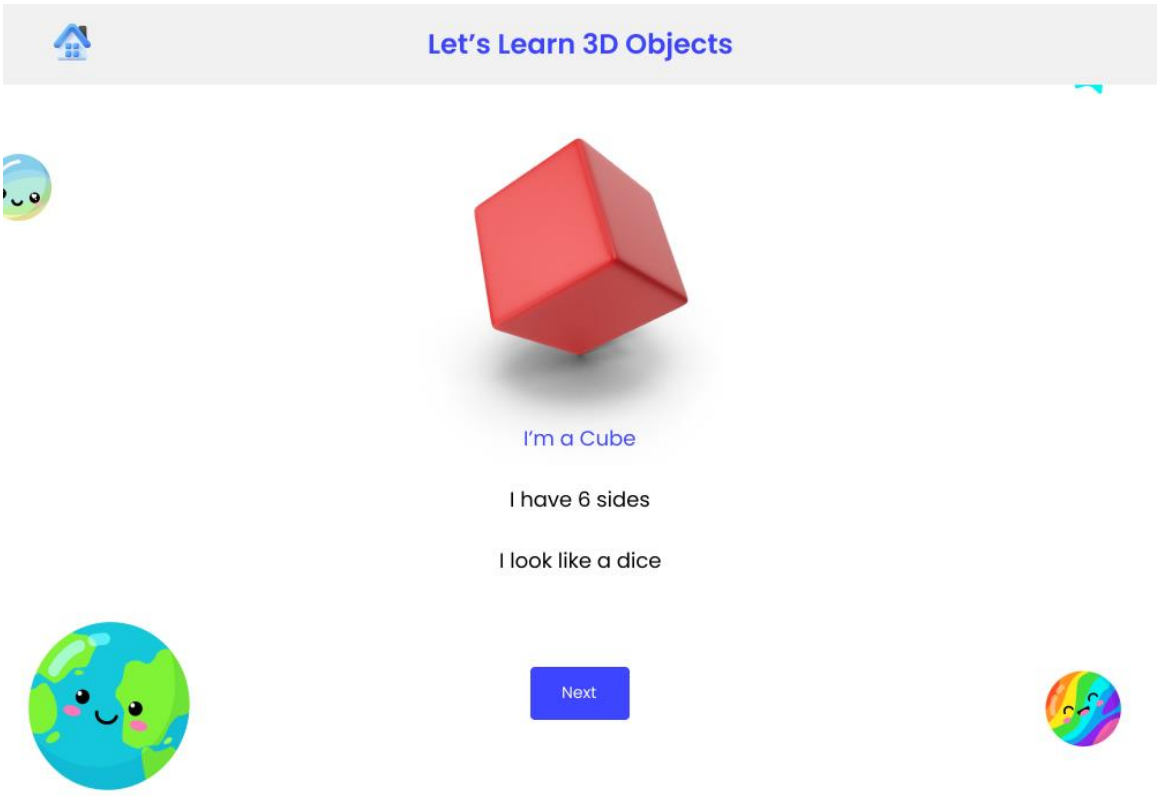

Figure 28: HF-3D Objects (Cube)

4.3.10 – 3D Space

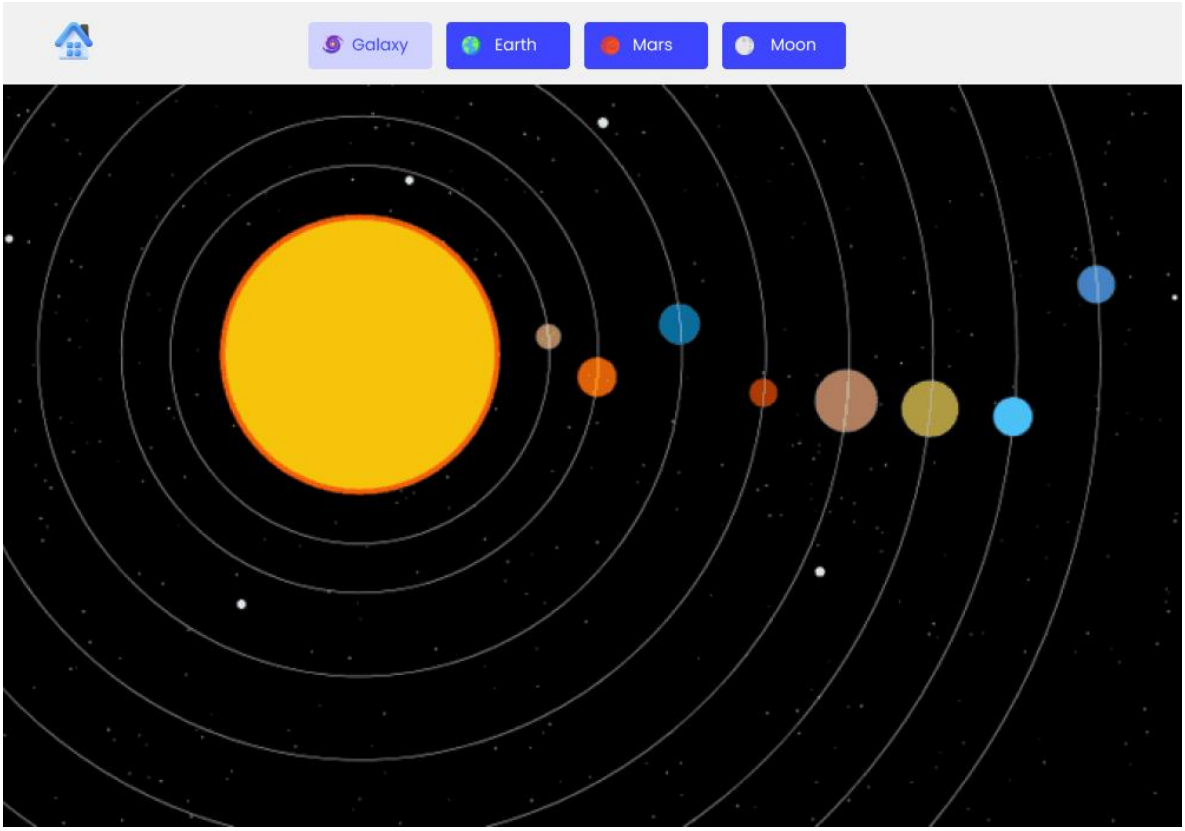

Figure 29: HF-3D Space (Galaxy)

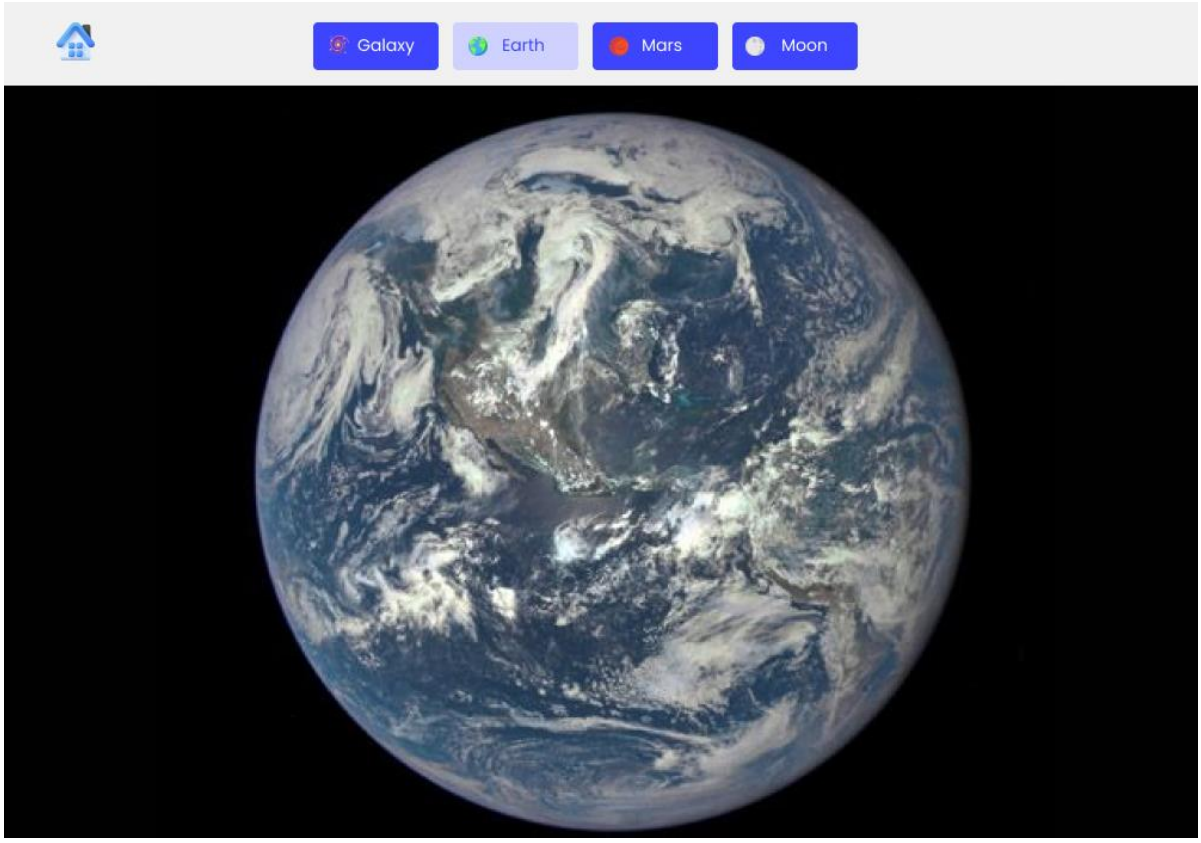

Figure 30: HF-3D Space (Earth)

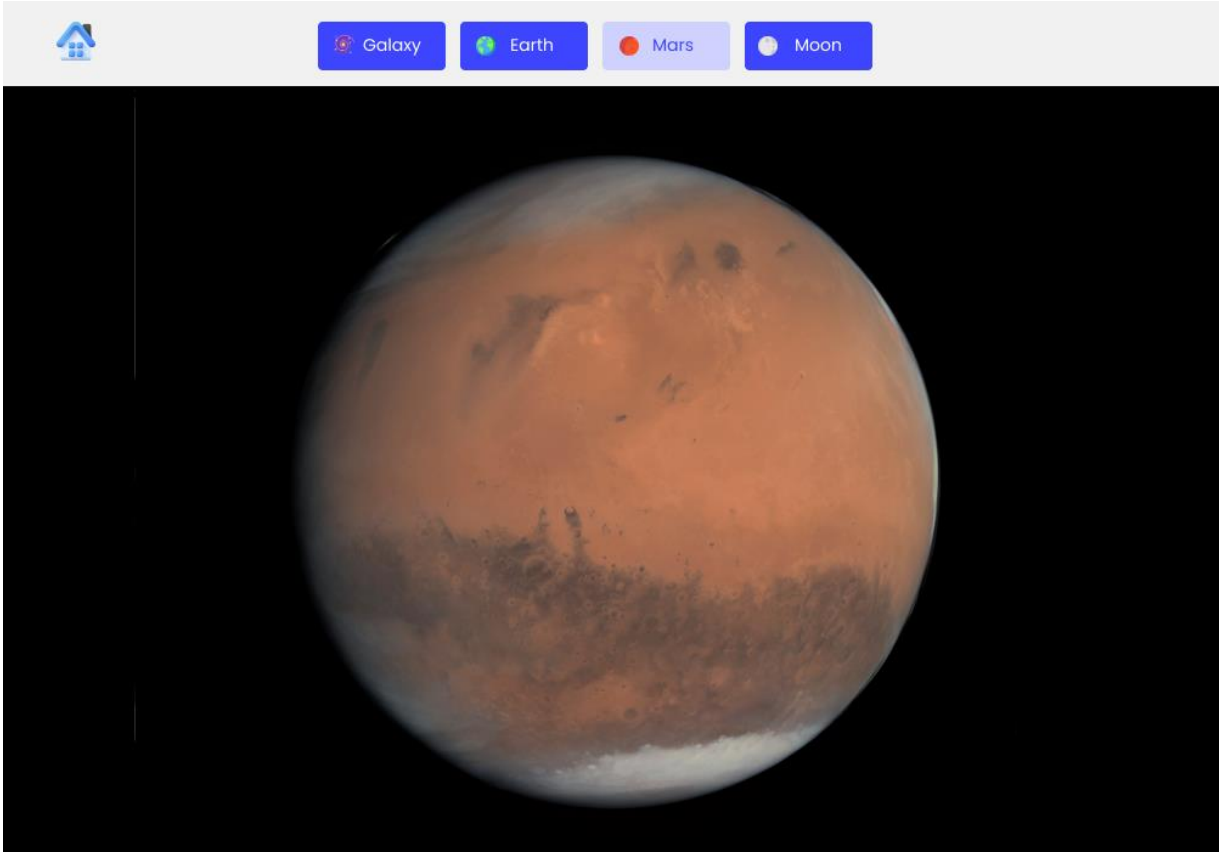

Figure 31: HF-3D Space (Mars)

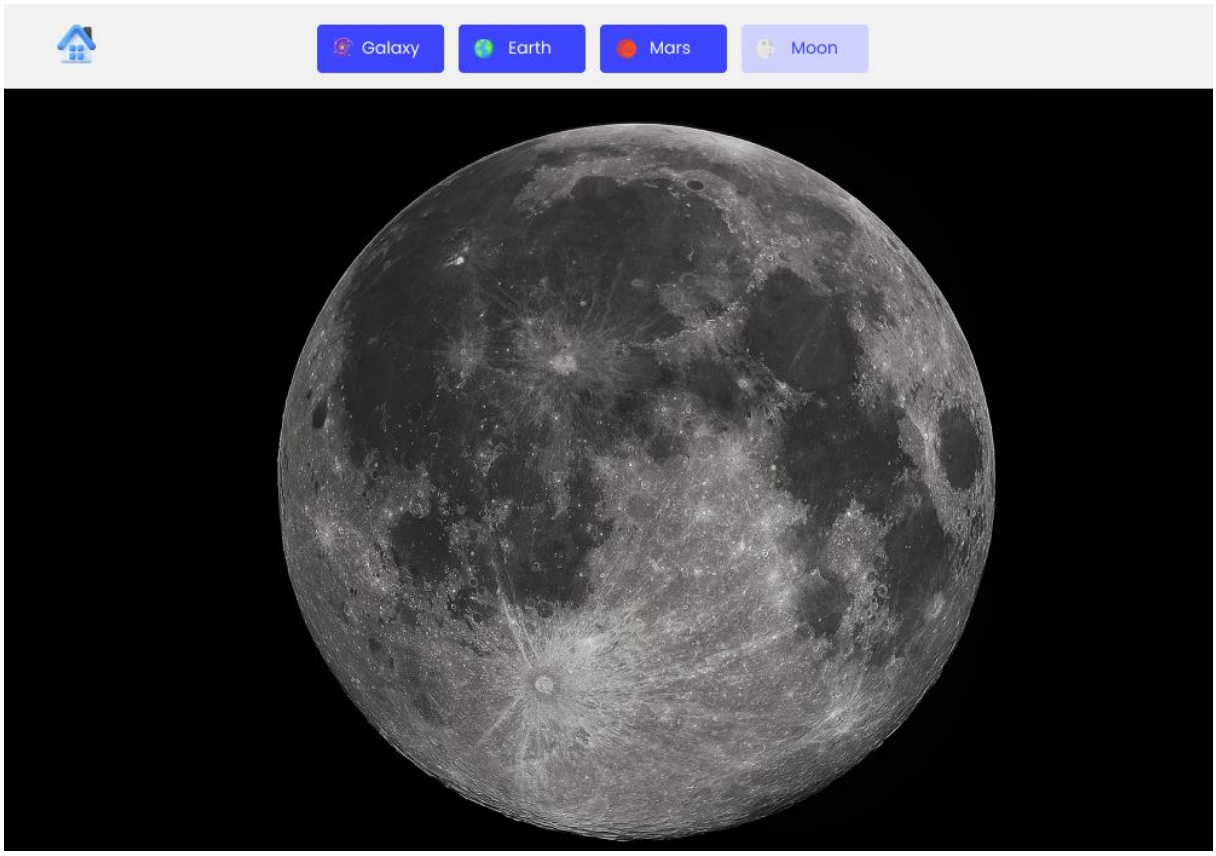

Figure 32: HF-3D Space (Moon)

Chapter 05 – Implementation

The implementation of the ShapeLand application was executed utilizing the Java Swing framework, which is a robust and widely adopted technology, as the development platform for this application. By leveraging the capabilities of Java Swing, the application's user interface (UI) was meticulously designed to provide an intuitive and engaging learning experience for primary school children. The UI elements, including buttons, menus, dialog boxes, and graphical representations of shapes, were created using Java Swing's extensive library of components.

GitHub Repository Link - https://github.com/Plymouth-University/main-coursework-phoenix

5.1 – Login

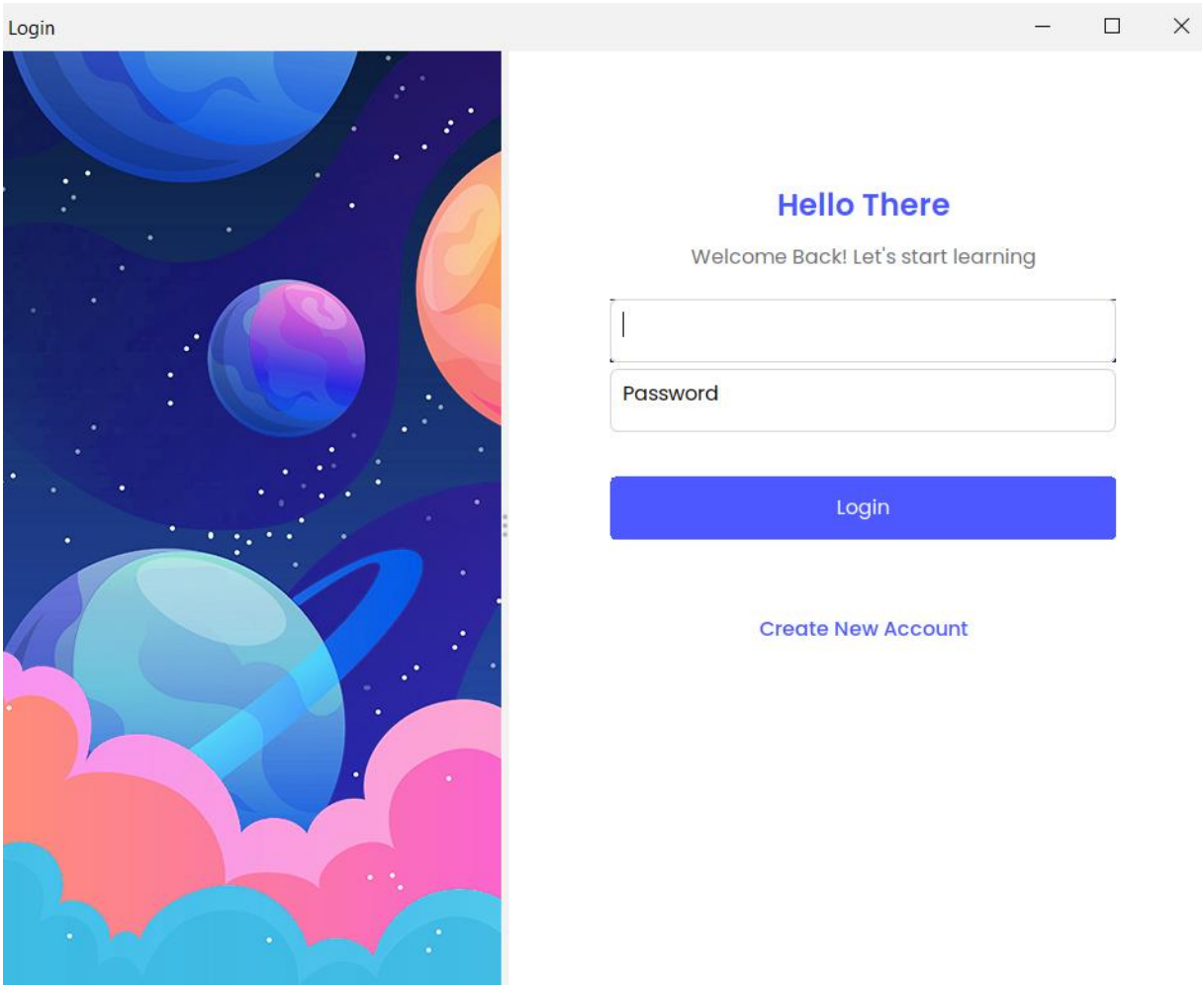

Figure 33: Login

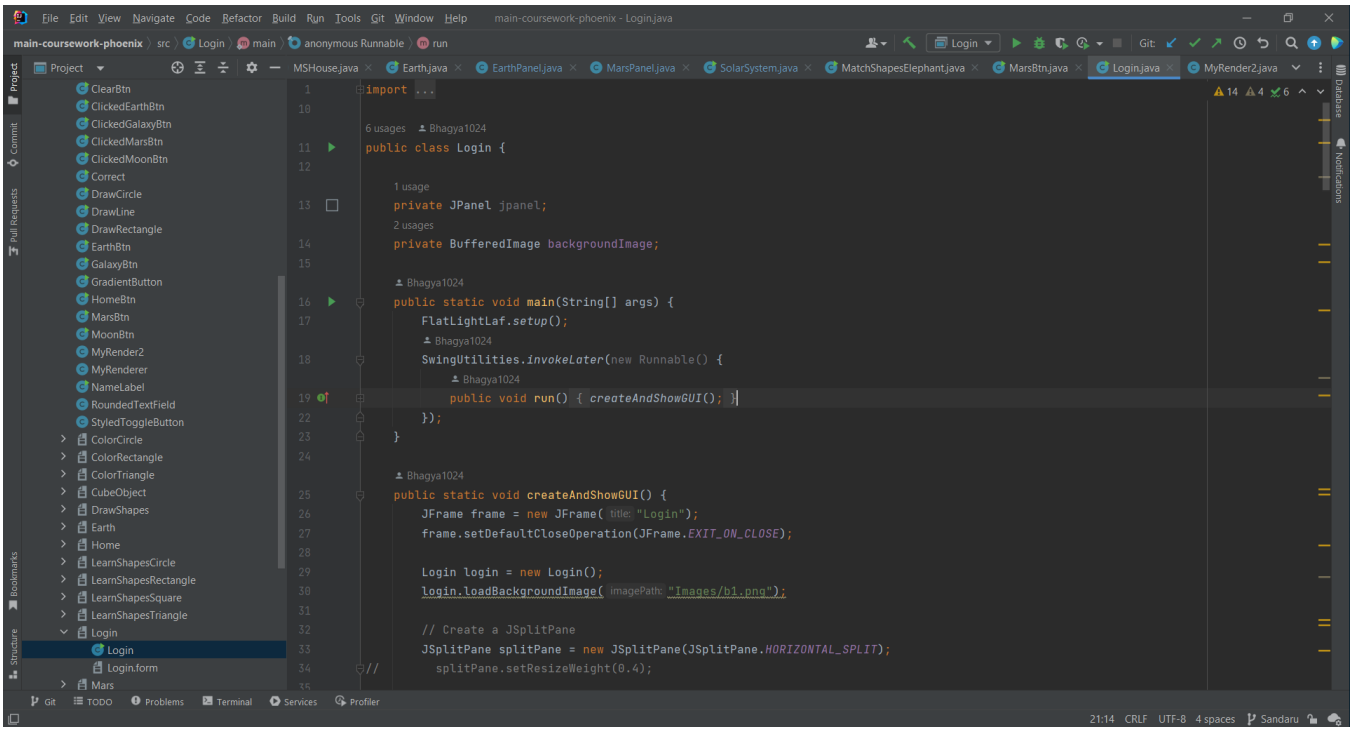

Figure 34: Source Code of Login

5.2 – Sign Up

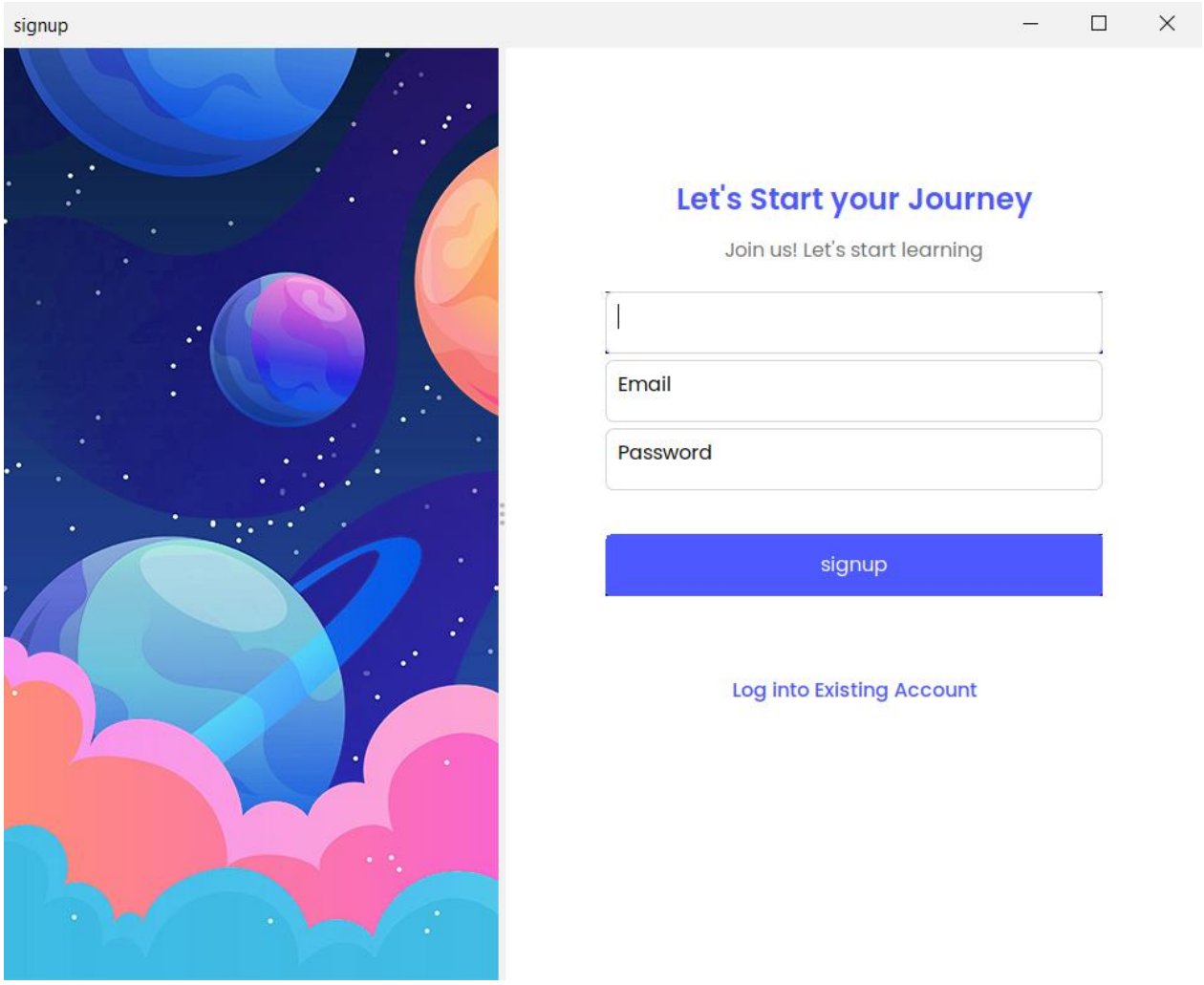

Figure 35: Sign Up

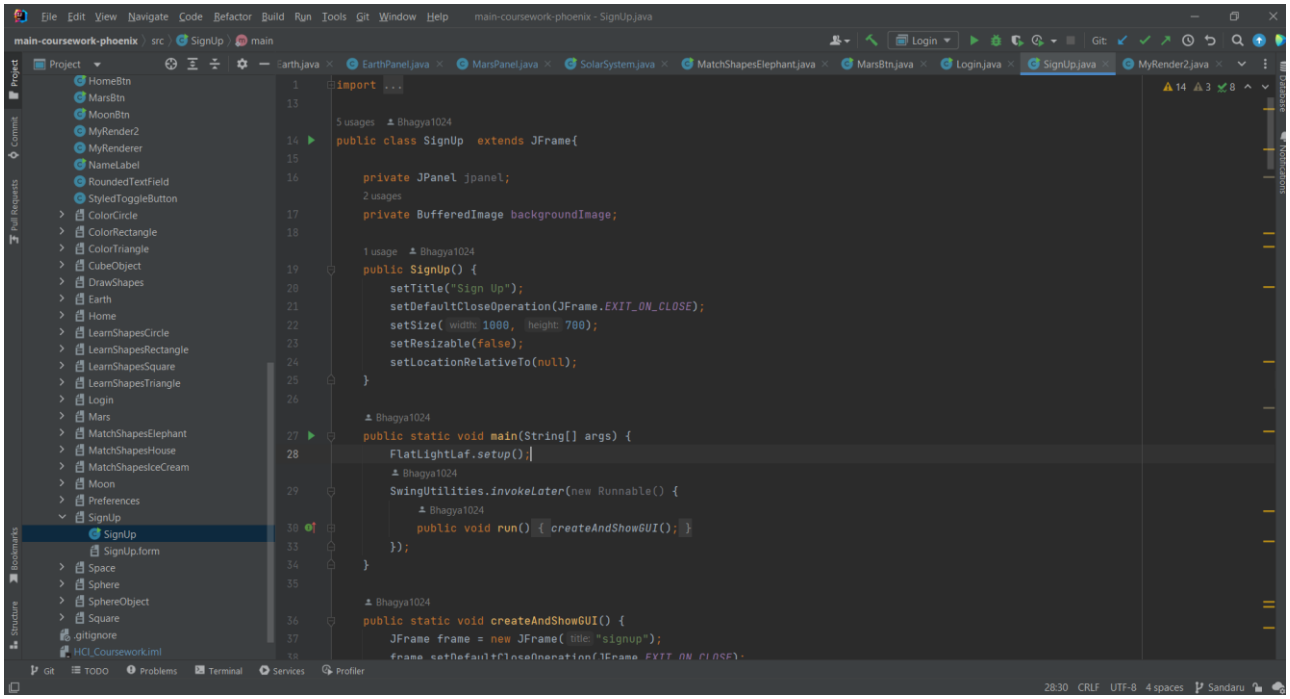

Figure 36: Source Code of Sign Up

5.3 – Dashboard

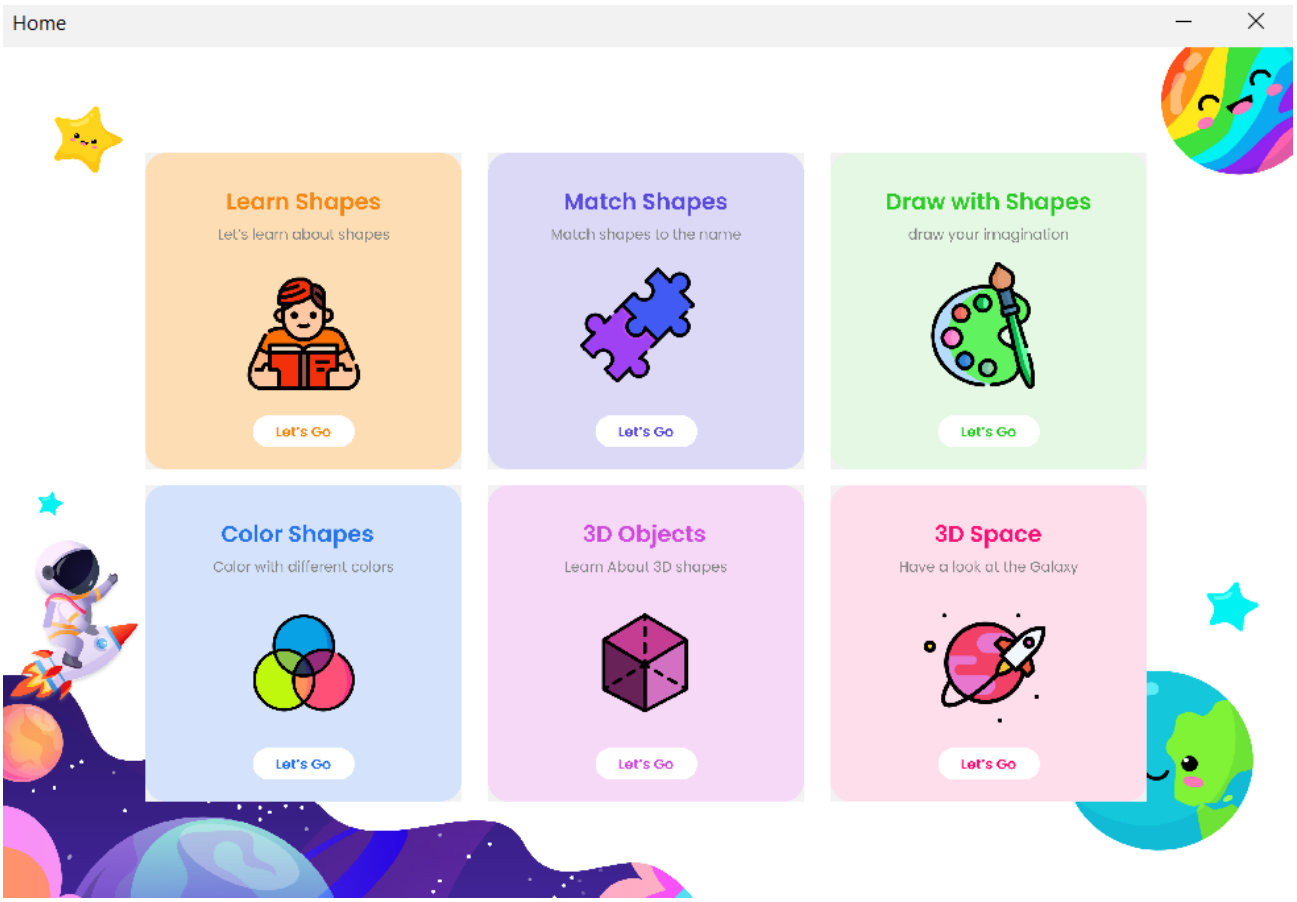

Figure 37: Dashboard

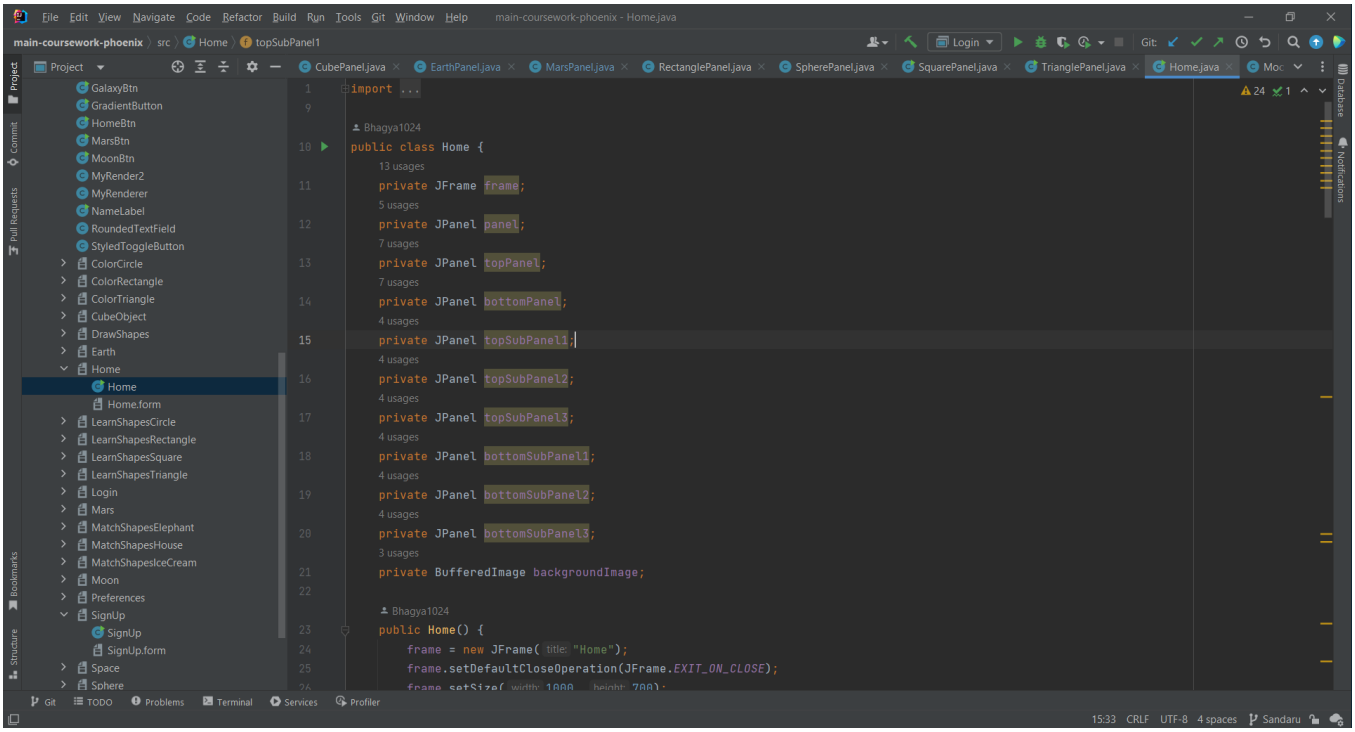

Figure 38: Source Code of Dashboard

5.4 – Learn Shapes

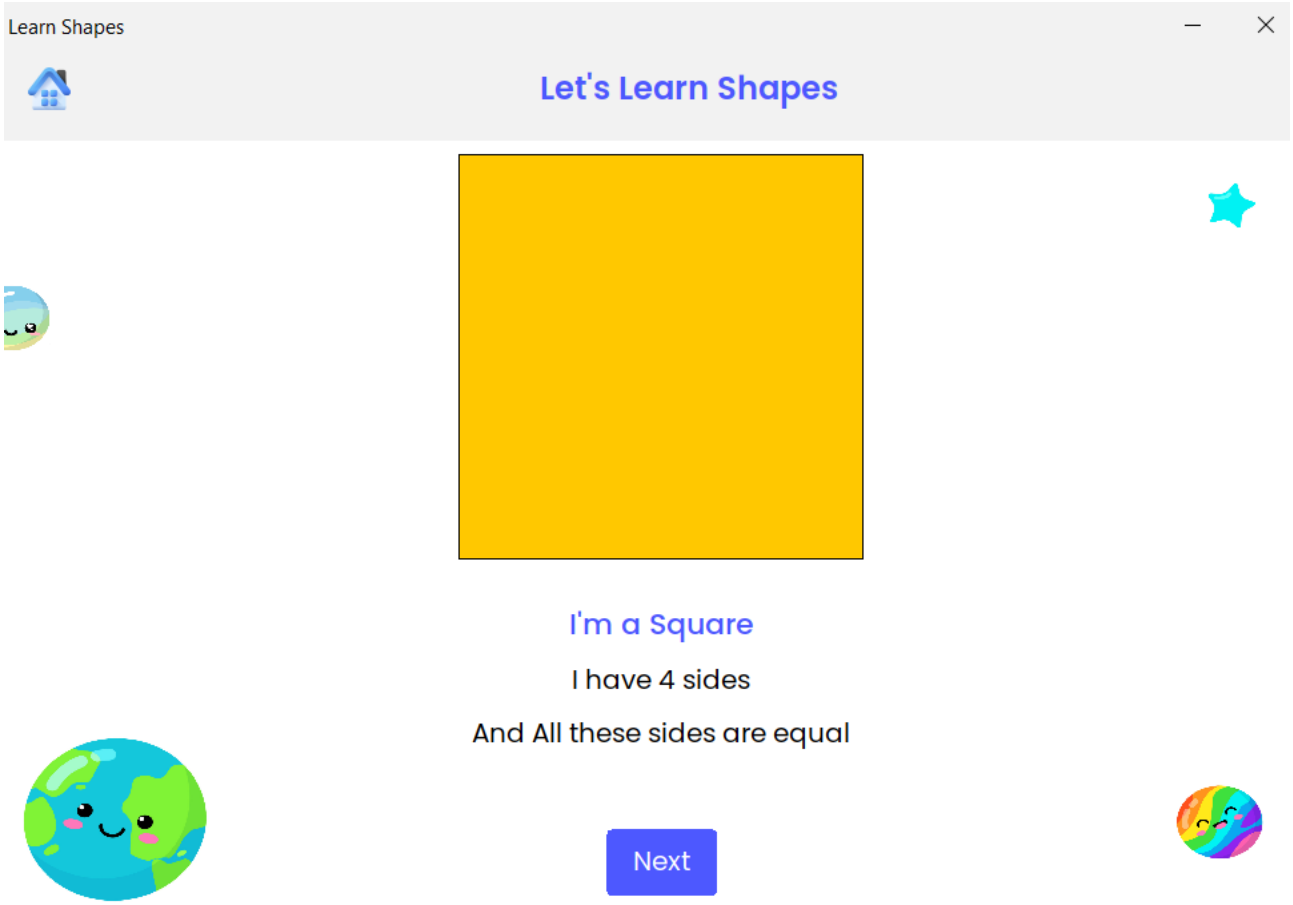

Figure 39: Square

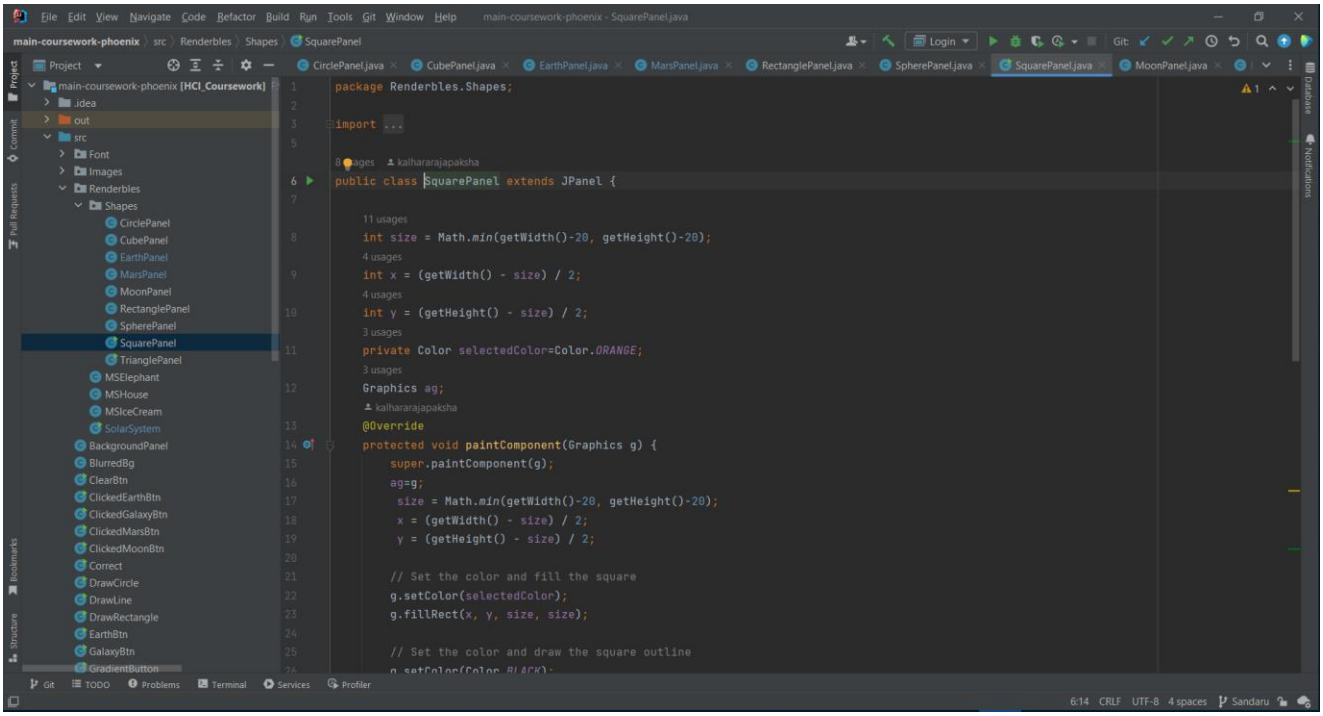

Figure 40: Source Code of Square

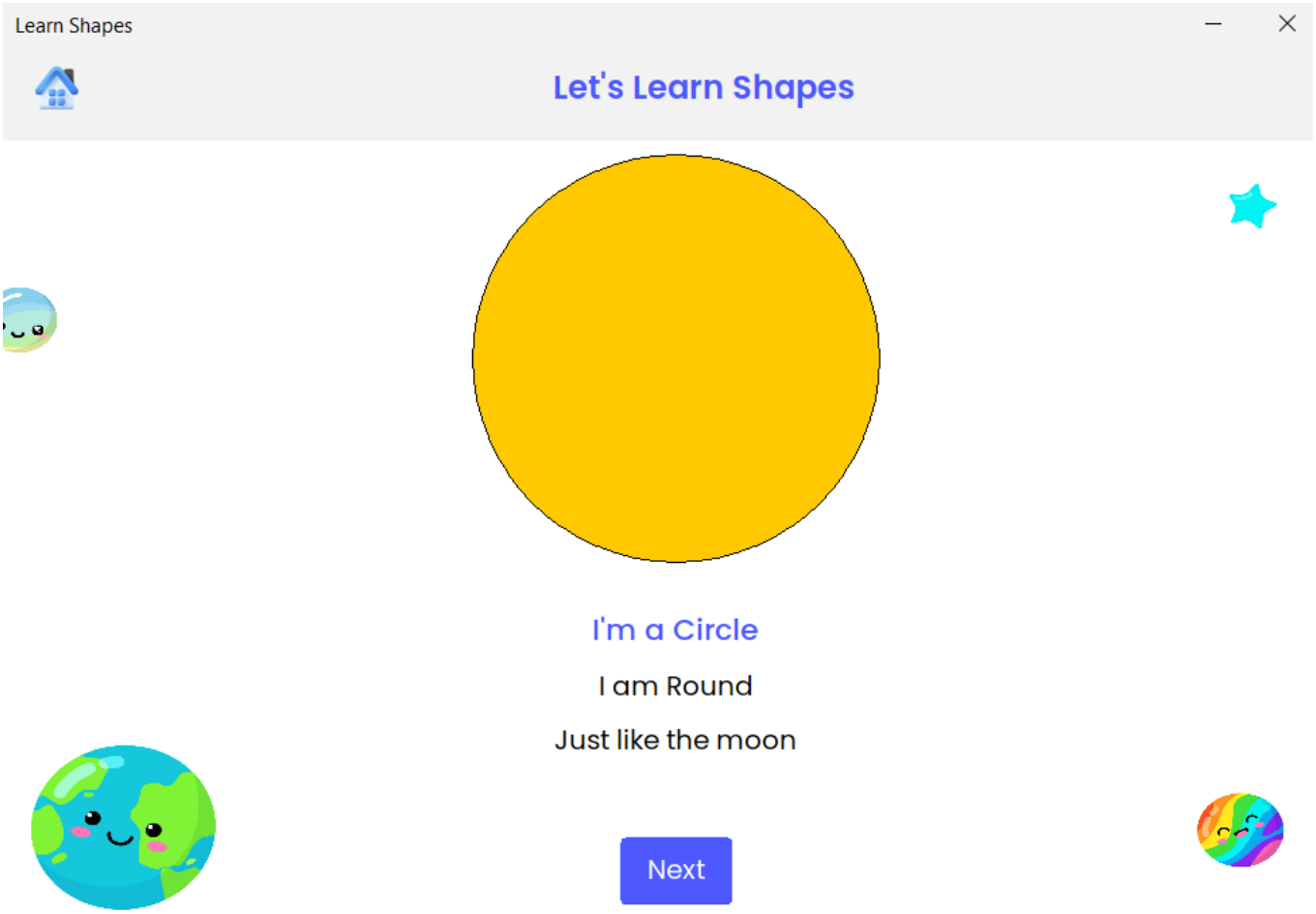

Figure 41: Circle

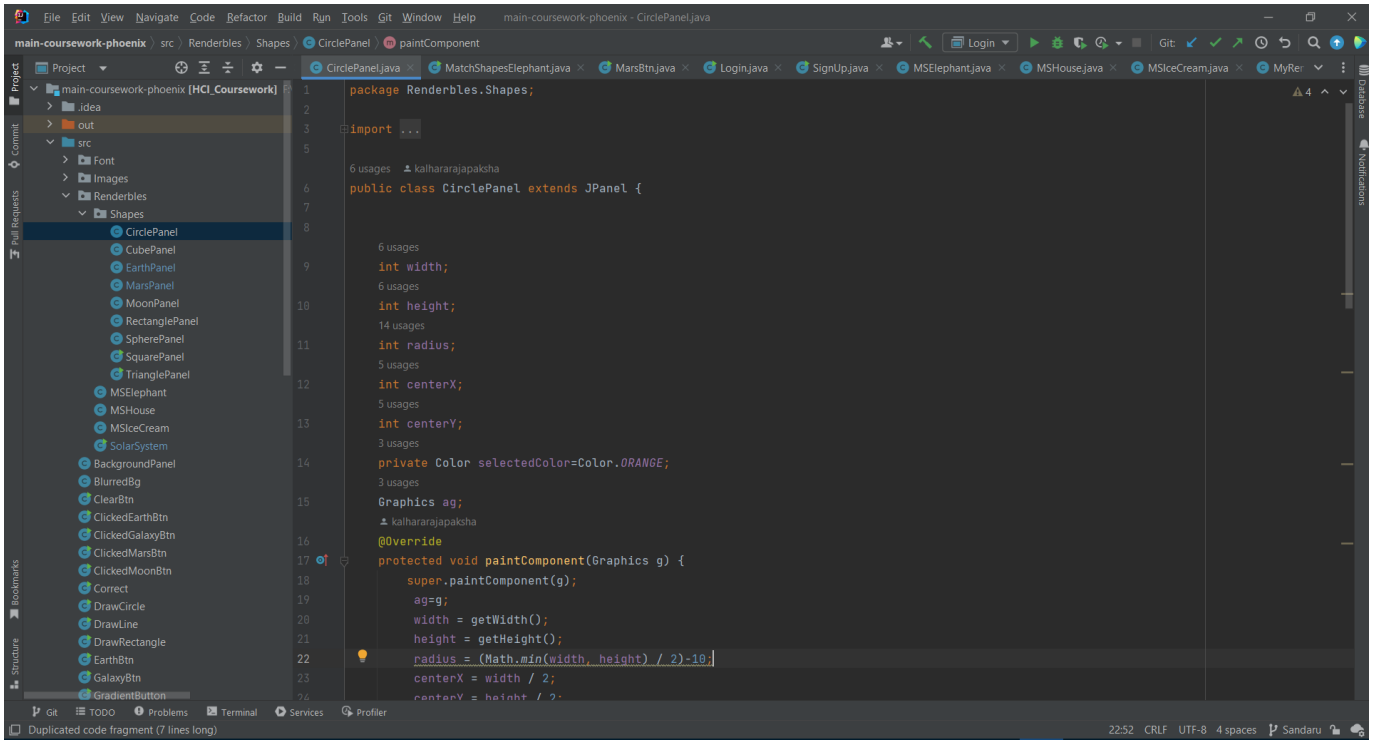

Figure 42: Source Code of Circle

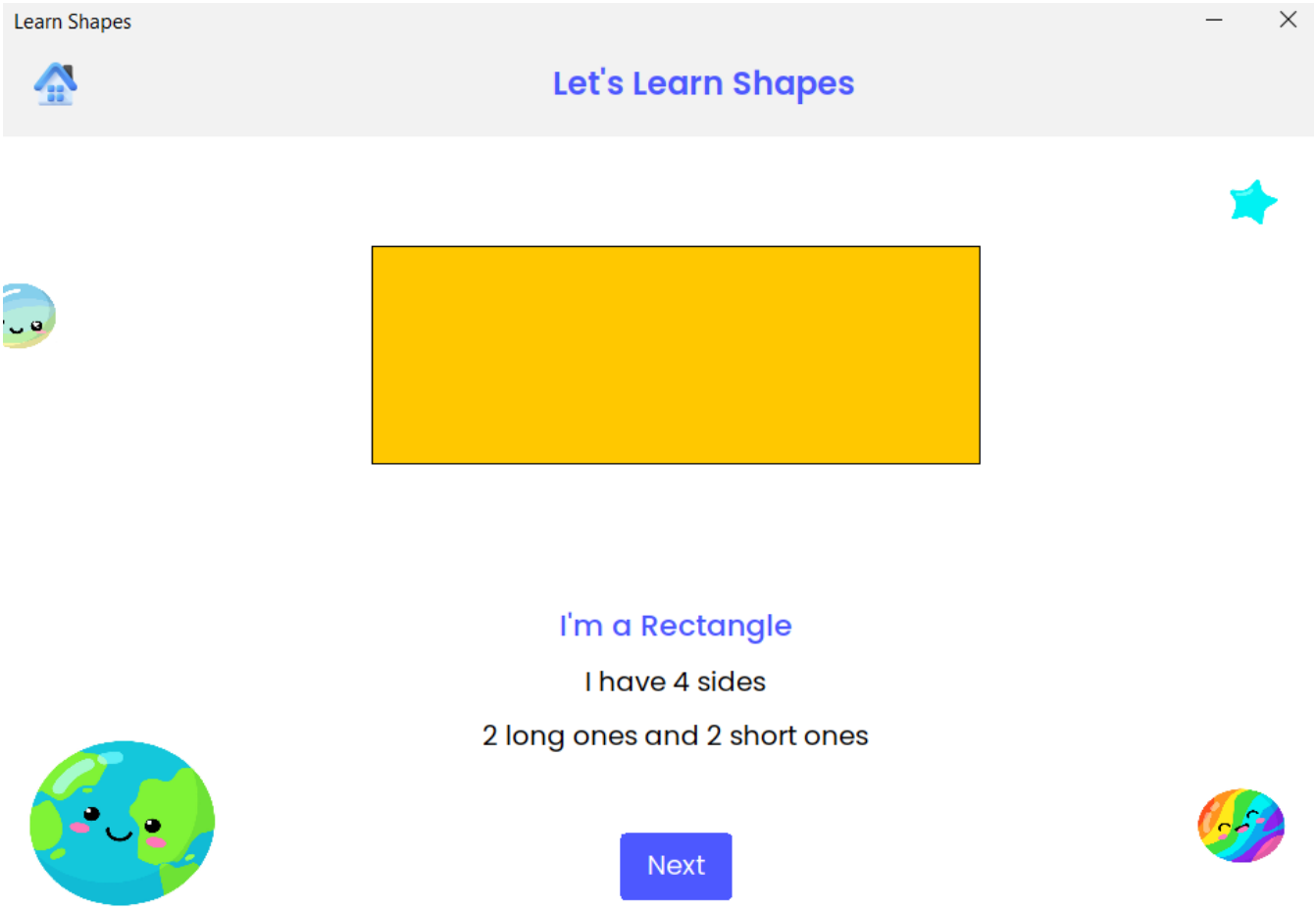

Figure 43: Rectangle

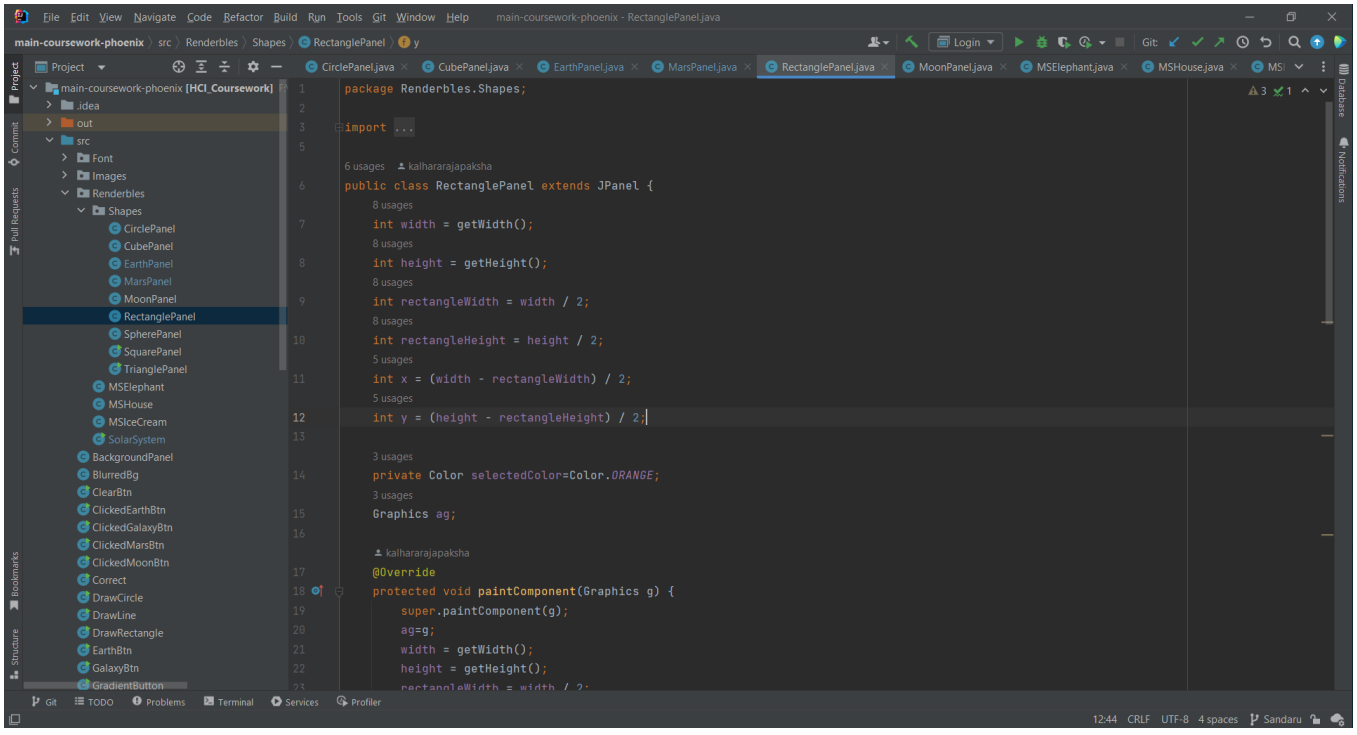

Figure 44: Source Code of Rectangle

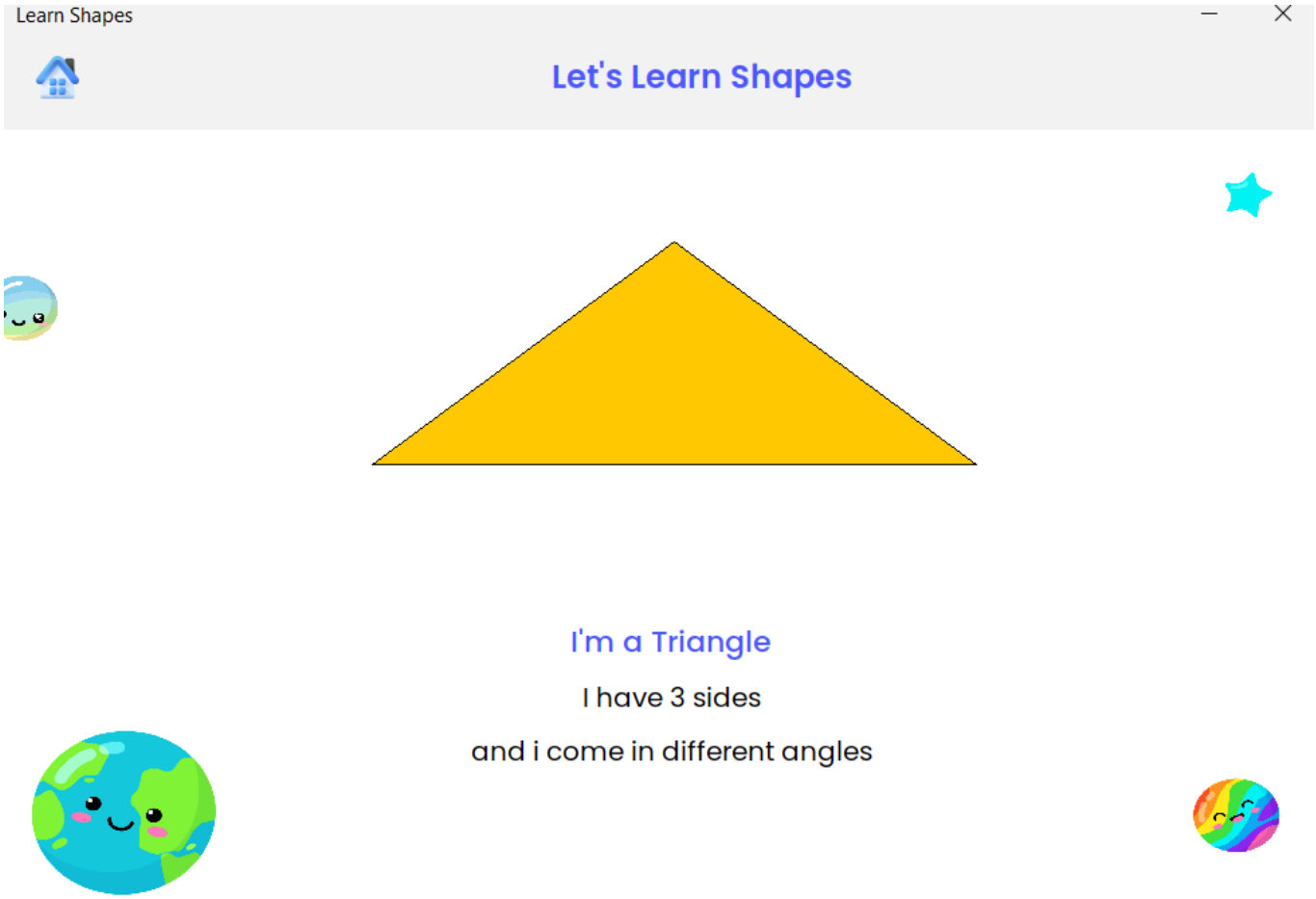

Figure 45: Triangle

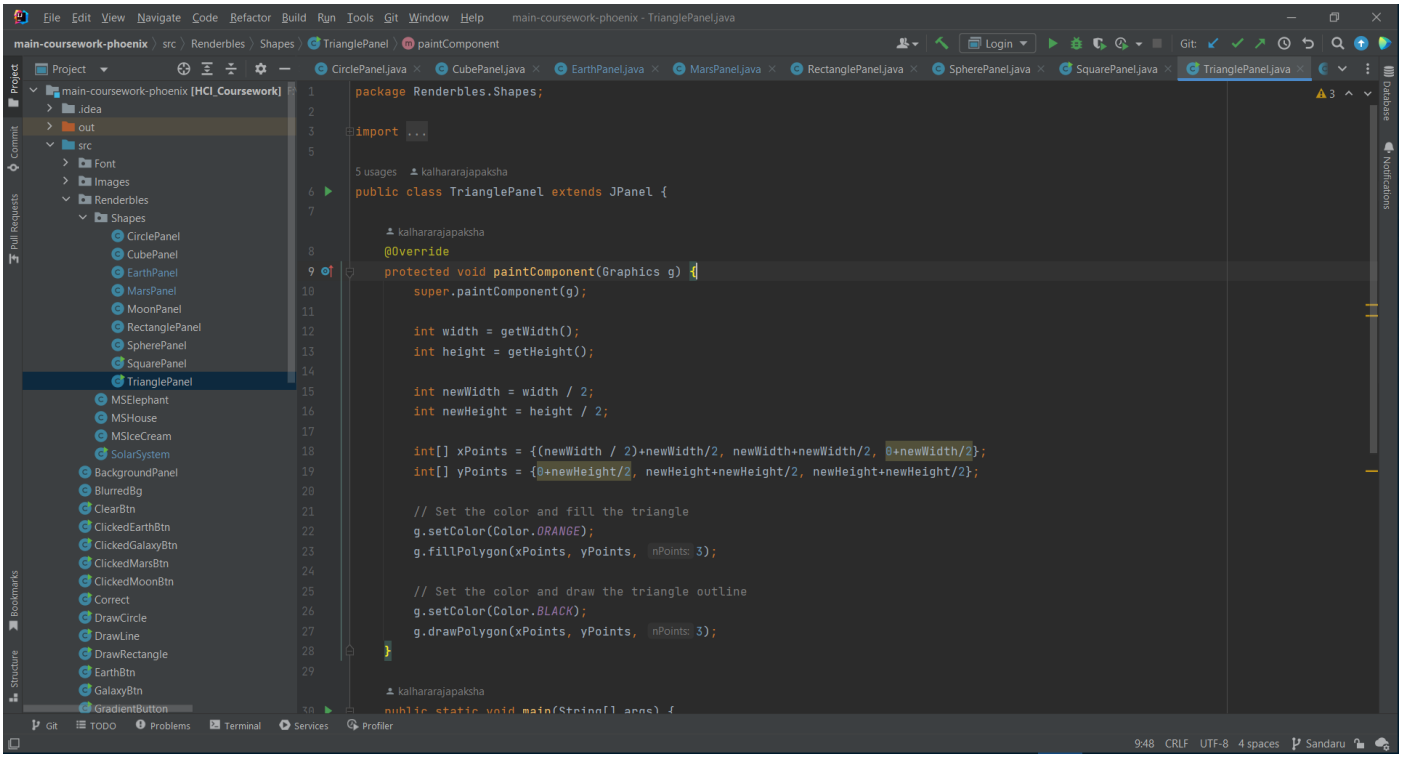

Figure 46: Source Code of Triangle

5.5 – Match Shapes

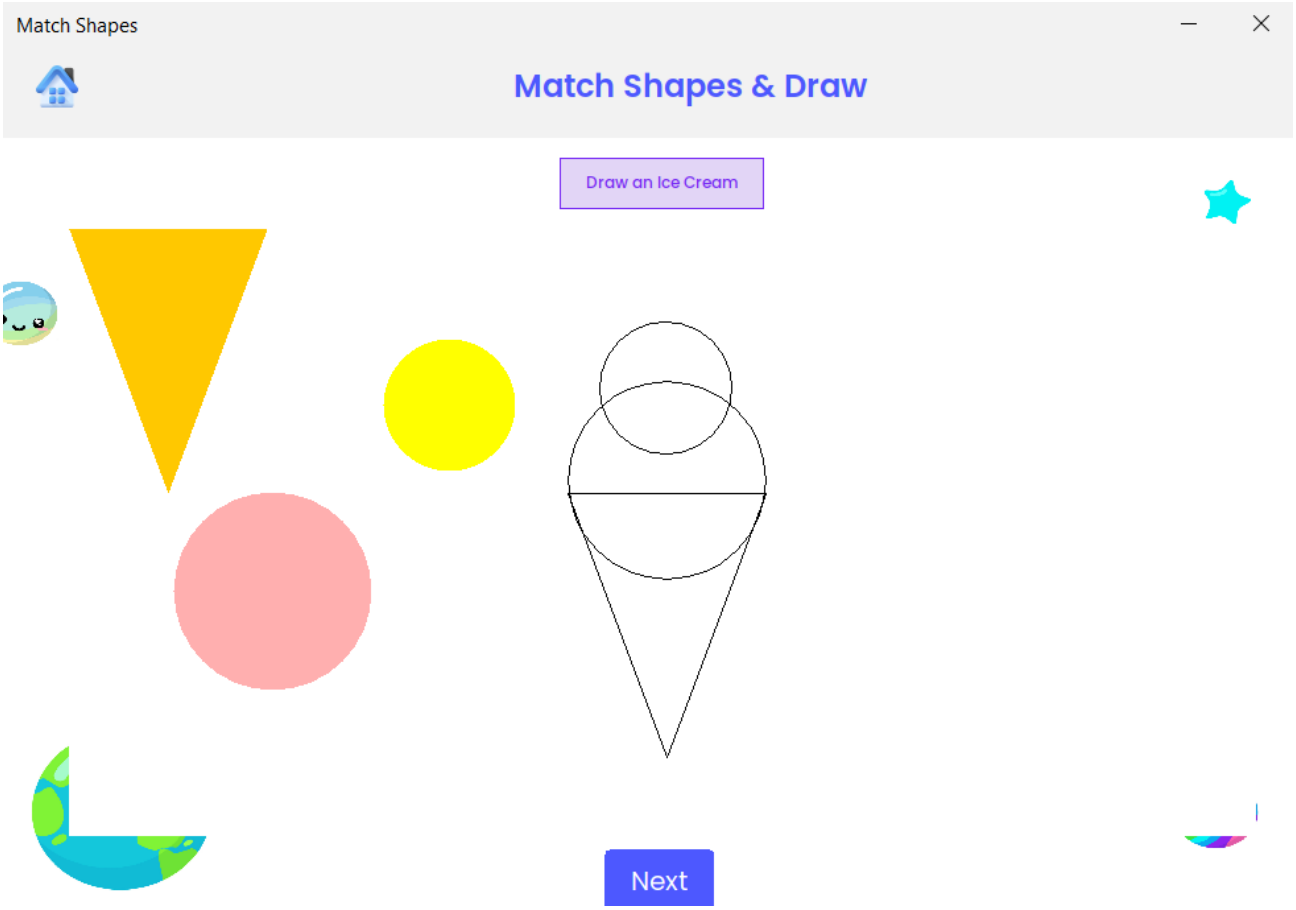

Figure 47: Create Ice Cream

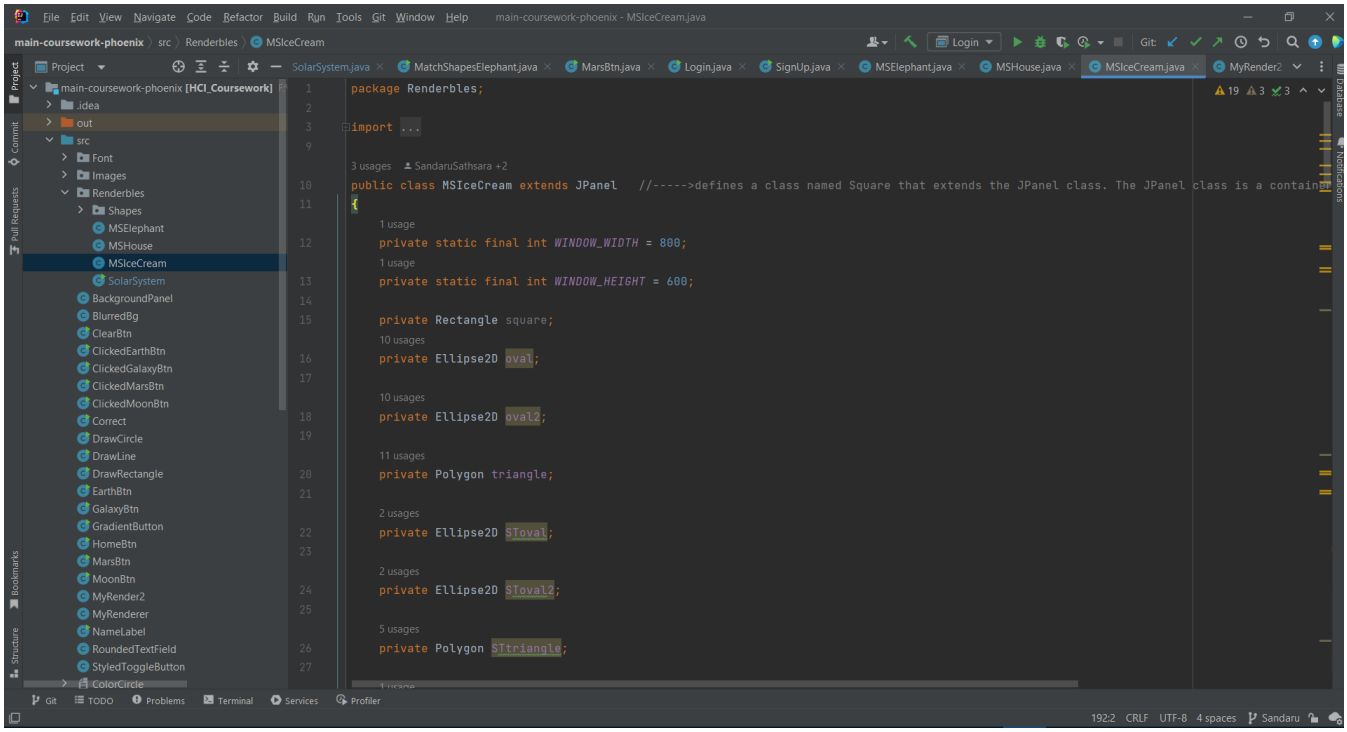

Figure 48: Source Code of Create Ice Cream

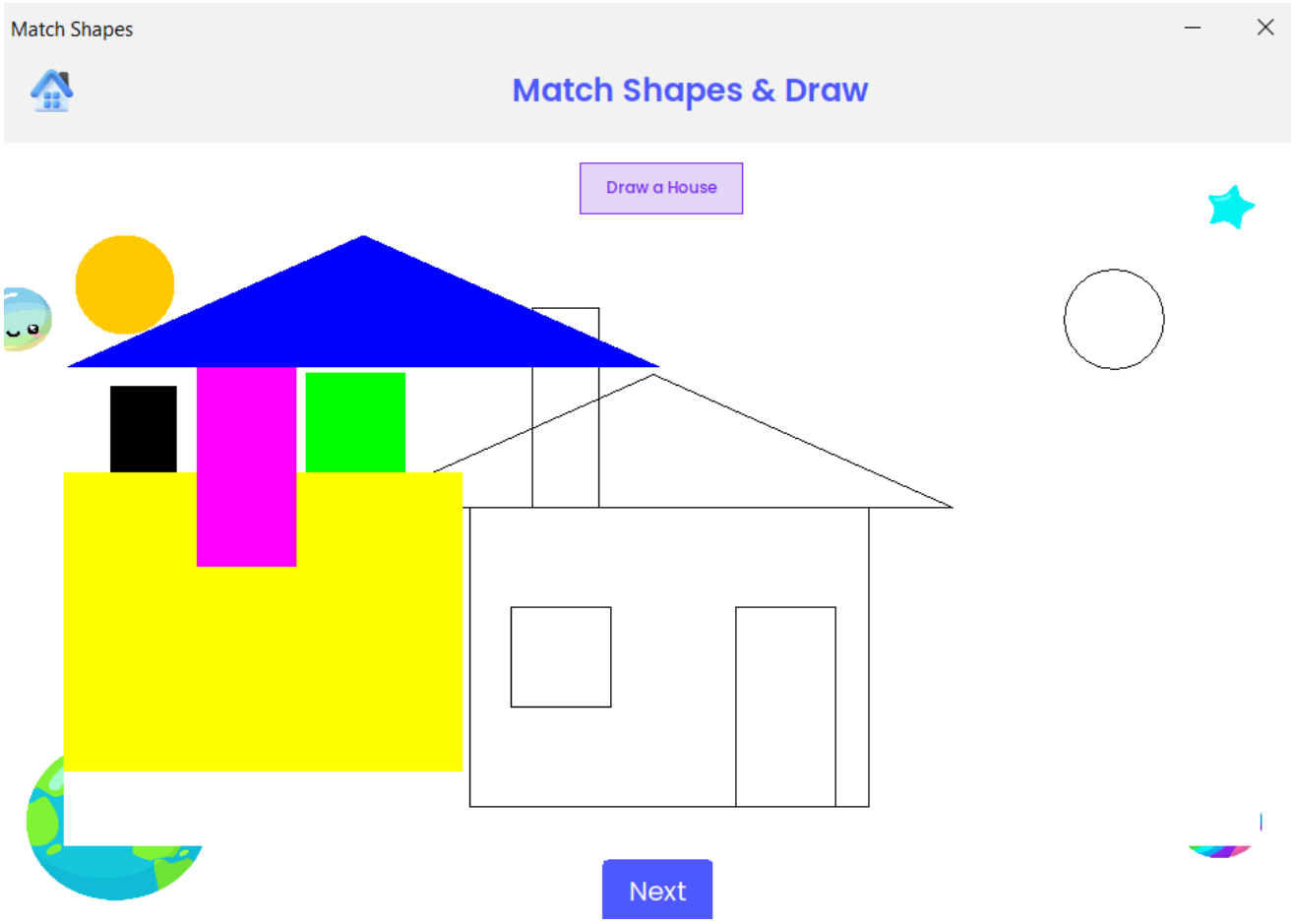

Figure 49: Create House

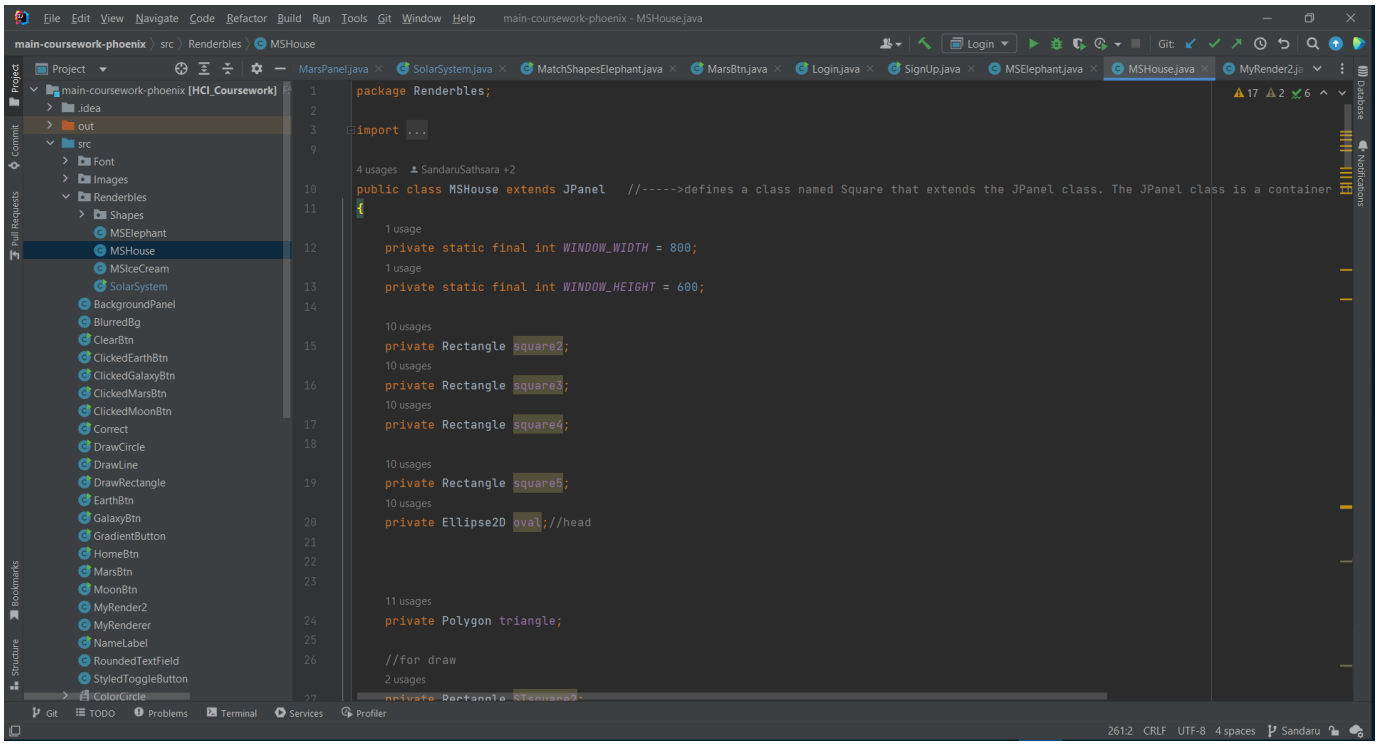

Figure 50: Source Code of Create House

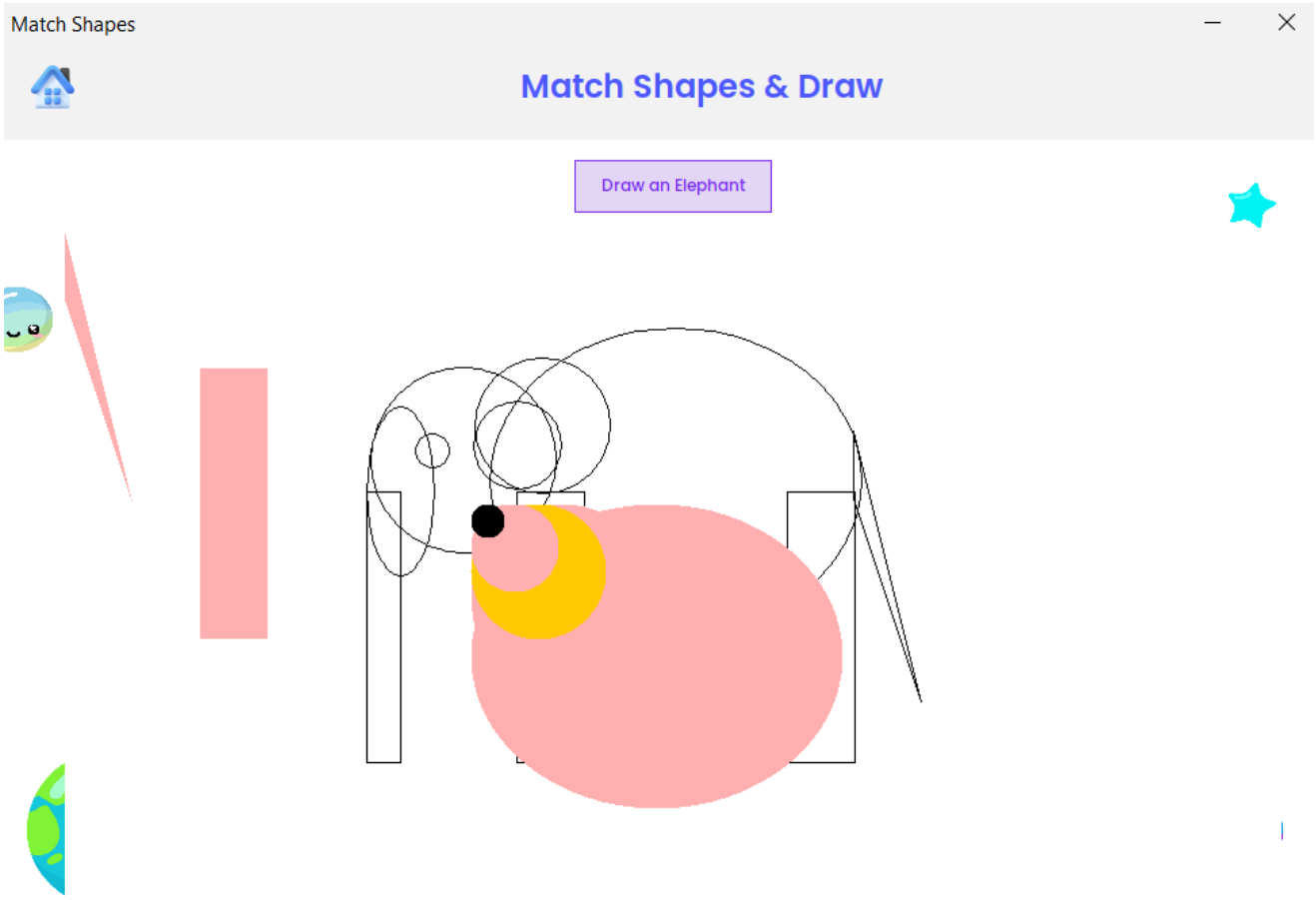

Figure 51: Create Elephant

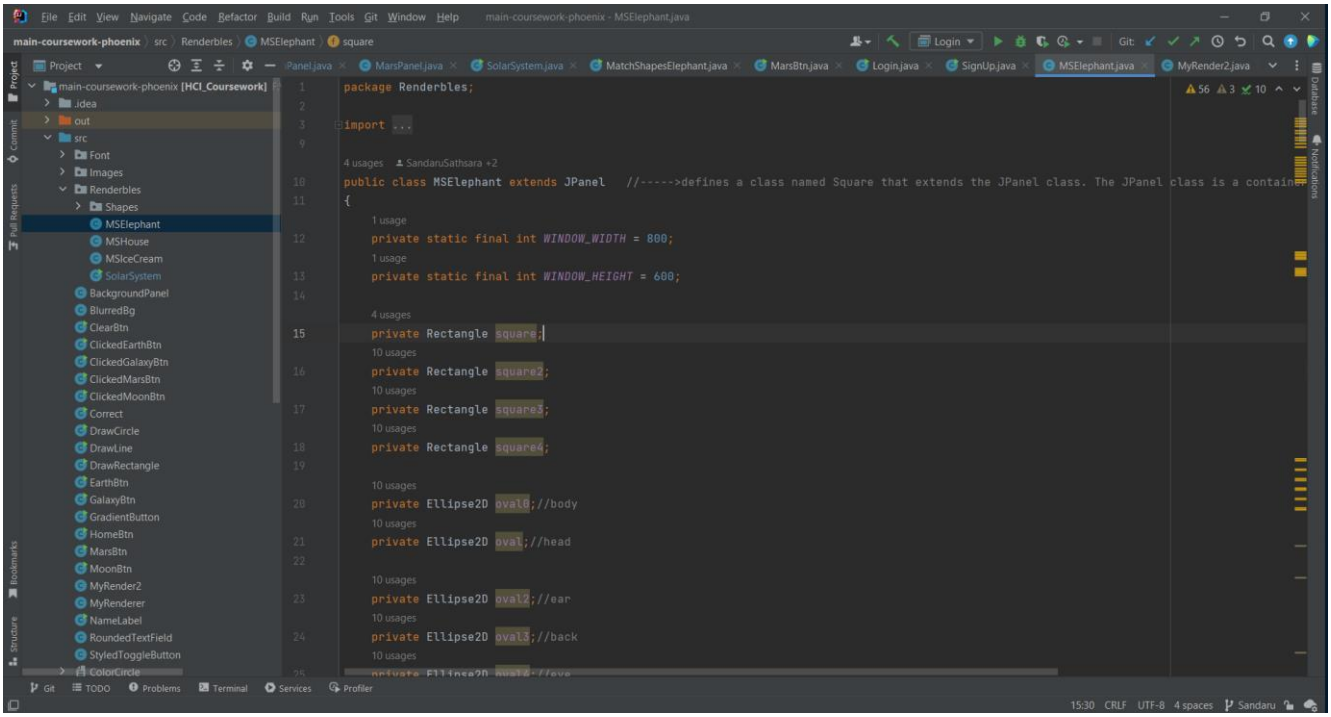

Figure 52: Source Code of Create Elephant

5.6 – Draw Shapes

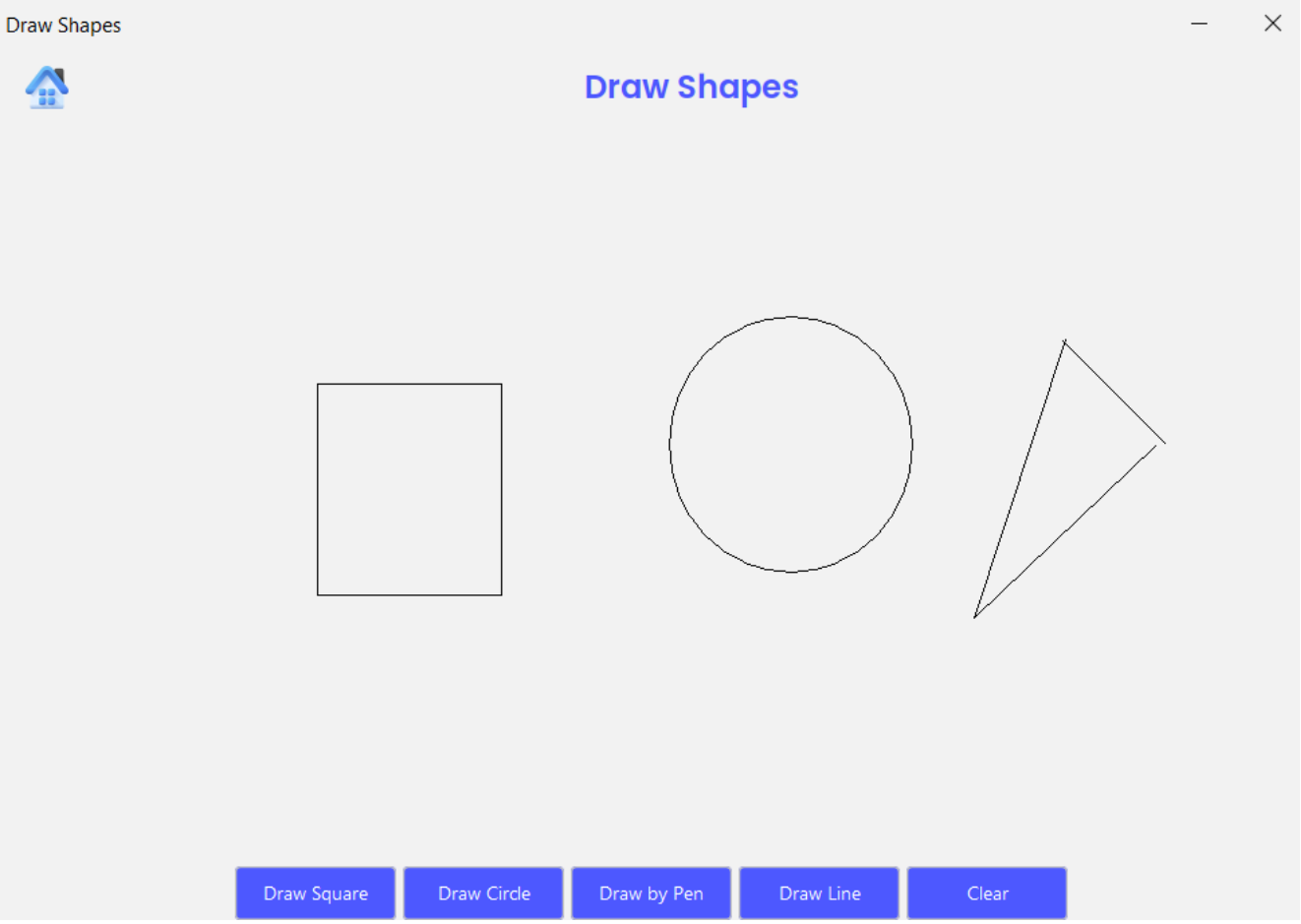

Figure 53: Draw Shapes

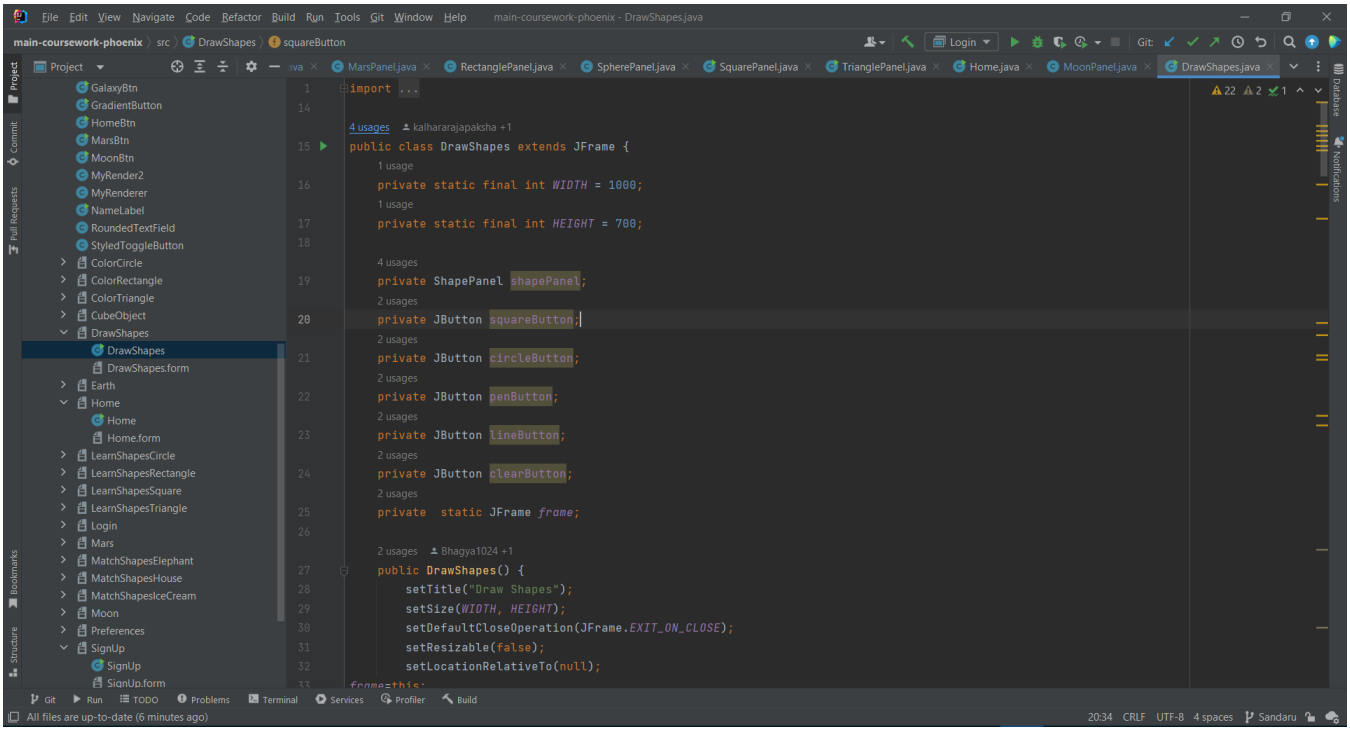

Figure 54: Source Code of Draw Shapes

5.7 – Color Shapes

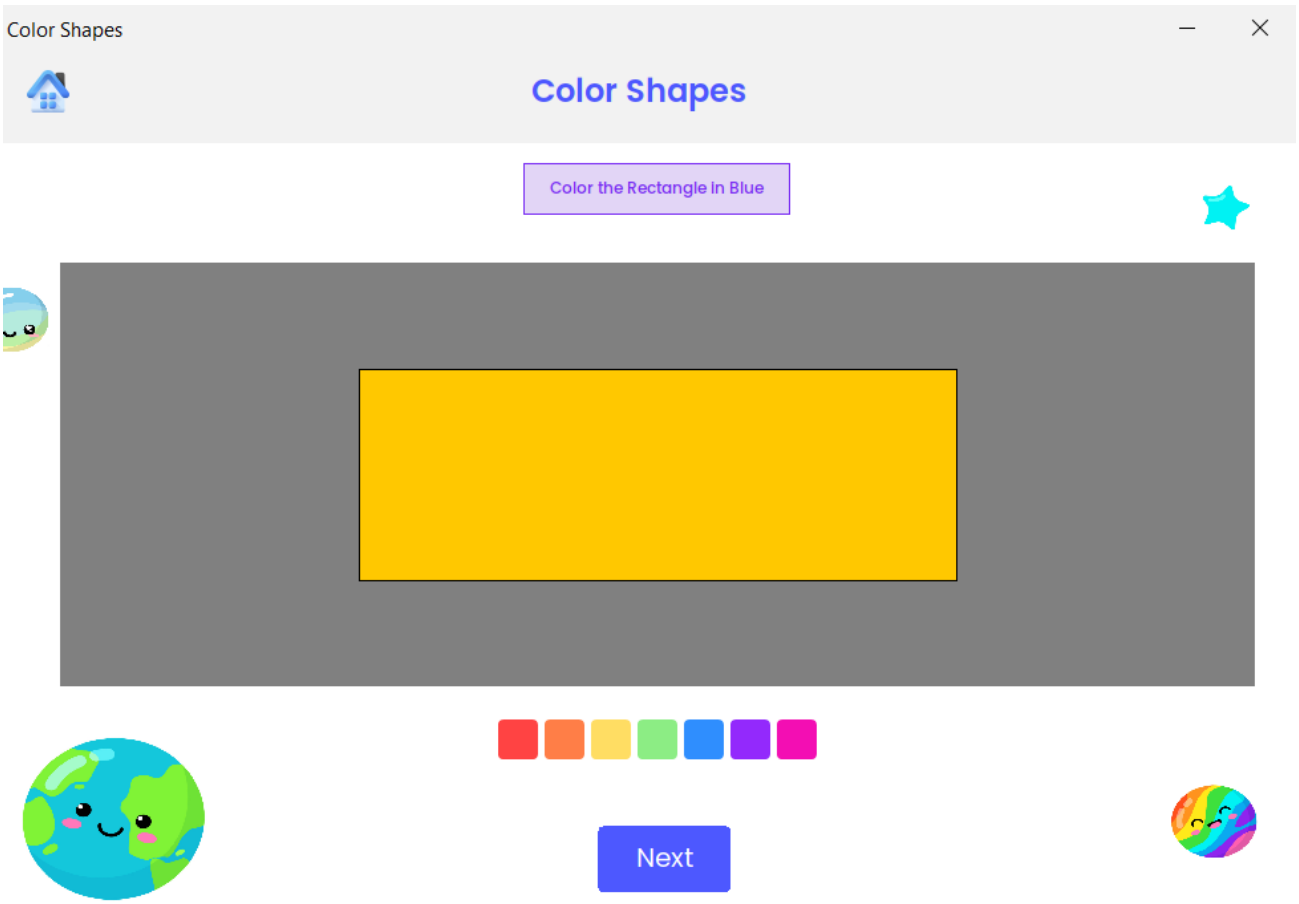

Figure 55: Color Rectangle

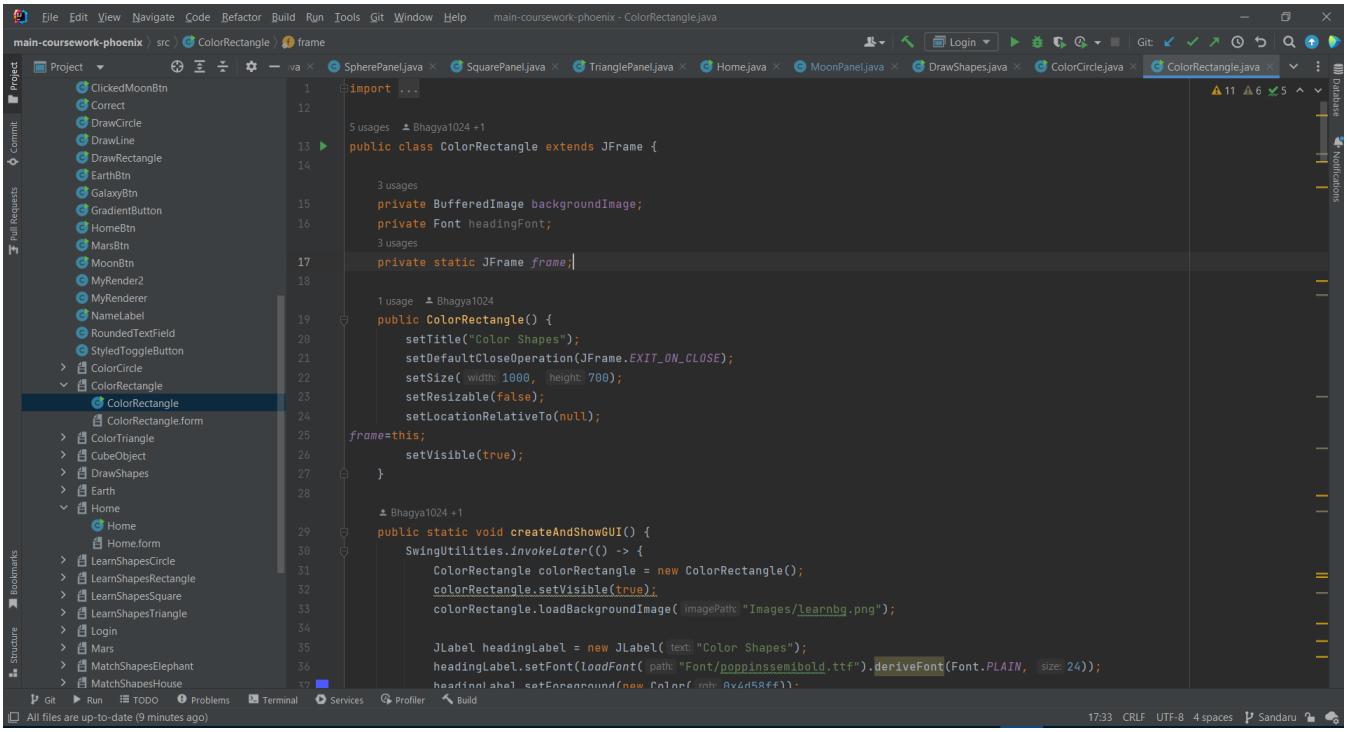

Figure 56: Source Code of Color Rectangle

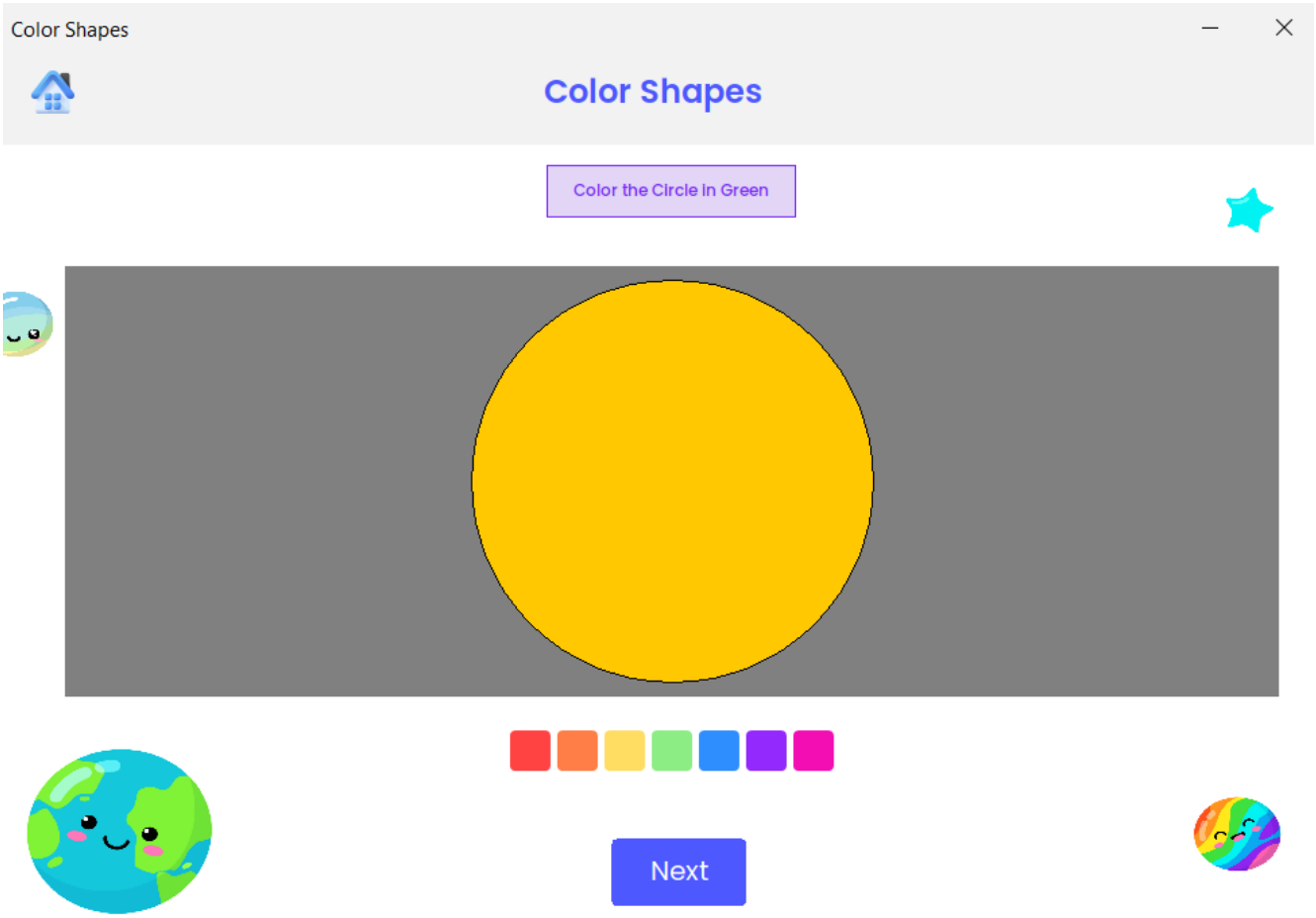

Figure 57: Color Circle

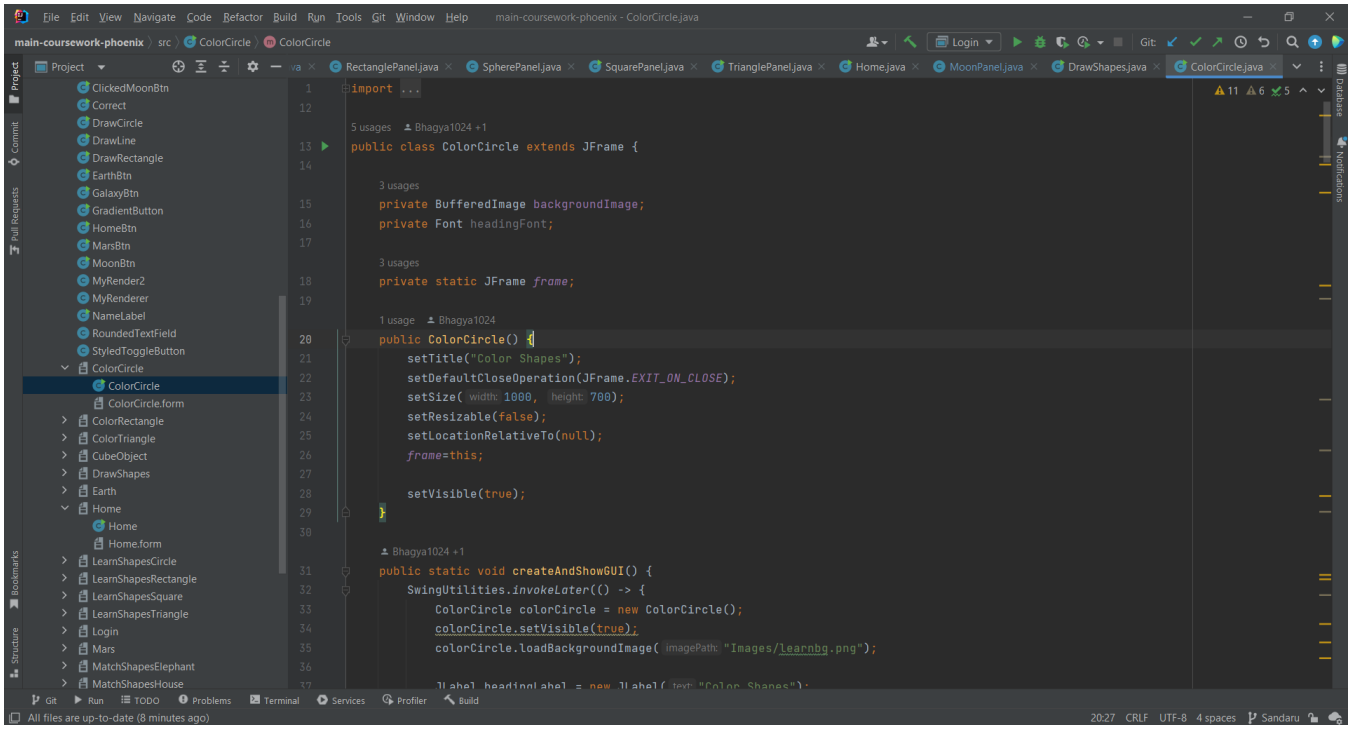

Figure 58: Source Code of Color Circle

5.8 – 3D Objects

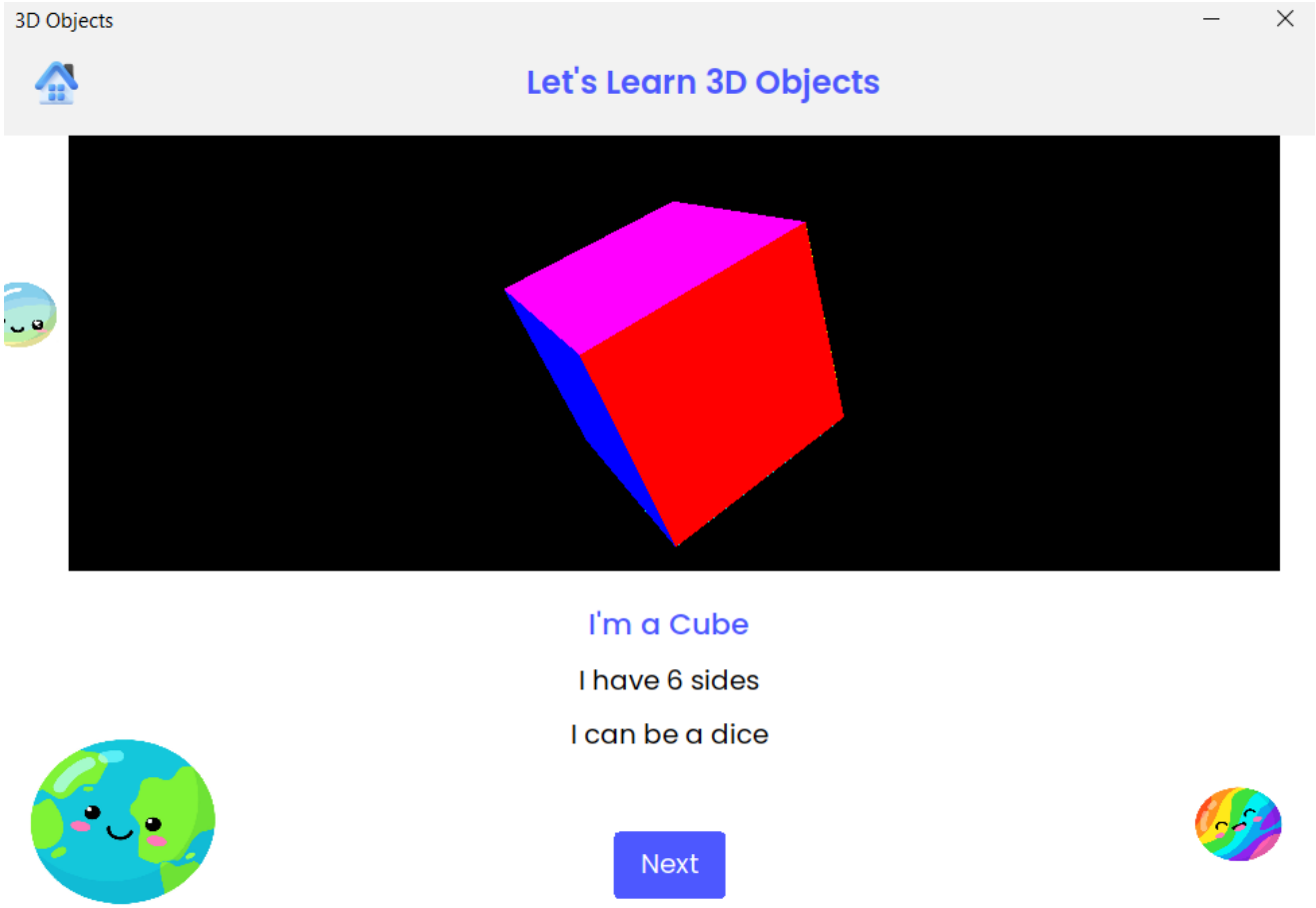

Figure 59: Cube Object

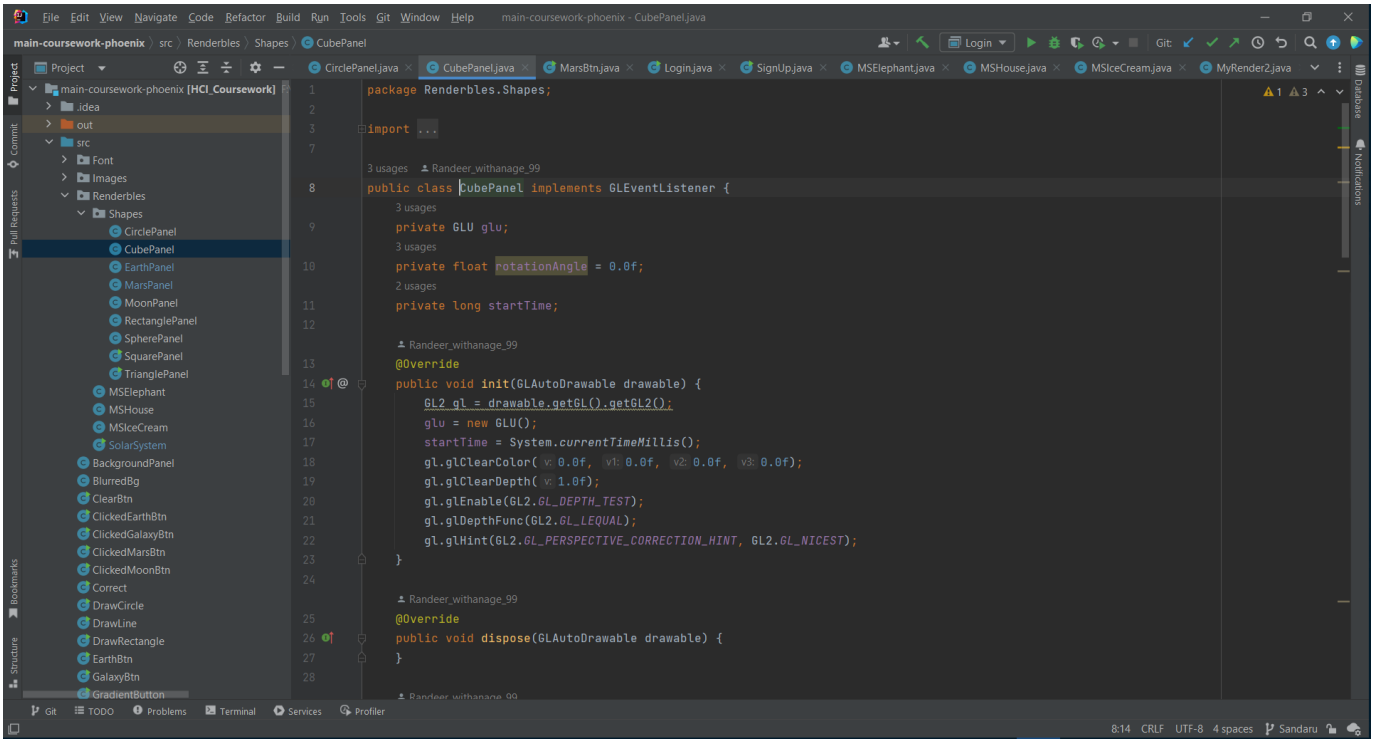

Figure 60: Source Code of Cube Object

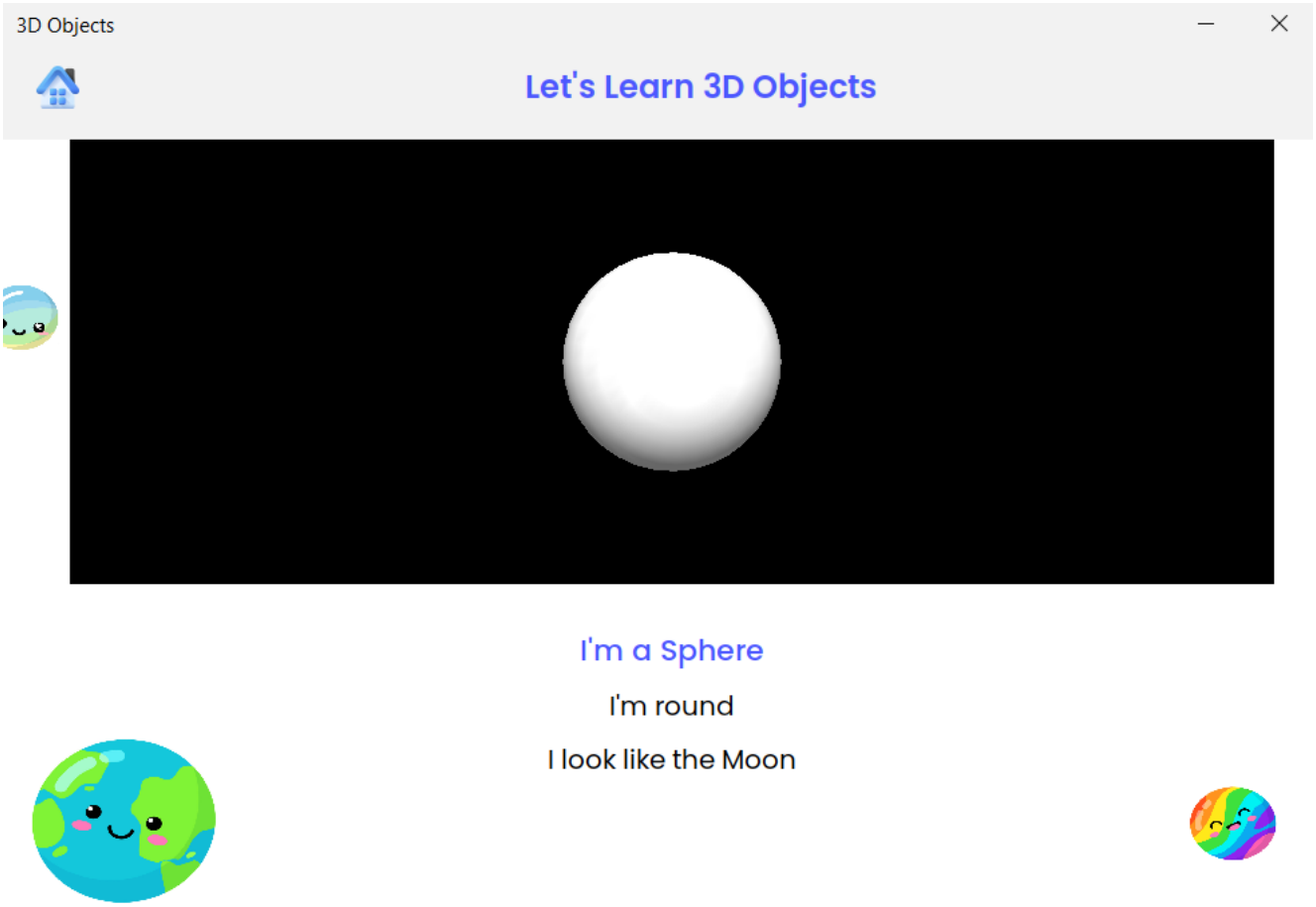

Figure 61: Sphere Object

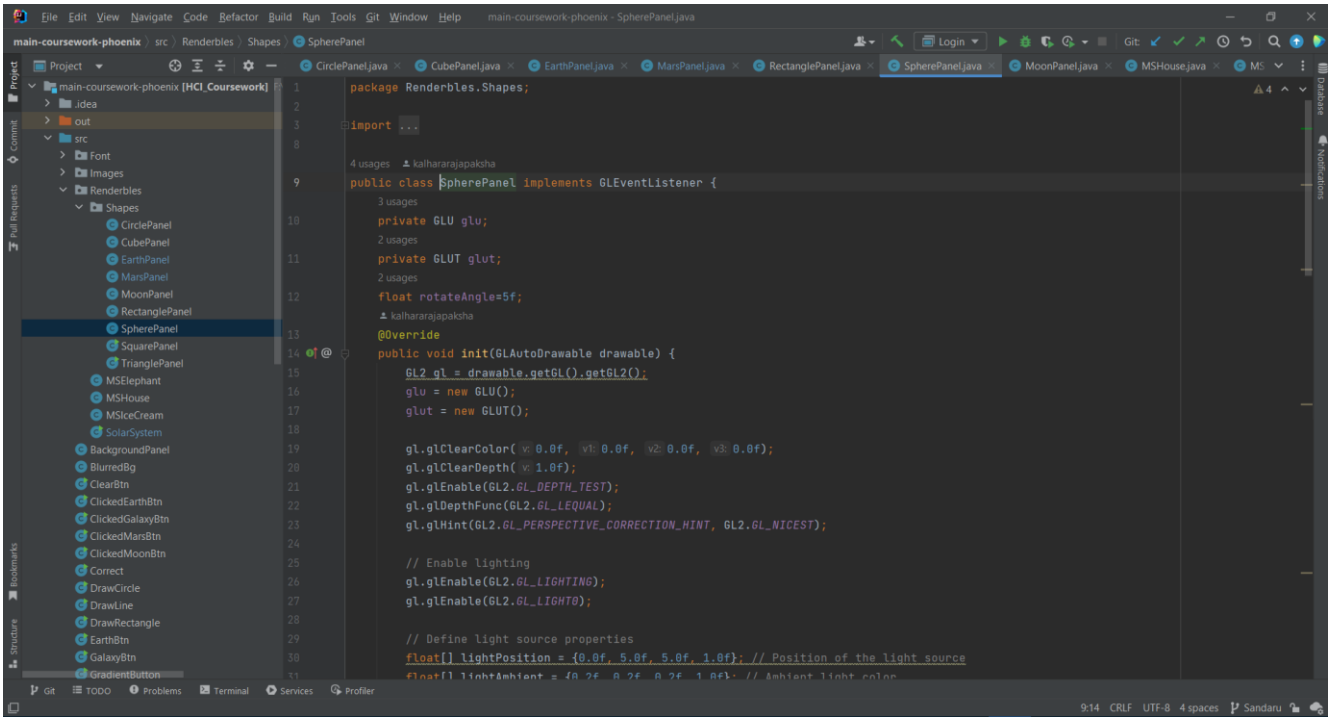

Figure 62: Source Code of Sphere Object

5.9 – 3D Space

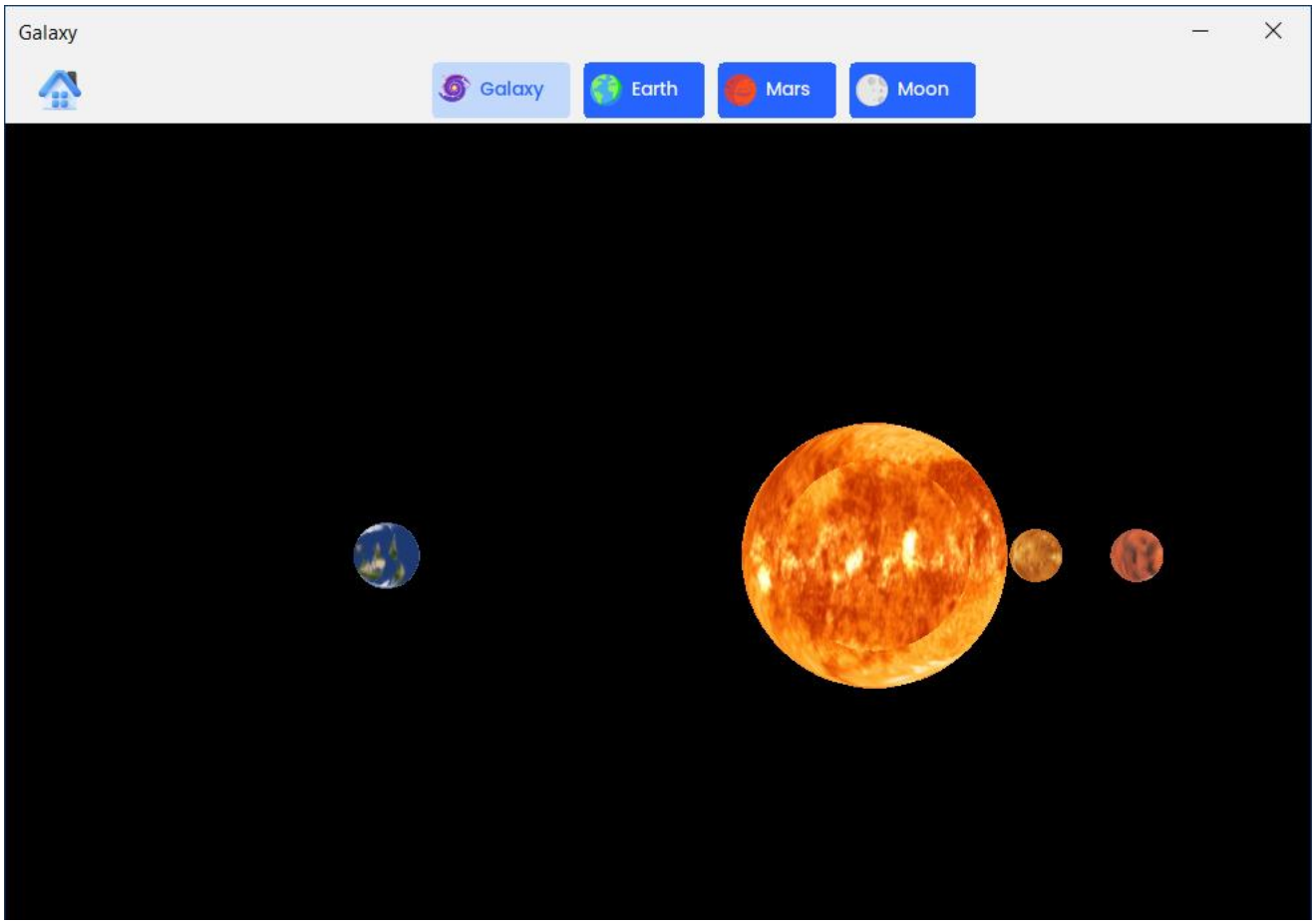

Figure 63: 3D Galaxy

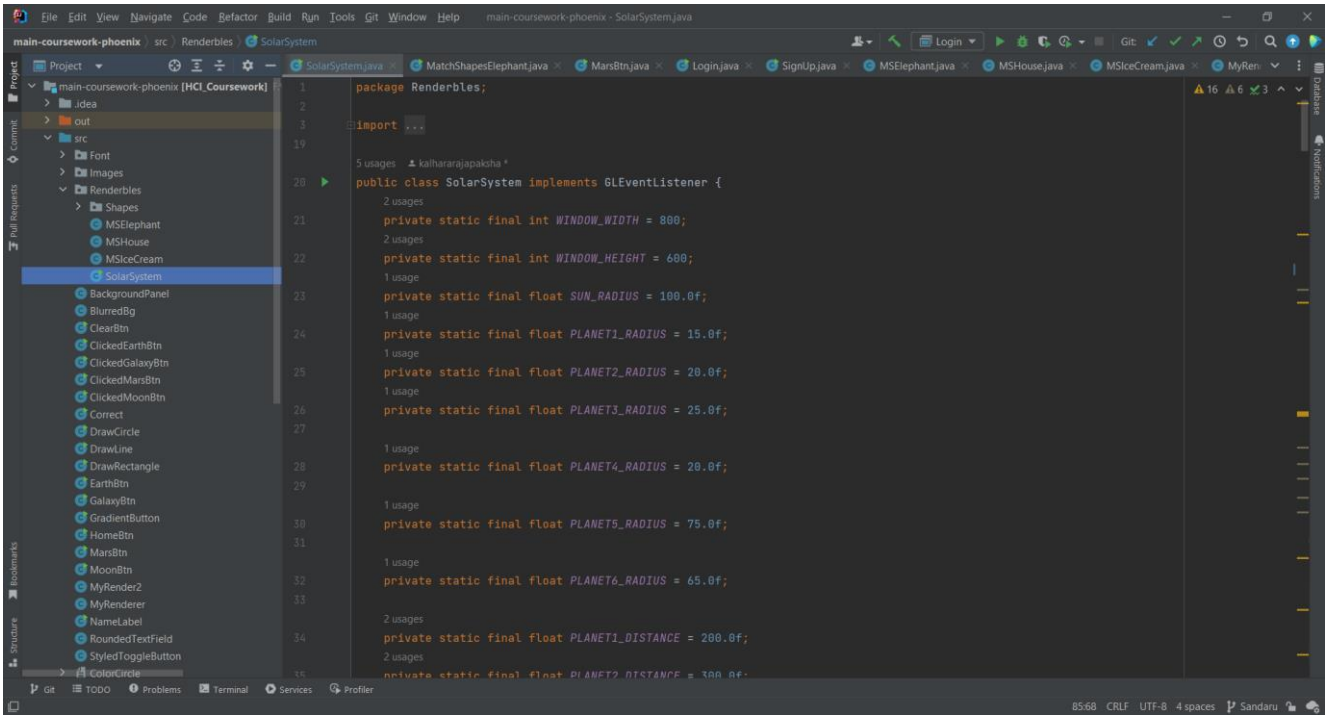

Figure 64: Source Code of 3D Galaxy

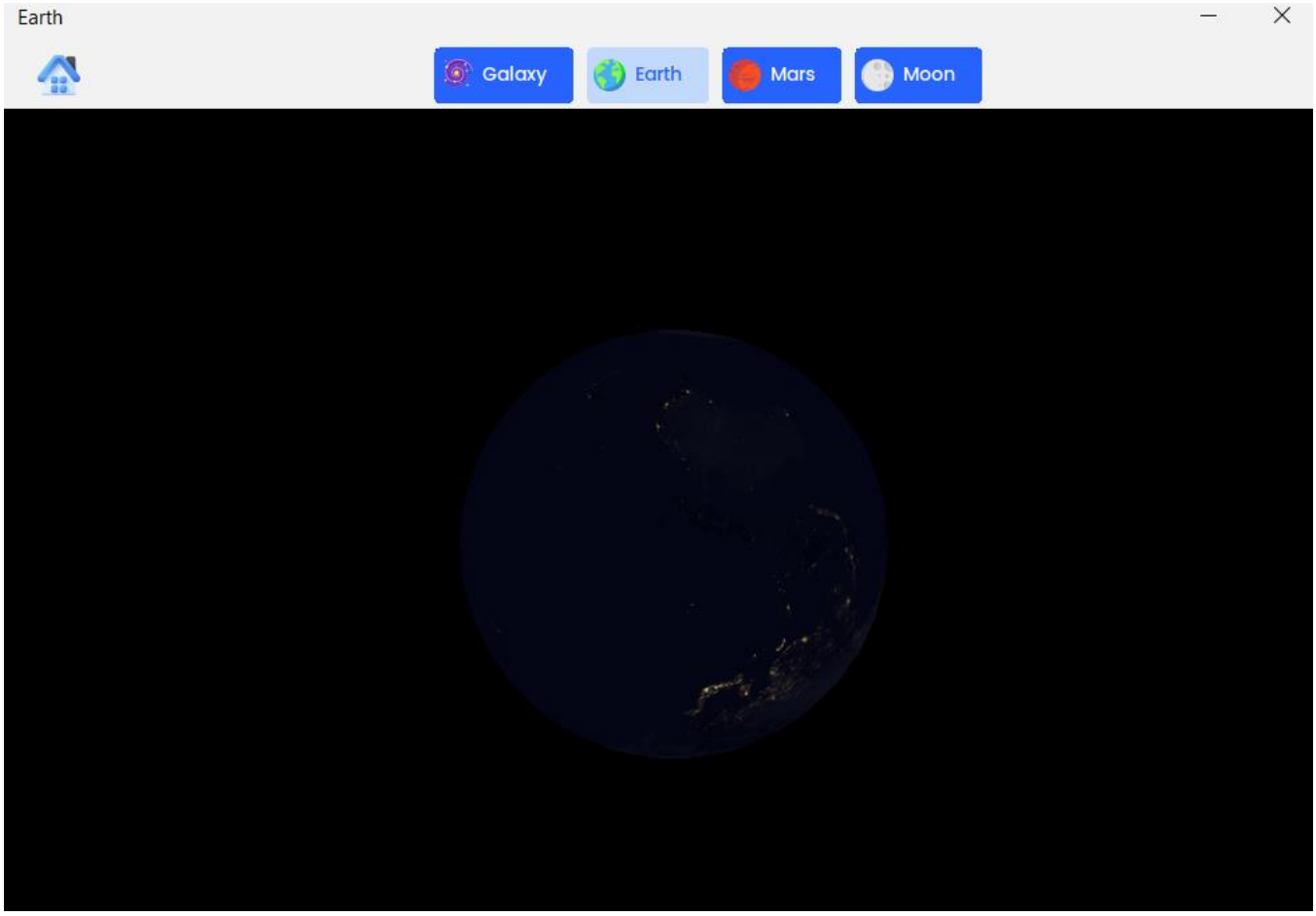

Figure 65: 3D Earth

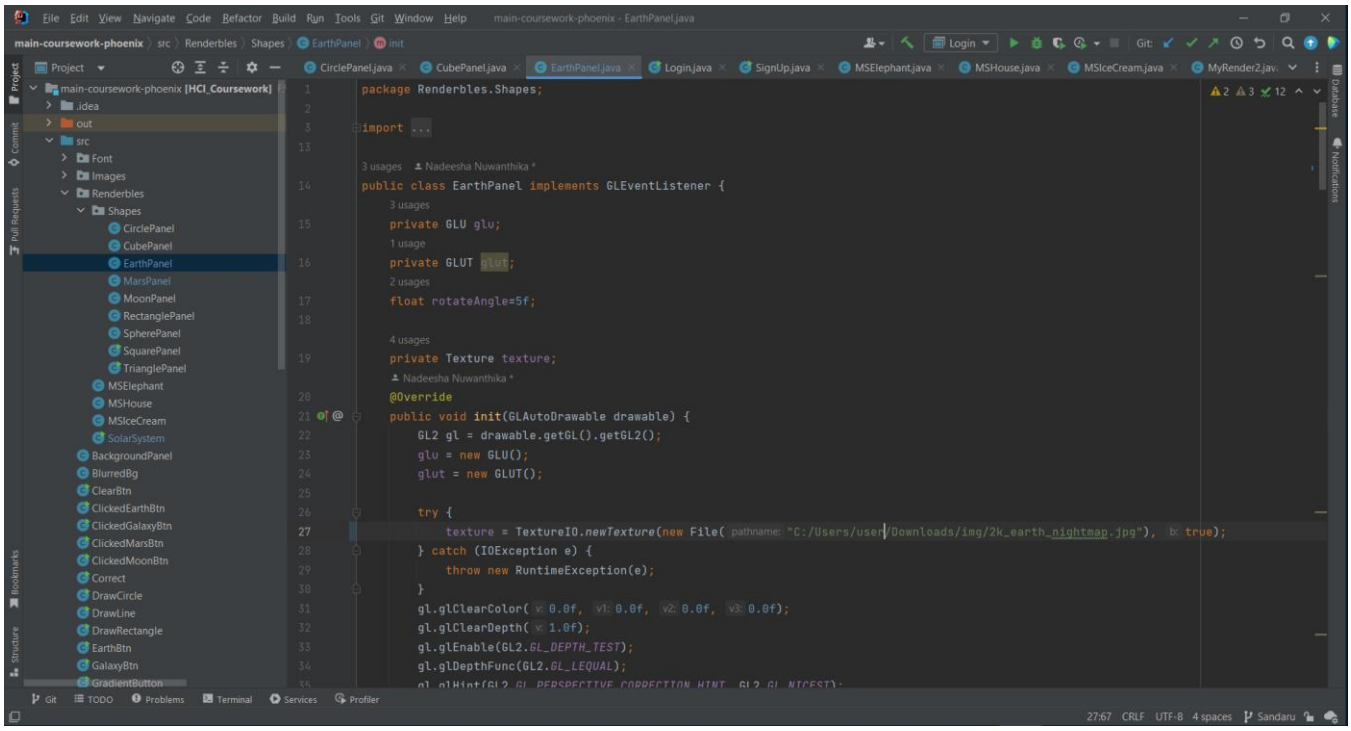

Figure 66: Source Code of 3D Earth

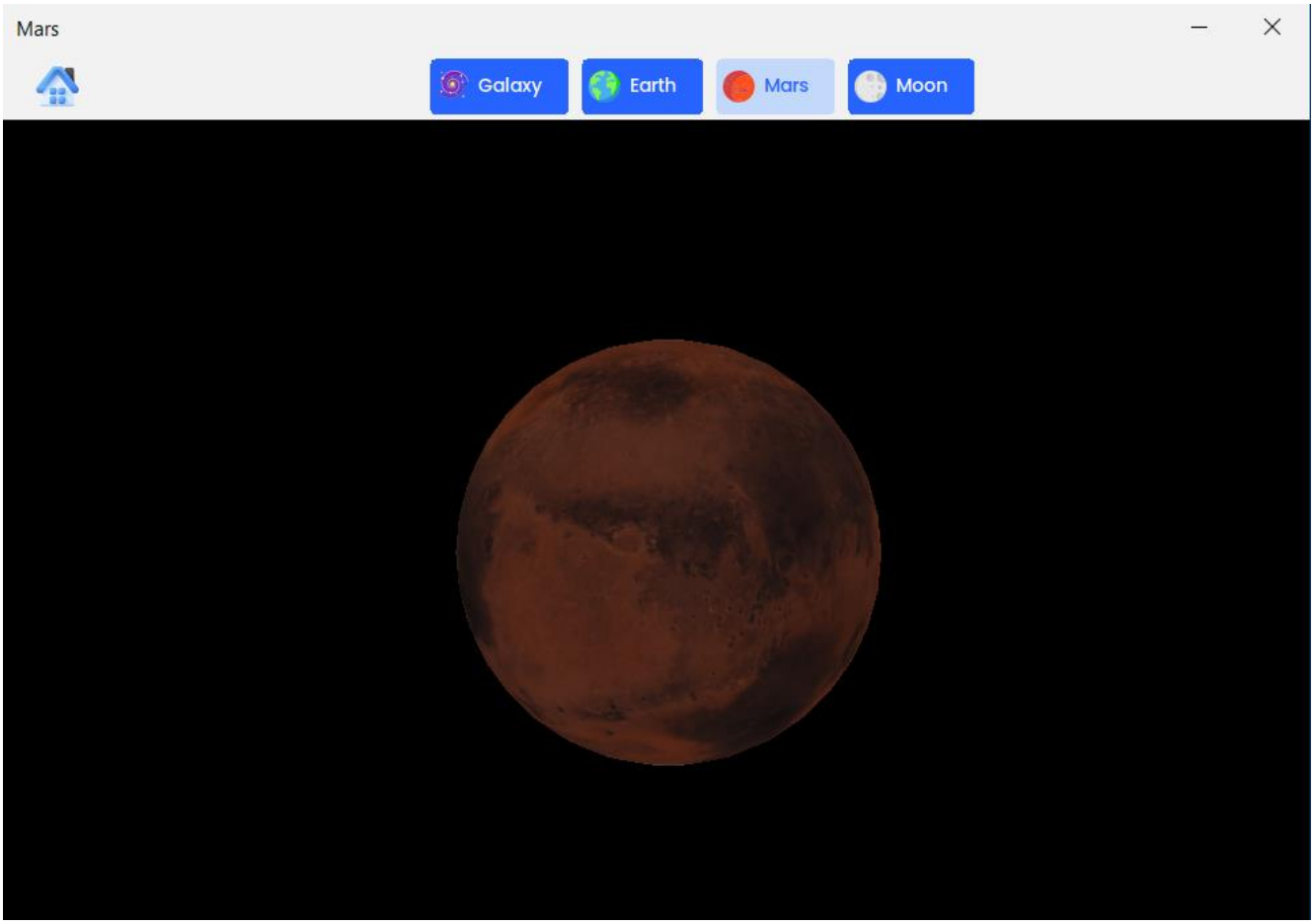

Figure 67: 3D Mars

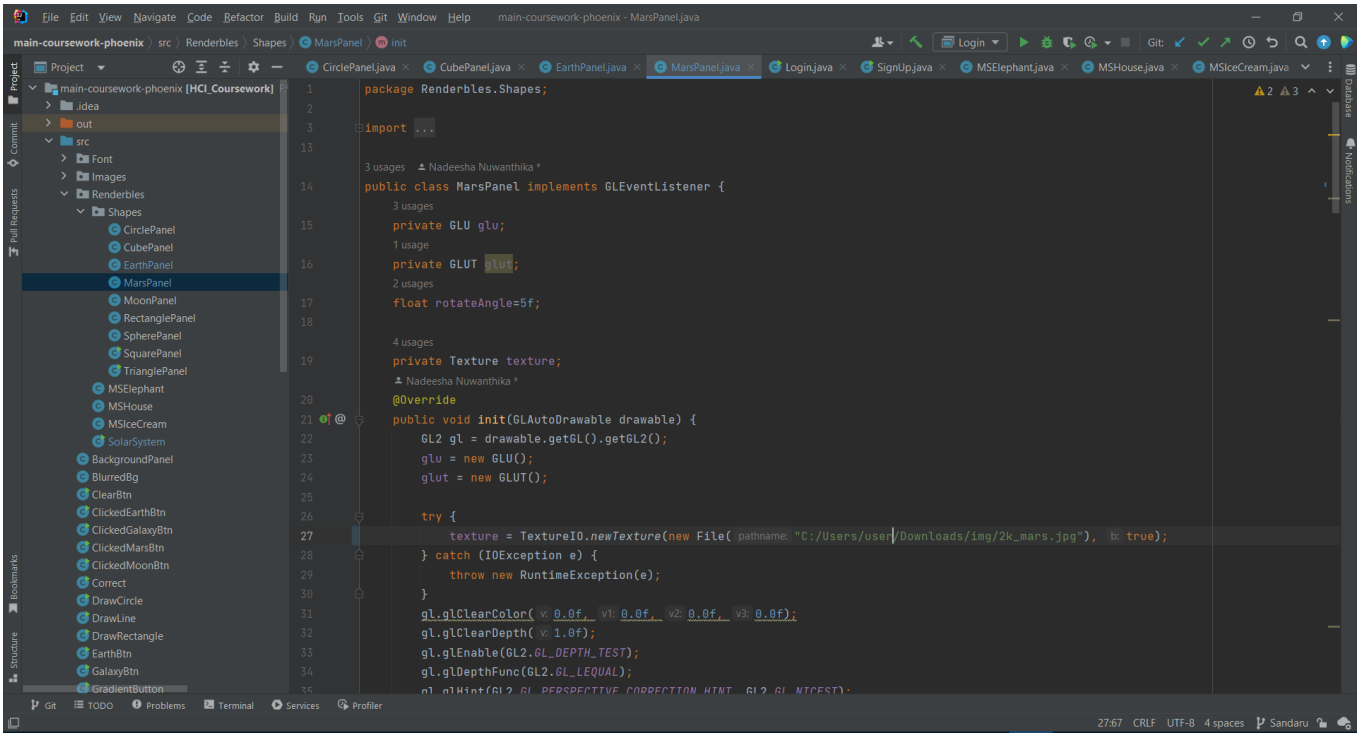

Figure 68: Source Code of 3D Mars

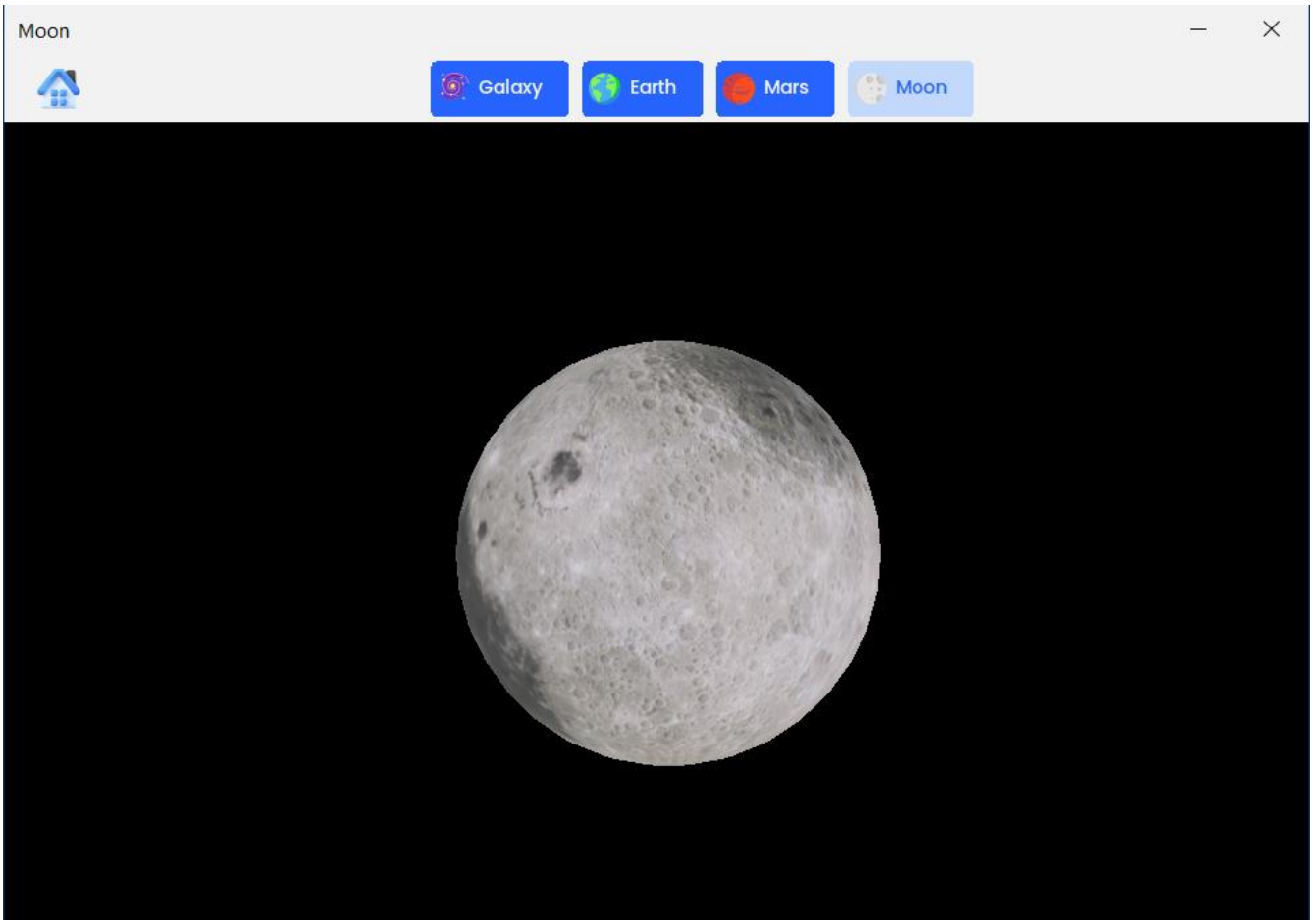

Figure 69: 3D Moon

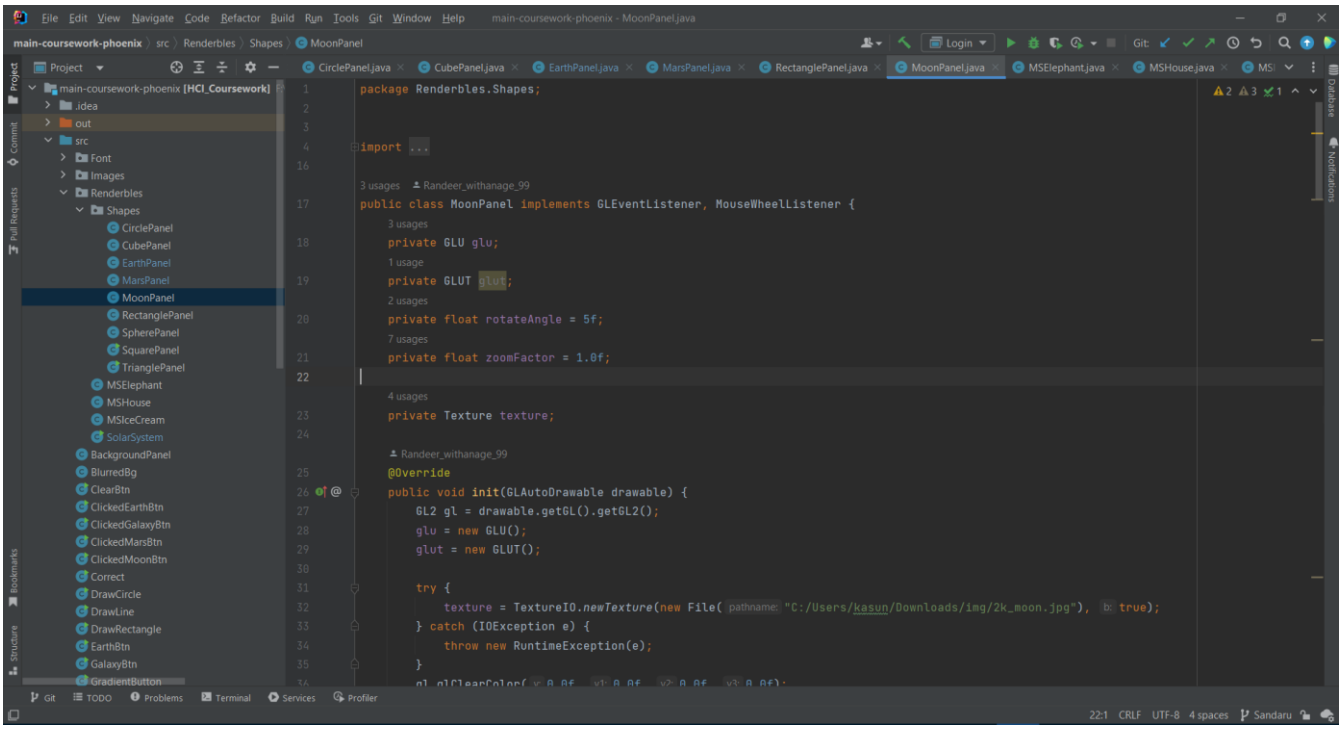

Figure 70: Source Code of 3D Moon

- Participant 1 – Rajapaksha Rajapaksha

The implementation of the JOGL (Java OpenGL) library serves as a fundamental tool for rendering both two-dimensional and three-dimensional graphics. In order to achieve an authentic representation of the solar system, the technique of texture mapping has been employed. This method entails the application of images, referred to as textures, onto the surfaces of three-dimensional entities. By utilizing high-resolution textures capturing the characteristics of celestial bodies, ranging from the sun to the planets, the visual quality has been significantly enhanced, effectively breathing life into the solar system.

Furthermore, lighting effects have been successfully applied to the objects present within the scene, resulting in a heightened sense of realism. These lighting effects contribute to a more convincing visual appearance of the objects, making them closely resemble their real-life counterparts. By amalgamating these techniques of lighting and shading, a visually captivating and interactive environment has been created, facilitating the exploration of shapes and enabling children to acquire knowledge about their properties.

- Participant 2 – Merenna Amarasinghe

The primary objective in designing the user interface was to create an engaging and child-friendly experience catering specifically to children between the ages of 4 and 6. To facilitate the learning process, vibrant colours and playful graphics were incorporated, aiming to captivate the attention and interest of the children. Simplicity emerged as a key focal point during the development of the user interface. The intentional emphasis on straightforwardness and ease of navigation ensures that even the youngest of learners can effortlessly explore the system. Recognizing the varying reading capabilities of the target audience, particular attention was given to the inclusion of easily identifiable buttons and icons, allowing all users, regardless of their reading proficiency, to access the system seamlessly.

Moreover, a Learn Shapes feature was implemented, and that feature serves as a pedagogical tool to aid students in comprehending two-dimensional shapes. Foundational shapes such as rectangles, squares, triangles, and circles were meticulously defined, accompanied by a clear exposition of their respective properties. In order to enhance the visual appeal and facilitate shape recognition, the Fill method was employed to apply appropriate colours to these shapes.

- Participant 3 – Sakaladhipathige Fernando

The implementation includes a "Match Shapes" feature. The primary objective of incorporating this feature was to foster the identification and correlation of shapes among children, while simultaneously nurturing the development of spatial reasoning skills and critical thinking abilities. This feature offers a diverse range of difficulty levels, ensuring that children can progress at their own individual pace, thus establishing a solid foundation in shape recognition.

Within this feature, two distinct types of shapes are presented: coloured shapes and colourless shapes. Coloured shapes were created utilizing a fixed size and were further enhanced using the fill method. Also, these coloured shapes possess interactive capabilities, permitting them to be manipulated via a mouse onClick listener, thereby facilitating an engaging and interactive user experience. The generation of colourless shapes is achieved through the implementation of the draw method.

- Participant 4 – Randeera Withanage

The incorporation of the 3D objects feature within the application aims to facilitate the instruction of students regarding the characteristics of three-dimensional objects. To achieve this, specific techniques were employed for the cube and sphere objects.

For the cube, the gluPerspective() function was utilized to apply perspective projection, generating a visual perception of depth and distance. The structure of the cube was defined by specifying the 3D coordinates of the vertices using the glVertex3f() function. To ensure accurate rendering, depth testing was enabled using the glEnable() function and the glDepthFunc() function, allowing for proper depiction of objects based on their distance from the viewer.

In the sphere, realistic lighting effects were achieved by enabling lighting using the glEnable() function for GL_LIGHTING and GL_LIGHT0. The properties of the light source, including position, ambient, diffuse, and specular colours, were defined using the glLightfv() function. This interaction between lighting and the sphere's material properties produced highlights and shadows, enhancing its realism.

- Participant 5 – Udugama Nuwanthika

A drawing tool has been developed to facilitate the creation of shapes, utilizing a list of predetermined shapes and effectively managing user interactions. This was accomplished through the implementation of mouse listeners to capture relevant mouse events, such as pressing, releasing, and dragging.

The Java 2D Graphics library was employed to realize the shape-drawing functionality. This library offers a range of classes, including Rectangle2D, Ellipse2D, and Line2D, which facilitate the creation and manipulation of geometric shapes. The rendering of these shapes on the panel is achieved by utilizing the Graphics2D object. Furthermore, the tool incorporates buttons that enable the clearing of the drawing area, thereby providing users with the ability to reset the canvas and start afresh.

- Participant 6 – Bopage Muthumala

The colour shape functionality allows users to fill shapes with their desired colours by utilizing the fill method. The chosen colour is selected from a colour palette and applied to the shape accordingly. To ensure the accuracy of colour selection, users are provided with instructions indicating the correct colour to be chosen from the colour palette. If the user selects the correct colour, a message will display saying “Great Job”. However, if user select an incorrect colour, then user is unable to proceed to the next activity, reinforcing the importance of accurate colour identification and selection.

Plymouth ID	Name	Contribution
10749121	Rajapaksha Rajapaksha	• 3D Space
10749150	Merenna Amarasinghe	• UI Designing & Prototyping • Learn Shapes
10749110	Sakaladhipathige Fernando	• Match Shapes • Report Writing
10749185	Randeera Withanage	• 3D Objects
10749139	Udugama Nuwanthika	• Draw with Shapes
10749145	Bopage Muthumala	• Colour Shapes

Figure 71: Workload Matrix

Presentation Video Link - https://liveplymouthac-my.sharepoint.com/:f:/g/personal/10749121_students_plymouth_ac_uk/Ei5uOqcX_EtLpaVrlY5Y95IBoaRRZNJKTaE3hhR_Ou0IBw?e=TEgOn4

Chapter 07 – Summary

This study provides an overview of a shape learning application developed for primary school children. It includes detailed information on the background, data gathering methods, design, implementation, and evaluation of the application. The primary goal of the application is to facilitate the learning of shapes in 2D and 3D formats, providing users with the ability to create, visualize, and manipulate shapes while learning fundamental drawing principles. Research, survey, and user feedbacks were utilized to gather data. These techniques were carefully chosen to ensure a comprehensive and reliable collection of relevant information. The design section consists of storyboard, and prototypes. In the protypes both low-fidelity and high-fidelity prototypes were utilized in the designing phase. The design considerations from a usability perspective to enhance the learning experience. The implementation section showcases the screenshots of source code, which include implementation process and the incorporation of Java Swing for creating the user interfaces and Java 3D for rendering 3D objects. In the evaluation section discusses the participants contribution, methods and techniques used to develop the application.

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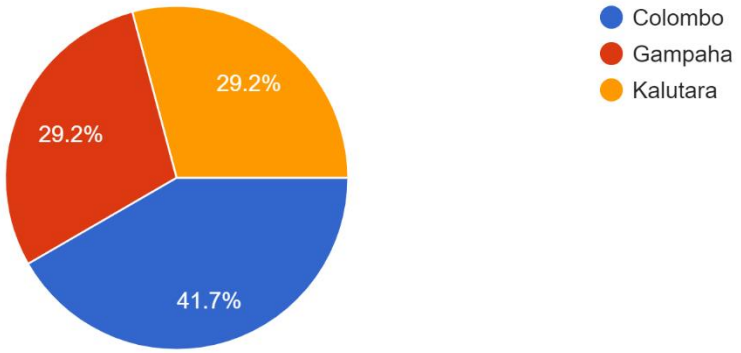
Appendices

Appendix 1 – Responses of Survey

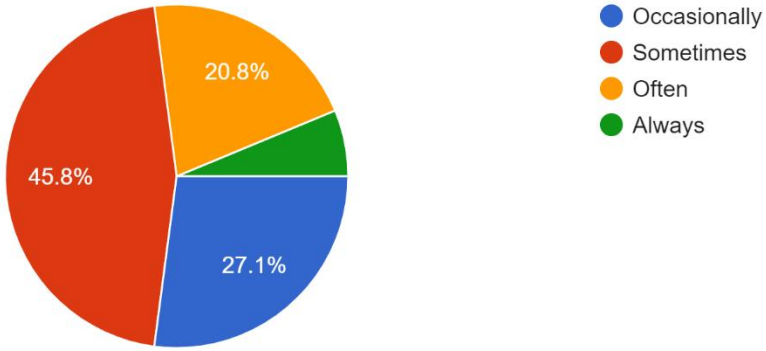
Please select the primary school district in which you are currently teaching.

48 responses



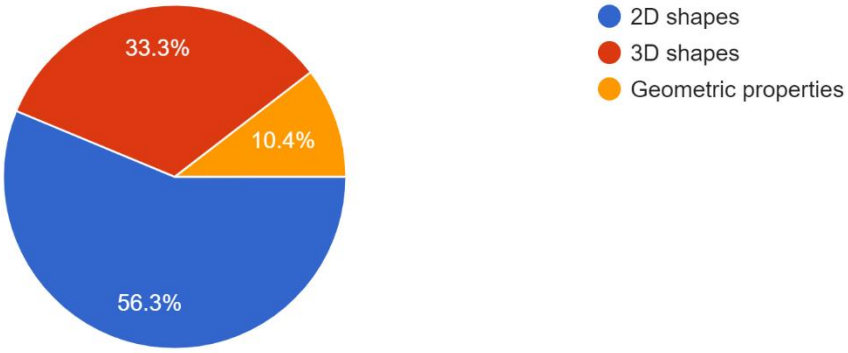
How frequently do you incorporate shape learning activities in your classroom?

48 responses



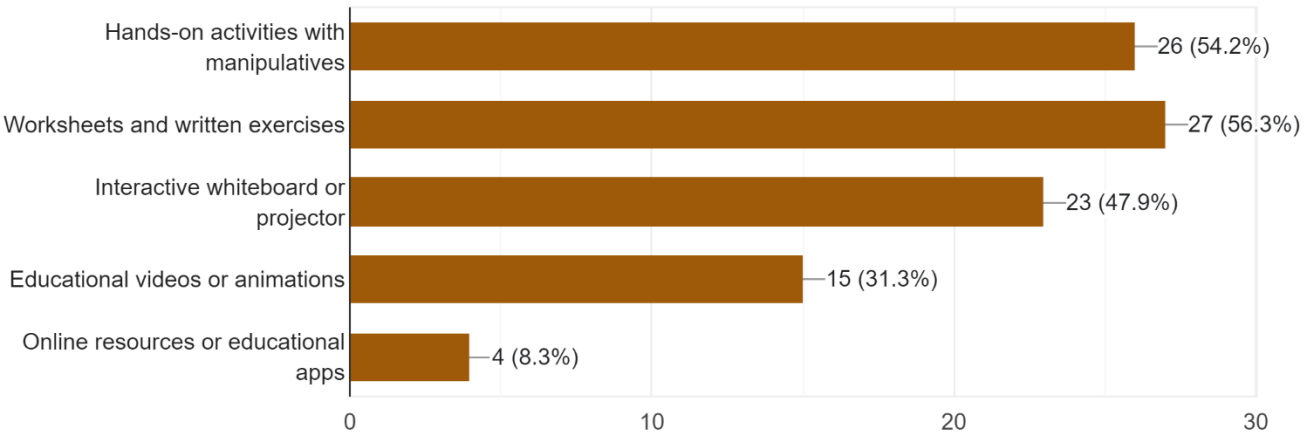
Which shape concepts do you focus on teaching in your classroom?

48 responses



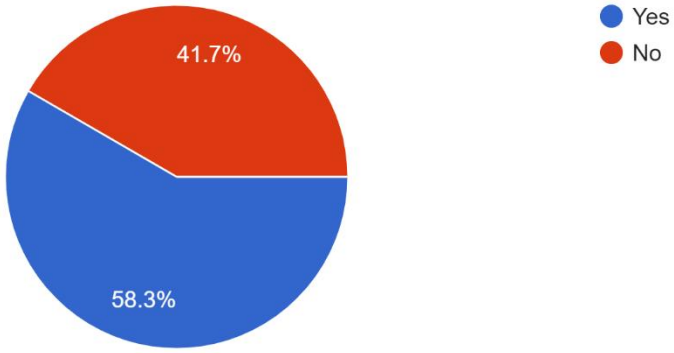
Which teaching methods do you use to introduce and reinforce shape concepts?

48 responses



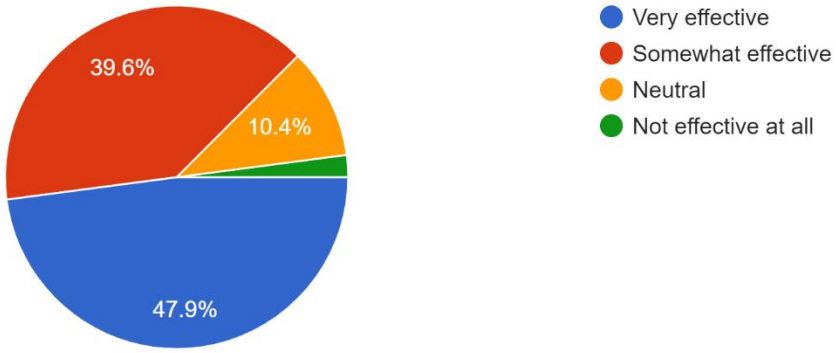
Have you used educational technology specifically designed for shape learning in your classroom?

48 responses



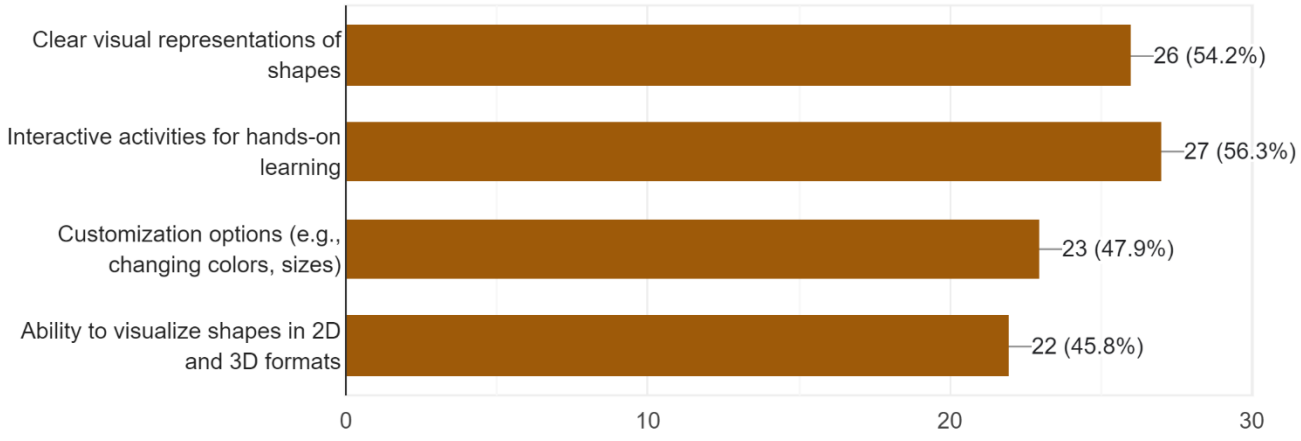
How effective do you think utilizing technology in supporting shape learning in primary education ?

48 responses

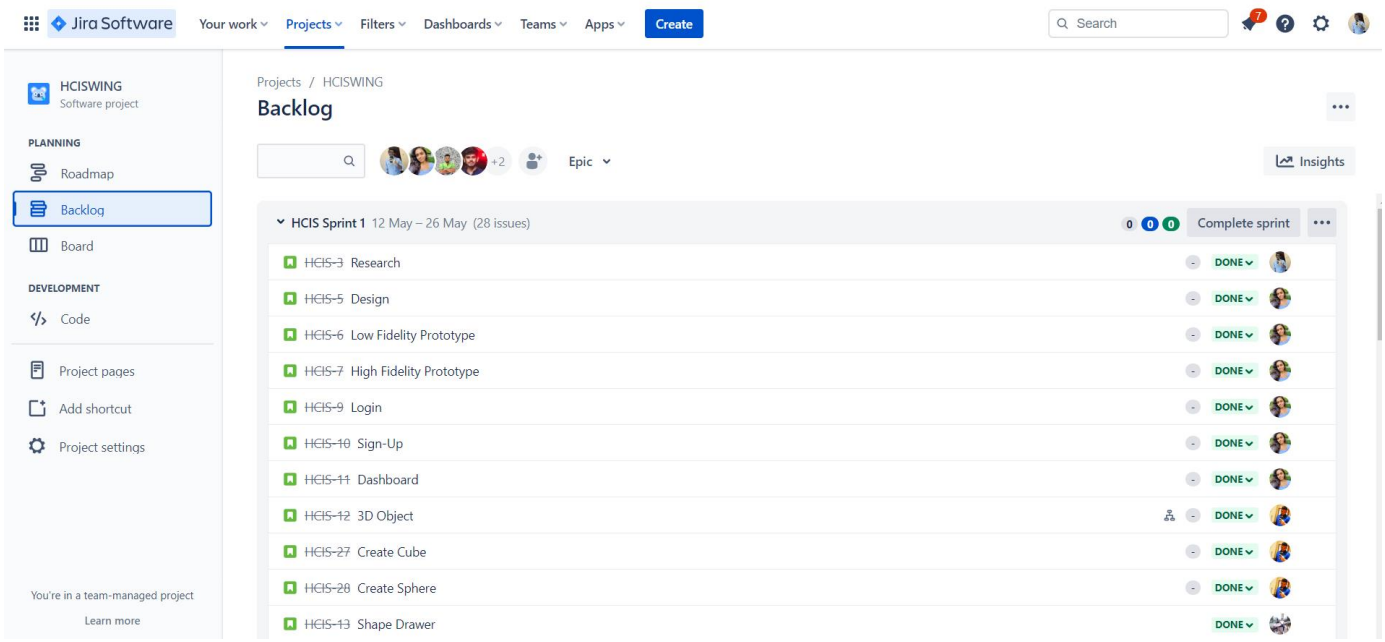


What features or functionalities do you consider important in an application designed to teach shapes to primary school children?

48 responses



Appendix 2 – Project Backlog



Appendix 3 – Kanban Board