Design Document
Visualising the life cycles of stars

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The design of a program plays an important role in human computer interaction. The interface is where a user can interact with a computer. This means that the design of the interface should be easy to understand. In addition, the design should look nice to grab the user's attention. It is also important to keep the main target users in mind when creating a program. A program is going to be created that helps the target users visualise the life cycle of a star. In this document the design of the program, the user analysis, the task analysis and the usability specifications are discussed.

1 Concept Interface Design

The goal for this project is to visualise the life cycles of different types of stars, as well as describing the fusion reactions that take place during each stage of the life cycle. Therefore, an interactive program is going to be created.

1.1 The Program

The interactive program is supposed to help target users visualise the life cycle of a star. The primary target users are astronomy students. Students often have a lot of experience with laptops and computers, which is why this program will be designed for the computer desktop. Users will be able to interact with the program by using the computer mouse. By using a mouse, the program will be easier to understand for the users. Since the program is for educational purposes, it is important to make the program easy to understand to prevent the users from getting overstimulated or distracted.

The program is going to be created in Unity because it makes it possible to create 3D animations and a graphical user interface. Unity uses C# as a programming language. In addition, programs created in Unity can be easily built and published for WebGL. This is an API where interactive 3D graphics can be rendered within compatible web browsers. The program can for example be published on *itch.io* so users can access it.

1.2 The Interface

When a user starts the program, they will immediately see a window with a timeline on a dark background. There will be a play and pause button located next to the timeline. With the start button, the user will be able to start an animation (Figure 7). This animation displays the stages of a star during its life cycle. The star will be visible in the centre of the screen. The animation can be controlled by the pause button, and the play button. These icons are familiar to almost everyone, which is why they are used for the design. The user will also be able to view the desired stage of a star during its life cycle by clicking on a dot on the timeline (Figure 8). This allows the user to view what the star looks like at any point in the life cycle. The clickable dots will represent the stages of the star in a chronological order. The first dot represents the first stage of the life cycle, and the last dot represents the last stage. Additionally, the dots will have

colours that correspond with the colours given to the layers. This way it will be easier for the user to understand which layer of fusion reactions is formed during which stage. The stages that haven't taken place yet are coloured grey on the timeline. The star and layers will have a bright colour, which makes it more visible on the dark background. The colour of the outside of the star changes throughout its life cycle, this will also be the case in the program.

In addition, the years that have passed will be displayed on the top of the screen during each stage. There is also going to be a button, on the top right of the screen, that allows the user to view the internal or external structure of the star (Figure 6). The timeline and animation work the same for both views. The internal view allows the user to look at the layers of fusion reactions that get formed during each stage of life cycle of the star. On top of that, the users will be able to hover over the star with a computer mouse so they can get more information on which fusion reaction takes place.

Since a lot colours are being used for the interface design, colour blindness needs to be taken into account. People with any type of colour blindness need to be able to see where one layer of the star ends and where the other one begins. This can for example be done by giving each layer a letter and by giving the dots on the timeline a corresponding letter.

The plan is that all of this should be created for one star with a certain mass for the first prototype. The finished program should contain multiple different life cycles of stars with a different mass. For the user to be able to look at the desired star, the user can click on a drop down menu (Figure 9). Here the user will be able to click on a certain mass. By clicking on a mass, the life cycle of a star with that certain mass will be displayed. The interaction controls of the interface will work the same for each star.

2 User Analysis

To further elaborate on the user analysis as provided in the project plan, let's imagine an average second year astronomy student by the name of Harm. He's 20 years old and came to Leiden from his home in a small farming village called Zwiggelte, Drenthe. He's a very social person, who particularly enjoys disco in his free time. He wanted to study physics, but in his first year discovered that he absolutely dislikes doing experiments, and so he made the switch to fairly similar field of astronomy. As a second year student, he now follows Stars, where he's learned to calculate the properties of certain stars using a series of complicated equations. The answer sheets say his calculations are correct, but although the numbers make sense to Harm, he's not used to the abstract approach of astronomy. As a physicist you can see the results of your calculations by testing them directly, but astronomers don't get this luxury. Stars are just too far away and doing any competent observation requires extremely expensive technology. His textbook shows some pictures, but not of the specific situation he's just done calculations on. As a very visual learner, Harm is worried that he won't be able to remember the results. This is where he could make good use of a visualisation that is not specific to one case, but is responsive to his particular situation. Calculate, visualise, remember, repeat. He doesn't need the visualisation to be too fancy, as long as it serves as a memetic device to put his theoretical results into context. Using our software, Harm will learn much more effectively and save a lot of time otherwise used searching for specific images or animations. Time which Harm can now spend in the disco with his friends in Drenthe.

3 Task Analysis

Users will be able to perform different tasks within the program. The main functional concept of the program is that the user will be able to click on the dots of the timeline or the play button to view the stages of the star during its life cycle. Additionally, the users will be able to view the internal/external structure of the star, the users will be able to get information on the layers of fusion reactions, and the users will be able to select a different star with a different mass. An overview of these tasks is given in Figure 1.

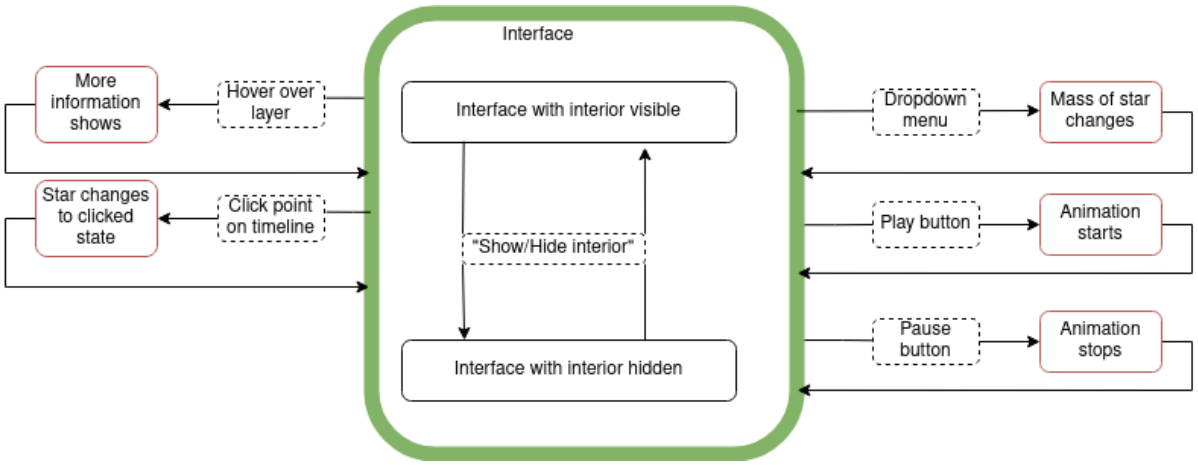

Figure 1: Actions the user can take that will change the view of the interface. Generally there are two states, internal view and external, which are grouped in the centre with a button to move between them. All other actions, shown to the side, change those two views in some way.

4 Interface & Design Sketches

The 'Concept Interface Design' section explains what the interface should look like. In addition to that, digital sketches are made to get a better overview of the interface and program design. These sketches can be seen below.

Figures 2 and 3 show the design of the interface during the first stage of the life cycle of a star with a relatively low mass. The users will be able to view the internal and external structure of the star. Figures 4 and 5 show what the interface should look like during the final stage of the star. Again, both the internal structure, and the external structure can be viewed.

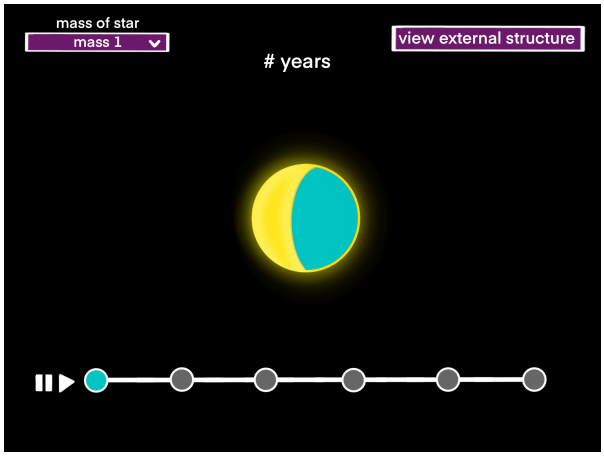

Figure 2: The interface: internal view during the first stage of the life cycle of a relatively small star.

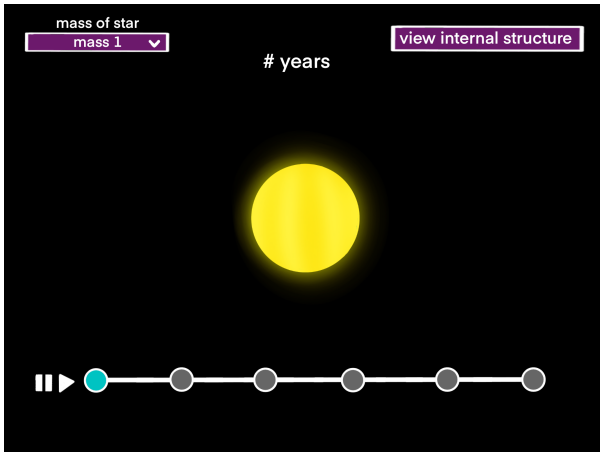

Figure 3: The interface: external view during the first stage of the life cycle of a relatively small star.

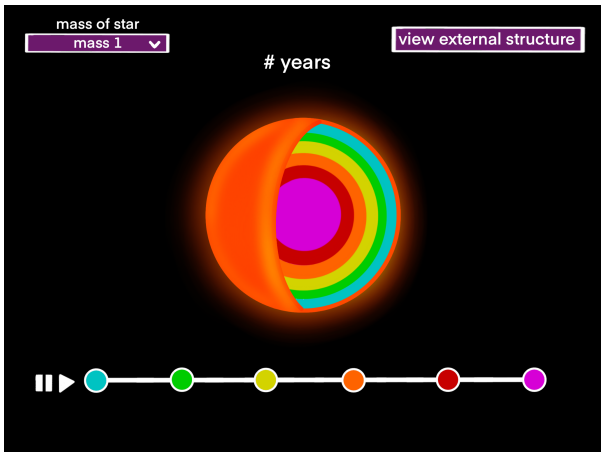

Figure 4: The interface: internal view during the last stage of the life cycle of a relatively small star.

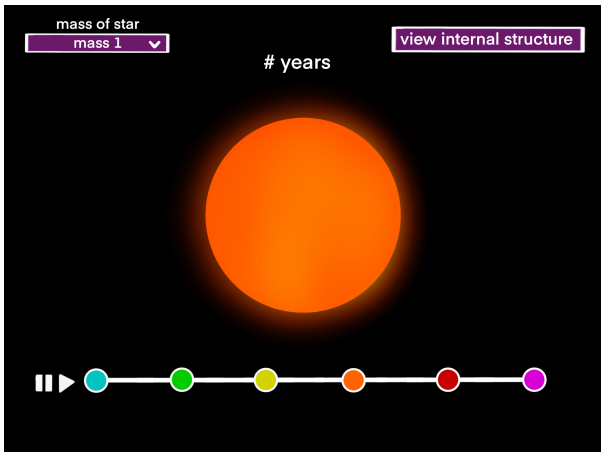

Figure 5: The interface: external view during the last stage of the life cycle of a relatively small star.

A user can click on the 'view external structure' button with a computer mouse to view the external structure of the star. This can be seen in Figure 6, where the red arrow points to where the user should click. The blue arrow points to the following state of the interface. The user will also be able to click on the 'view internal structure' button that appears after clicking the 'view external structure' button. This allows the user to view the internal structure of the star again.

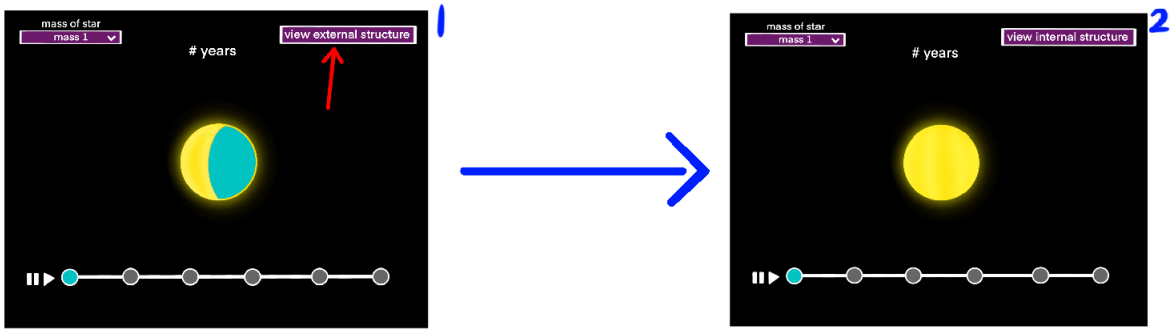

Figure 6: The interface: how the user can switch between the internal and external structure of the star.

The animation of the life cycle can be started by clicking on the play button. In Figure 7 a simple example is shown on what the beginning of the animation should look like. The animation can be started at any point. Users can also click on the pause button to stop the animation at any point.

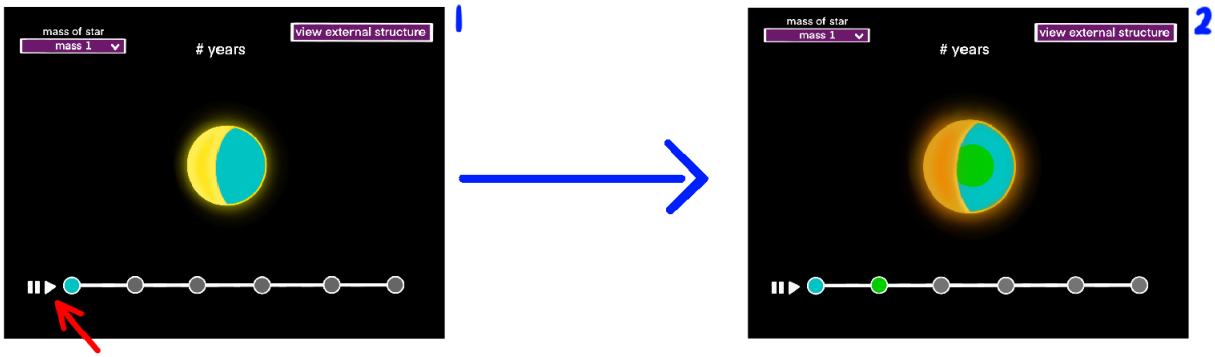

Figure 7: The interface: starting the animation.

Another way of looking at the stages of the star during its life cycle, is by clicking on the dots of the timeline itself. This is shown in Figure 8.

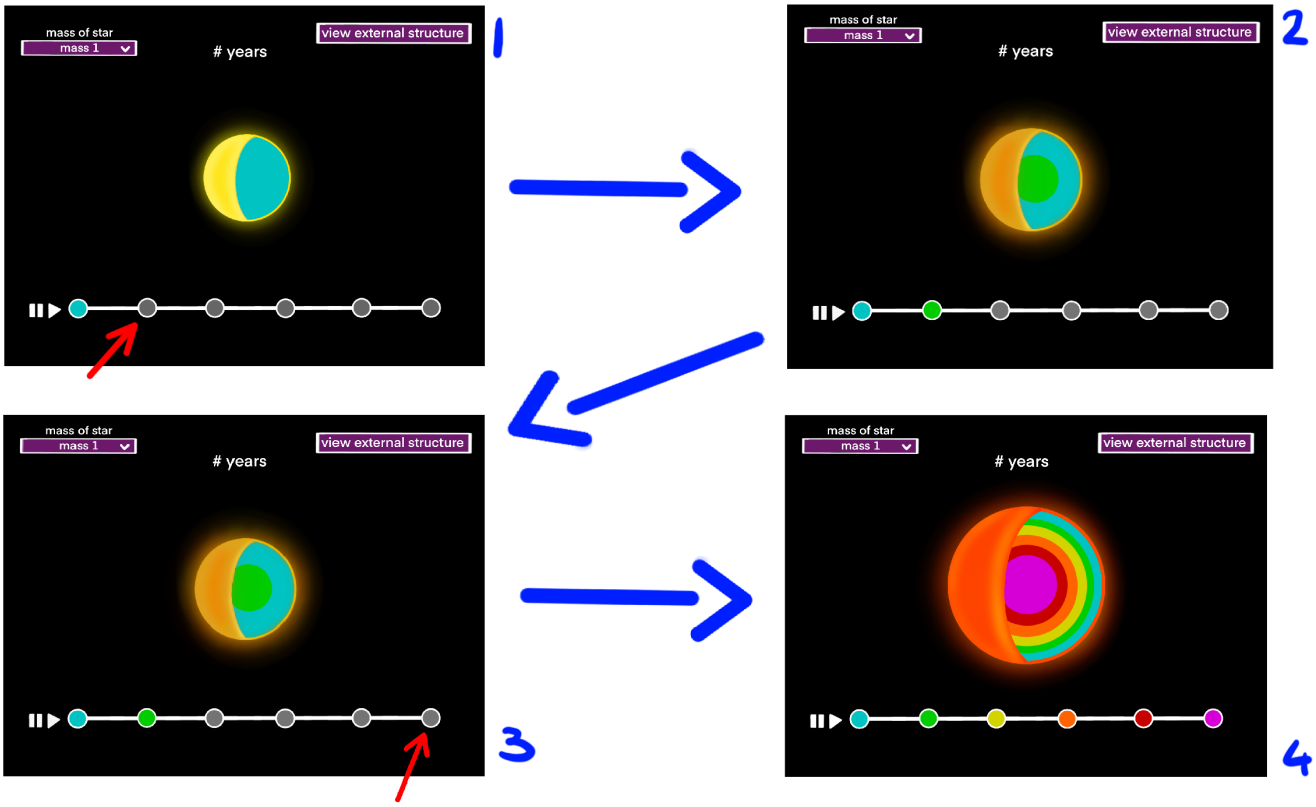

Figure 8: The interface: clickable dots that enables the user to view the desire stage of the star.

To select a star with a different mass, the user should click on the drop down menu. This menu will contain multiple different buttons that allow the user to select the desired mass of the star they want to view. An example of the drop down menu is shown in Figure 9.

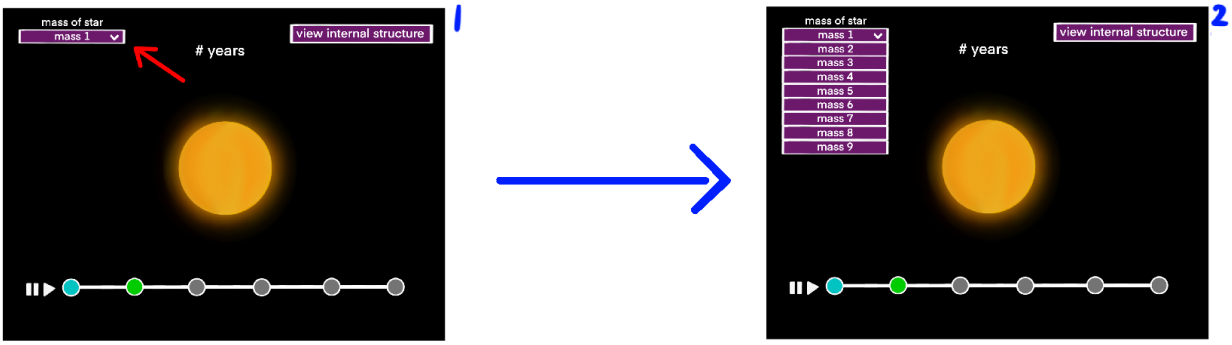

Figure 9: The interface: drop down menu that allows the user to pick the desired mass of a star.

5 Usability Specifications

Usability attribute	Measurement	Value to measure	Min	Goal	Max
Operation speed	Navigate to specific time	Time (s)	6	3	1
Operation speed	Change mass of star	Time (s)	8	4	1
Error tolerance	Navigate to specific time	# errors	2	1	0
Error tolerance	Change mass of star	# errors	2	1	0
Suitability	Questionnaire	Avg score	5.5	8	10
Learnability	Questionnaire	Avg score	5.5	8	10
Satisfaction	Questionnaire	Avg score	5.5	8	10
Educational value	Questionnaire	Avg score	5.5	8	10

Table 1: Usability specifications that we will test during user evaluation sessions. 'Min' is the lowest acceptable score, 'Goal' is our target score and 'Max' is the best possible score.