Visual Programming for Gaming Device Customization

Master Project in Computer Science

Logitech Europe S.A.

Faculty Supervisor:
Dr. Pearl Pu

Student:
Thanuditha Ruchiranga Wickramasinghe

Industry Supervisor:
Mr. Sidney Bovet

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Lausanne, 12 March 2021

Abstract

The Logitech G HUB software provides a Lua scripting environment for users to perform advanced customizations on Logitech Gaming gear. This feature requires the user to have some familiarity with programming in Lua language and a lengthy reference manual has to be referred to learn the Lua API functions provided by G HUB. This project aims to explore how visual programming can be utilized in this setup to make this scripting environment in G HUB easy to use, more intuitive and more approachable, for users without any programming experience. The project follows a User Centered Design process where progress is made in iterations, carrying out user tests at each step to verify the design decisions.
To start with, two types of candidate visual programming setups were evaluated. One setup used a notion of blocks that fit together to create meaningful programs. The other setup used a notion of a graph of nodes connected to each other using lines that specify the flow of execution and the flow of data. Low fidelity prototypes of the two setups were developed and tested with users. Based on user input, it was decided to proceed with the blocks based setup. Thereafter, a high fidelity visual programming prototype that functioned fully integrated with the G HUB software was developed. A final round of user tests was carried out to discover any further usability issues in the prototype to be addressed in future iterations. A majority of the participants of the high fidelity prototype user test, stated with confidence that they would prefer to use the prototype rather than write code in text to perform device customizations.

Key words: Visual Programming, User Centered Design, Logitech G HUB

Contents

List of Figures

List of Tables

1 Introduction

Logitech is one of the world's leading manufacturers of input and interface devices for personal computers and various other digital products. Logitech G is a team within Logitech that focuses on bringing out the best experience for PC gamers with a set of advanced and fully customizable gaming gear. Logitech G HUB is the main software that enables users to customize and personalize the Logitech Gaming gear they own.

The device customization needs of users can vary significantly. Some gamers could prefer to use their devices in the simplest ways possible with no customizations, some could prefer to use some preset customizations that they would personally find useful, where as some could prefer making unique customizations to their devices to address their individually unique needs. In order to cater for different levels of customization users need, G HUB currently provides three conceptual layers of customization. The simplest level provides the users with a set of preset actions that can be easily assigned to different configurable buttons or keys of the connected devices. Figure 1.1 shows this interface. Key assignments can be done simply by dragging a command from the left panel and dropping it onto a configurable keyboard key. A step beyond that, G HUB provides a macro editor where users can create simple sequences or repetitions of actions that can also then be assigned to different configurable buttons or keys of the connected devices. Figure 1.2 shows a macro that automates reloading of multiple weapons in a game. This assumes the keys 1, 2 and 3 selects the weapons in-game and the key R reloads them. Finally, to cater for advanced customization needs, G HUB provides a script editor tool that lets users write their own scripts in Lua language. A script can consume different events triggered by the gaming devices and perform various actions based on them. Figure 1.3 shows this Lua script editor.

Unlike the simple configurations and macro features in G HUB, the script editor feature, understandably, can be expected to be appealing to a niche group of users who have some unique advanced customization needs as well as some skills in programming. In fact, the software usage analytic information show that less than 1% of G HUB users even attempt to open the script editor. While we do not have statistics on the number of people who actually have written their own scripts, it would be fair to expect that, that number is even less.

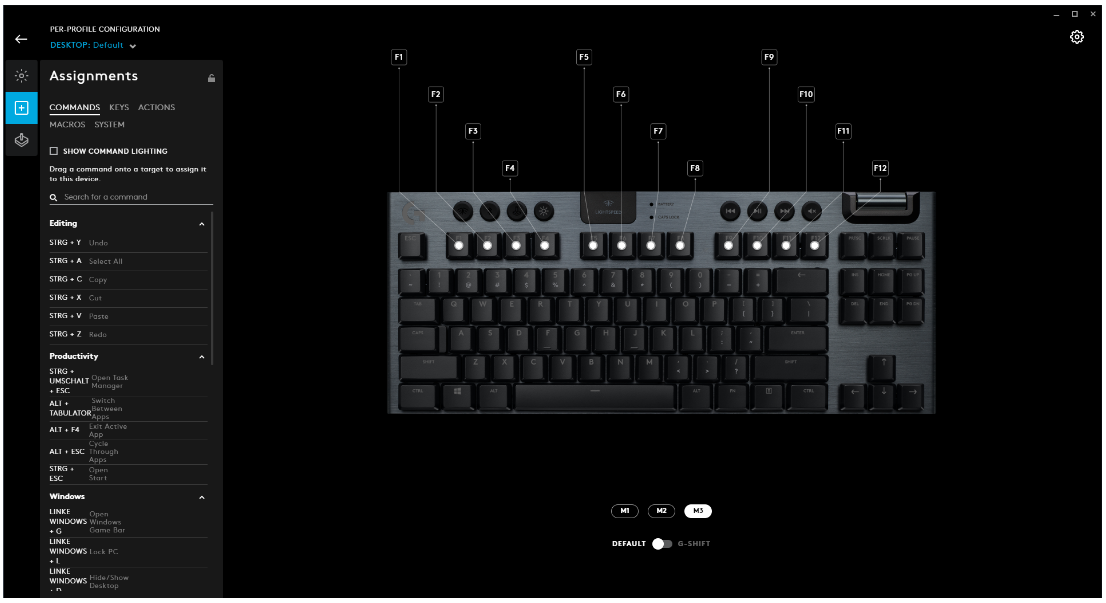


Figure 1.1 – Keyboard key assignment configuration tool in G HUB

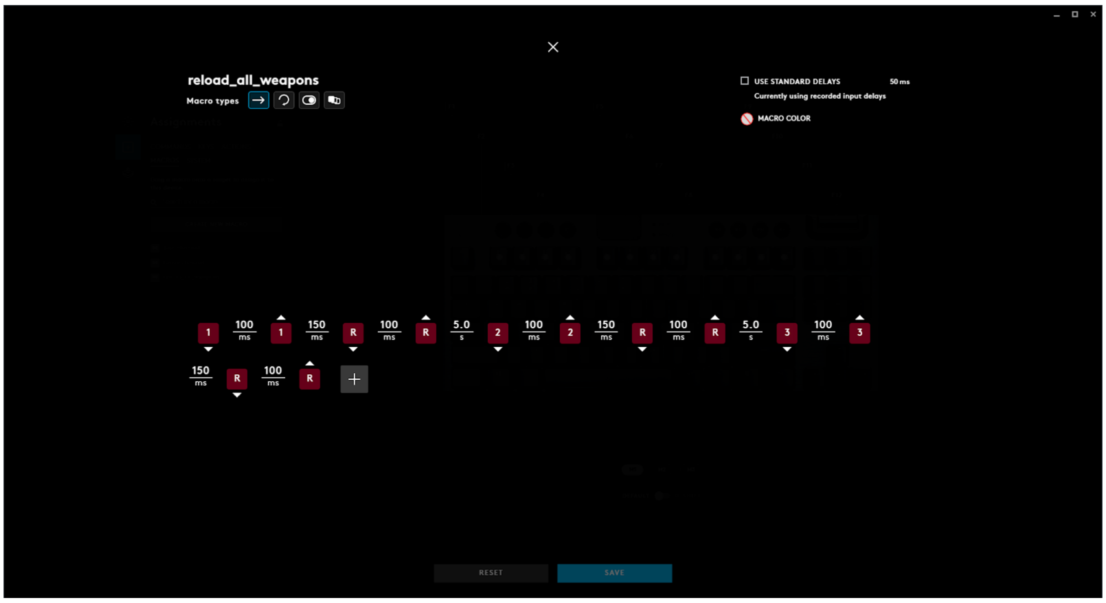
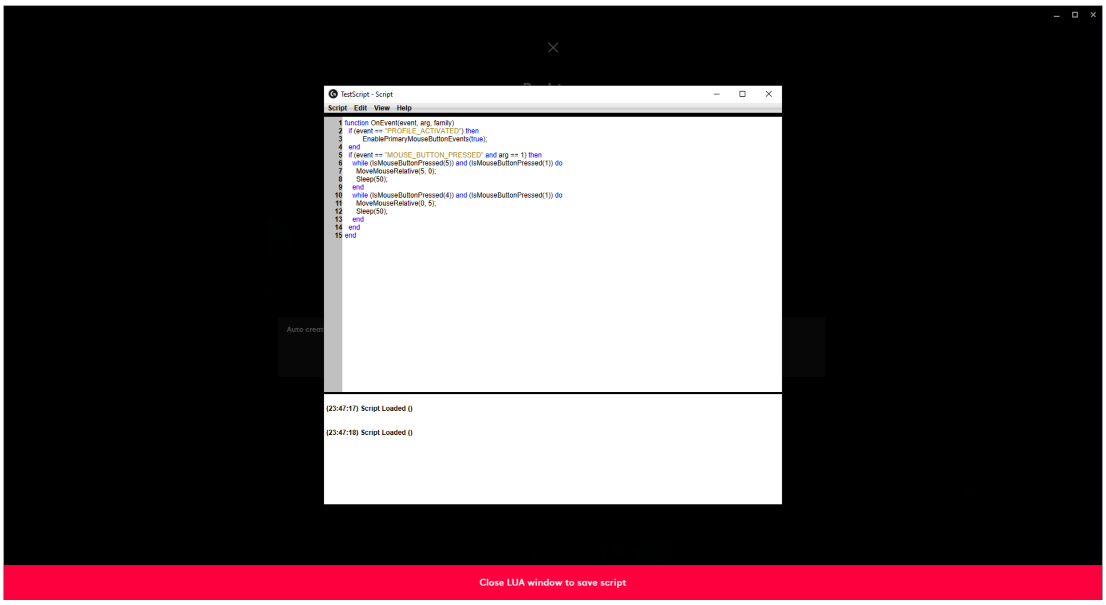


Figure 1.2 – A macro that automates reloading of multiple weapons in a game, created using the G HUB Macro editor.

The objective of this project is to explore means of introducing visual programming to try to broaden the aforementioned user base by making the script editor more accessible and intuitive to use for both users with basic coding skills as well as users without any coding experience. This visual programming tool will be a new conceptual layer of customization that lie between the Macros feature and the textual script editing feature, providing the same customization capabilities of a Lua script while still trying to be as close as possible to the



```
function OnEvent(event, arg, family)
 if (event == "PROFILE_ACTIVATED") then
      EnablePrimaryMouseButtonEvents(true);
 end
 if (event == "MOUSE_BUTTON_PRESSED" and arg == 1) then
  while (IsMouseButtonPressed(5)) and (IsMouseButtonPressed(1)) do
   MoveMouseRelative(5, 0);
   Sleep(50);
  end
  while (IsMouseButtonPressed(4)) and (IsMouseButtonPressed(1)) do
   MoveMouseRelative(0, 5);
   Sleep(50);
  end
 end
end
```

```
(23:47:17) Script Loaded ()

(23:47:18) Script Loaded ()
```

Figure 1.3 – G HUB Lua script editor.

Macro editor in terms of intuitiveness, and simplicity.

The project followed a User Centered Design approach where design and development was carried out in iterations. Two initial low fidelity prototypes following two different paradigms of visual programming were created and user tests were carried out to evaluate and compare the applicability of them into this specific use case. Based on the user input received, one paradigm was chosen to proceed with. A high fidelity prototype of the chosen kind was then developed and another round of user tests were carried out to identify further usability issues and avenues for improvement.

2 Visual Programming - Current State of the Art

The general concept of Visual Programming (VP) refers to creation of programs utilizing graphical elements arranged spatially in specific ways that imply a flow of commands getting executed. A visual programming environment can assist users in creating programs in three different levels (Repenning, 2017).

1. **Syntactic**: Provision of pre-built graphical elements that represent programming constructs can reduce or even completely eliminate the need to worry about syntactic errors such as misspelled keywords, improper indentations or missing statement terminators. This lets users produce well-formed programs without necessarily having to be familiar with a set of syntactic rules.
2. **Semantic**: The use of graphical elements in visual programming enables means of assisting users with the comprehension of the meaning of programming primitives. For instance, the graphical elements can provide documentations in terms of tooltips or help functions.
3. **Pragmatic**: Visual Programming Languages (VPLs) can support the users in comprehending programs in the context of specific situations. In most situations, this means allowing the user to manipulate the state of the artifacts created with the VPL to explore how the program reacts to that.

A number of different VPLs exist today and there is active research happening on their applicability in various domains. While a majority of the VPLs and VP tools have been made targeting the educational sector, especially in teaching children how to code, they have been successfully utilized in other domains as well such as multimedia, video game design and development, simulation, automation and data warehousing[I].

Each of the many VPLs that exist today can be categorized based on the visual style and setup they use as follows (ai craft, 2015).

[I]Visual programming language [Page Version ID: 1008802939]. (2021). Retrieved February 26, 2021, from https://en.wikipedia.org/w/index.php?title=Visual_programming_language&oldid=1008802939.

- **Blocks**: Block based VPLs can be considered to be the closest of all types to the source code of a classical imperative programming language. Their grammar is essentially similar to that of an imperative programming language, but the visual cues provided with the graphical elements makes it easier for the user to discover syntax and understand how to combine different blocks together to manipulate the execution flow and the data flow as a well-formed program. The Scratch programming language developed by MIT (Resnick et al., 2009) is a famous block based VPL.

- **Flowcharts**: Flowchart based VPLs follow the concept of "boxes and arrows" that is commonly used in representing algorithms. "Boxes" can take different forms such as inputs, outputs, processing steps and decision points. Arrows signify the flow of execution. Owing to the simplicity of the concept of flowcharts, these VPLs are rather easy to understand. Yet the logical constructs that can be built using them is limited. For instance, a flow chart cannot intuitively represent an event driven execution setup. Data-flow VPLs and Finite-state Machine VPLs resemble Flowchart VPLs and they try to address these gaps. Bonita BPM[II], which is a business process management tool and Flowgorithm (Cook, 2015) are some examples of Flowchart based VPLs.

- **Data-flows/Nodes**: Data flow based VPLs can most commonly be seen in professional applications that has a target audience of designers, rather than novice programmers. These VPLs use a setup of nodes that are connected to each other with links that connect the output socket of one node to the input socket of another. Links are used to represent both the data flow as well the execution flow. All the processing instructions of the program are embedded in each of the nodes and pre-built nodes with specific functionality are usually provided for the user. Although this graph based setup makes it look simple, it requires some understanding on the notions of data flow and execution flow in programming. Blueprints[III] and Nodes[IV] are some tools that follow this data-flow based visual programming setup.

- **Finite-state Machines**: Similar to Data-flow setup, these VPLs also use nodes and links connecting each other. But unlike in Data-flow setup, the nodes here represent states and the links represent state transitions. Each node has its conditions to transit to a certain other state specified within itself and instructions are triggered when the state changes. The applicability of this setup could be limited to specific use cases and it also requires the user to be familiar with the concepts of state machines. Yet, because of the "boxes and arrows" setup, the visual grammar becomes simple and the user gets to see the overall picture of how the program behaves. Mecanim[V] is a tool that provides a

[II]BPM software & open source workflow for your processes | Bonitasoft. (n.d.). Retrieved February 26, 2021, from https://www.bonitasoft.com/business-process-management-bpm.

[III]Unreal Engine | The most powerful real-time 3D creation platform. (n.d.). Retrieved February 26, 2021, from https://www.unrealengine.com/en-US/.

[IV]Blender.org - Home of the Blender project - Free and Open 3D Creation Software. (n.d.). Retrieved February 26, 2021, from https://www.blender.org/.

[V]Unity - Manual: Animation System Overview. (n.d.). Retrieved February 26, 2021, from https://docs.unity3d.com/Manual/AnimationOverview.html.

Finite-state machine based visual programming environment for setting up animations.

- **Behaviour Trees**: Behaviour Trees based VPLs essentially follow the same concept of Data-flow based VPLs except for the visual presentation of the programs. They consist of nodes and links arranged in the form of a tree. Each node can have multiple child nodes and each children node returns a status value ('success' of 'failure') back to its parent node after performing its assigned task. The parent node is able to control the flow of execution depending on the status values returned by its children nodes. For instance, a "sequence" node evaluates its children in a sequential order from left to right and stops if one of them fails. Similar to data-flow based VPLs, Behaviour Trees based VPLs require the user to understand how the execution flows in a given tree program, which in this case, is akin to a stack based tree processing in classical programming. Tools such as Craft.ai[VI] that provide Artificial Intelligence services utilize this kind of a VPL at its core.

- **Event-based Rules**: These are very simple VPLs that follow rules of 'If this, then that' (IFTTT) pattern. A set of instructions are executed when the specified conditions are met. The simplicity of these VPLs makes them very intuitive and accessible even for users without any programming experience. On the other hand, these VPLs perform extremely poor in terms of expressive power as a programming language. Zapier[VII] and IFTTT[VIII] are some popular tools that utilize VPLs that follow event-based rules.

The objective of this project is to explore a suitable VP alternative to complement the existing textual Lua script editor in G HUB software and this VP tool needs to offer the same expressive power that the existing textual script editor offers to the users. Looking at the types of VPLs described above, it becomes clear that use of simple flowchart based VPLs would make representing complex scripts unnecessarily convoluted and it would lack the necessary constructs to represent processing of events that get triggered based on user interactions with the devices. A simple Event-based rules setup will fail to match the expressive power of a textual scripting tool. A Finite-state Machine based setup will not match the use case as trying to map the execution of an imperative language script to states and transitions makes things unnecessarily complicated. A Behaviour Tree based VPL could represent sequential and conditional execution flows of a program with great clarity, yet, the representation of loop structures become less intuitive owing to its acyclic nature. This leaves us with two candidate VP setups that can possibly help us achieve the final objective of the project: Blocks based VPLs and Data-flow/Node based VPLs. Accordingly, one popular existing VP tool from each of those two categories were studied in detail to draw inspiration from them for the next steps of the project.

[VI] Craft ai | Explainable AI, as-a-service. (n.d.). Retrieved February 26, 2021, from https://www.craft.ai/.

[VII] Zapier | The easiest way to automate your work. (n.d.). Retrieved February 26, 2021, from https://zapier.com/.

[VIII] IFTTT. (n.d.). Retrieved February 26, 2021, from https://ifttt.com.

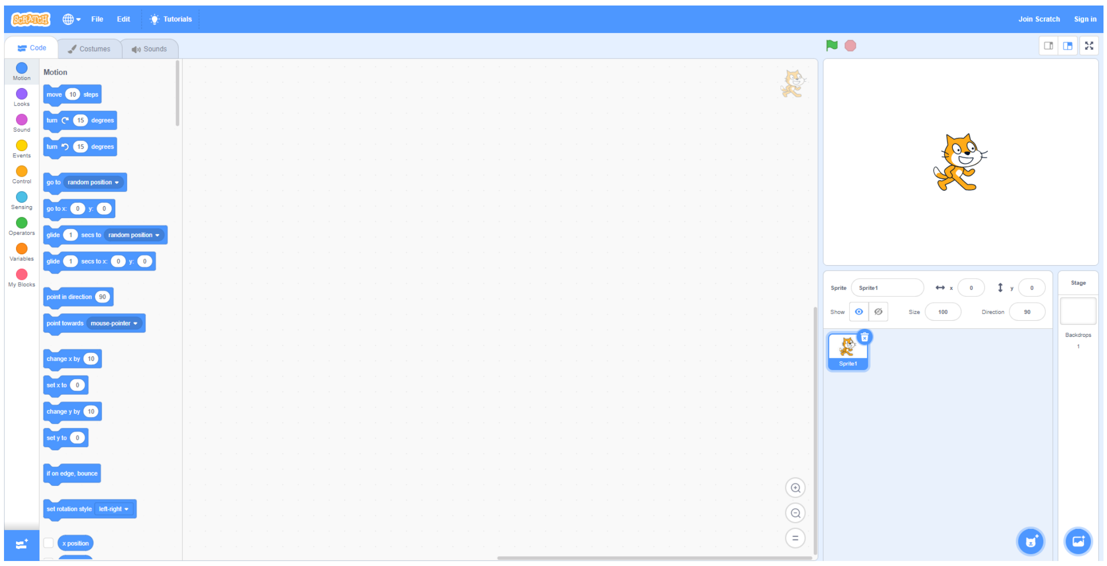


Figure 2.1 – The user interface of Scratch with its three primary ares: the toolbox area, canvas area and the stage area.

2.1 Scratch Programming

Developed by the MIT Media Lab at the Massachusetts Institute of Technology, Scratch, as a Block based VPL, has gained much popularity among children as well as educators. As of March, 2021, more than 70 million projects have been created and shared with the community by more than 65 million registered users[IX]. Scratch was developed primary targeted at children of ages from 8 to 16 as an educational tool for teaching them how to code while working on personally meaningful projects such as animated stories and games (Maloney et al., 2010).

The Scratch user interface consists of three primary regions; a tool box which has all the programming elements (blocks) made available for the user, a canvas area where the user can drag and drop the blocks onto and create programs and finally a stage area where the results of the program being executed are reflected on. Figure 2.1 shows a screen capture of this user interface. The toolbox is accompanied by a category menu that makes the search for a specific block easier. For instance, 'Motion' category contains all the blocks that represents actions related with the motion of the cartoon sprite in the staging area such as 'Move n steps' and 'Turn θ degrees'. Similarly, 'Looks' and 'Sound' categories, as the names suggest, contain action blocks that manipulate the looks of the cartoon sprite and the sounds it can make respectively. The 'Event' category has blocks that lets the users specify when a certain piece of Scratch code should be executed. 'When space key is pressed' is one such example. The 'Sensing' category holds a set of blocks that primarily lets the user perform checks on the cartoon sprite, such as whether the mouse arrow is touching it, or checks on the input devices such as whether a certain keyboard key is pressed. The Operators category primarily has

[IX]Scratch - Imagine, Program, Share. (n.d.). Retrieved March 1, 2021, from https://scratch.mit.edu/statistics/.

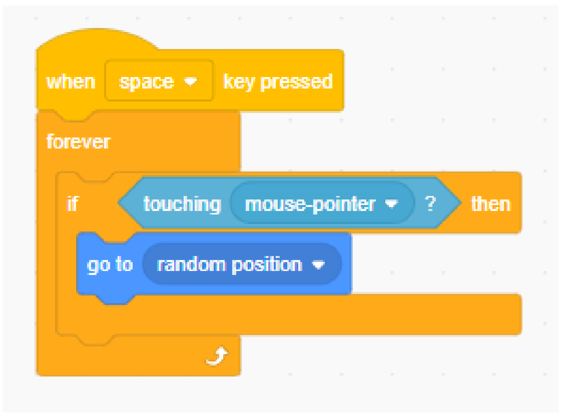
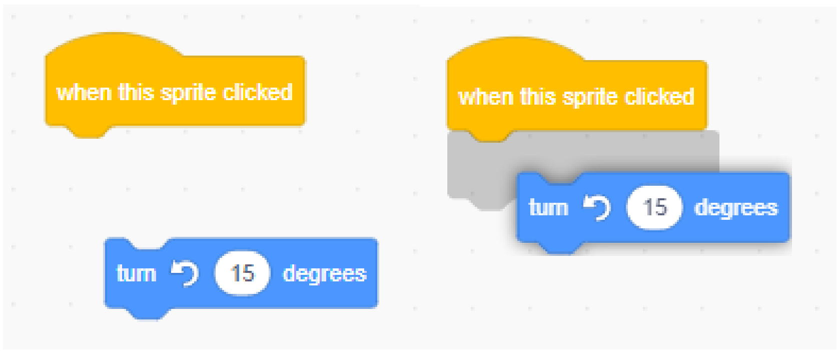


Figure 2.2 – A simple Scratch program that repeatedly checks if the mouse pointer is touching the cartoon sprite and moves it to a random position if so.

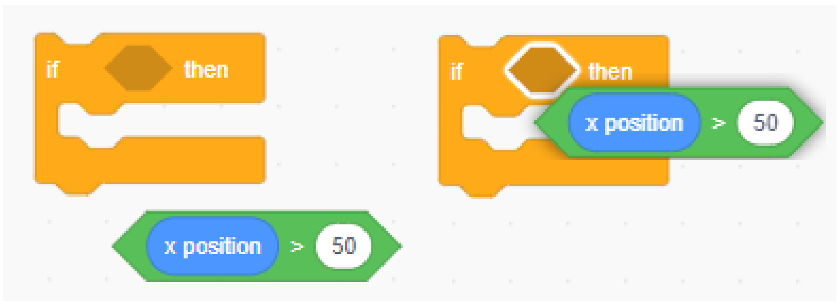
blocks that represent the common operators used in classical programming such as addition, subtraction, multiplication, division, inequalities as well as some additional operations like round off, absolute value and contains. The 'Control' category holds the blocks that help manipulate execution flow such as loops and conditional statements. 'Variables' category lets the user create variables to store values and a setter and a getter block for the variable is made available in the toolbox the moment a variable is created. Finally, the 'My Blocks' category lets the users create blocks that are akin to function definitions in classical programming. They user first gets to create the function signature by graphically configuring a block with the appropriate parameter values. Once that is done, a holder appears on the canvas for the user to then proceed with stacking blocks underneath to define its implementation.

Figure 2.2 depicts a Scratch program created using one 'Event' block, two 'Control' blocks, one 'Sensing' block and finally one 'Motion' block. The arrangement and the wording of the blocks makes it possible for the user to read what the program does as a story. The functionality of this script turned into words is almost the same as reading what is mentioned on the blocks from top to bottom: "When the space key is pressed, repeat forever to check if the mouse-pointer is touching the cartoon sprite and if it is, move the sprite to a random position". This little piece of code can be seen as a simple game for kids where every time they try to touch the cartoon character with the mouse arrow, they fail as it immediately moves to a different position.

Scratch manages to enforce data type constraints by means of different block shapes. For instance, blocks that give out boolean values always take the shape of a diamond where as blocks that give out values such as numbers of strings has an oval shape. At places where a boolean value is expected, the socket takes the same shape, which makes it intuitive that an oval shape block will not fit in there. Figure 2.3(b) depicts this idea with the condition input socket for the 'if' block being of diamond shape. Scratch also provides visual cues on when a certain block can fit at a certain socket when it is brought close by either with a shadow showing how the block would look if it was fitted there or by simply highlighting the socket. Figure 2.3 demonstrates this feature.



((a)) Visual prompt showing a shadow of what the ‘Motion’ block looks like when it is fit under the ‘Event’ block.



((b)) Visual prompt highlighting condition input socket of ‘if’ block implying the inequality block can fit in there.

Figure 2.3 – Scratch provides visual cues to convince the user that a certain block can fit at a certain place when a block is dragged and brought closer by.

2.2 Blueprints Visual Scripting

Unreal Engine is one if the world’s most advanced 3D creation tools originally created as a state-of-the-art game engine, which subsequently evolved to serve creators across industries such as architecture, transportation, film and simulation in creating interactive experiences and immersive 3D virtual worlds[X]. Unreal Engine 4, which was released in 2014 introduced the ‘Blueprints’ visual scripting system with the aim of enabling technical artists and designers to work on the game logic as well without having to write code. It follows a data-flow based VP setup where users create graphical structures that consist of nodes that perform actions or listen on events and wires connecting them to infer the flow of execution and data.

Figure 2.4 shows the 3D Perspective Viewport an example Unreal game development project. As can be seen in the figure, the environment contains different objects such as a humanoid player character, certain structures and game objects such as the white box shown selected at the center of the figure. Blueprints enable the user to attach certain behaviours to these objects.

[X]Unreal Engine | The most powerful real-time 3D creation platform. (n.d.). Retrieved February 26, 2021, from https://www.unrealengine.com/en-US/.

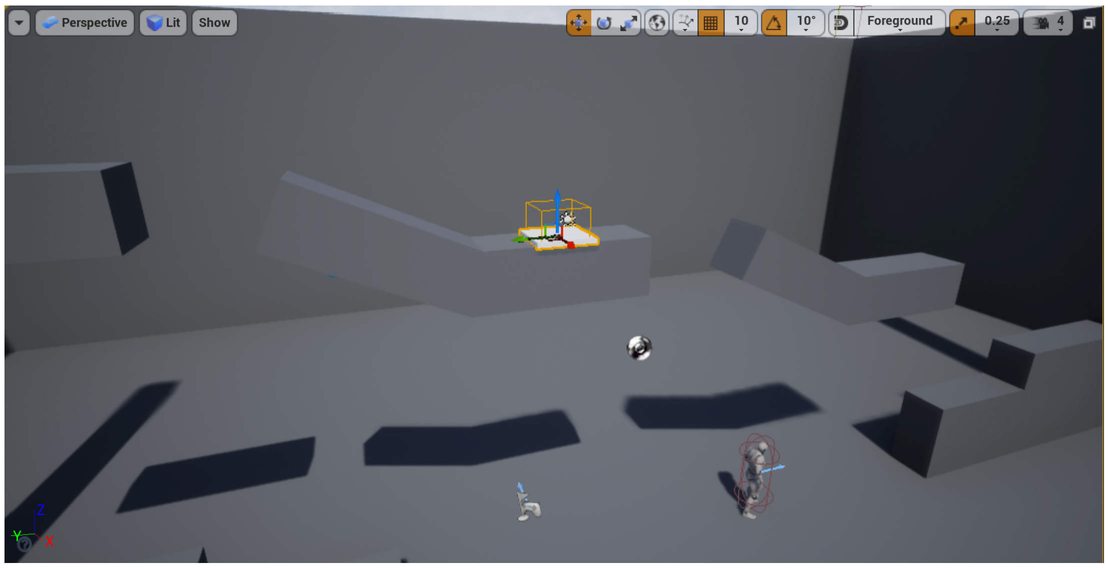
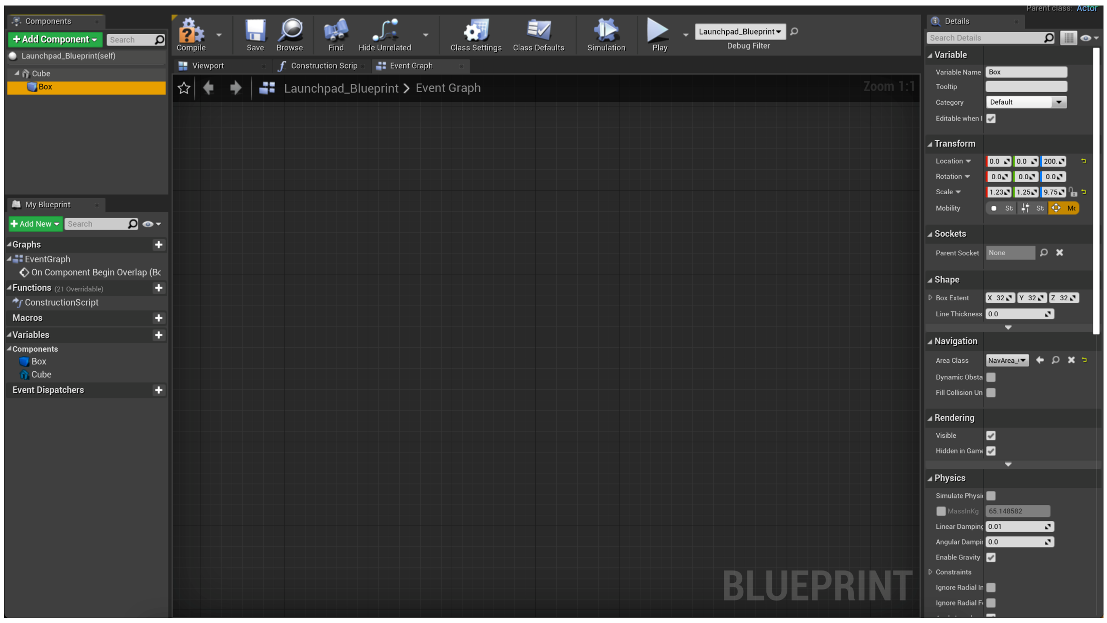


Figure 2.4 – The viewport of a sample game development project in Unreal Engine 4.

Figure 2.5 shows the user interface of the Blueprints editor. The interface has the prominent empty canvas area in the middle where the users can create the visual programs. New nodes can be added to the canvas by accessing a menu that appears when right-clicked on an empty space on the canvas. Figure 2.6(a) shows how this menu is categorized into a number of categories. A search bar is provided to make it easier to find a specific node. This particular menu is by default context sensitive, meaning that it filters the contents in the menu to reduce clutter and narrow down the options that the user can use in a particular situation. Creating new nodes can also be intuitively done by dragging off a line from a socket of an existing node in the canvas and once the mouse button is released, the menu shown has only the nodes that can possibly connect to the node the line is being dragged from. Figure 2.6(b) shows this.

Blueprints facilitates using graphs of nodes for purposes such as object construction, function calls and general gameplay event handling in order to implement behaviour and other functionality[XI]. Blueprint scripts can be attached to any object created in the scene. Figure 2.7 shows a sample script that is created attached to the white Box structure that is seen in Figure 2.4. The purpose of this script is to launch the Player Pawn up into the air when the Player Pawn walks onto the Box during gameplay. Accordingly, the script is made to be run when the humanoid player moves over the the Box object. The 'On Component Begin Overlap' node with a red header in Figure 2.7 specifies this. Figure 2.6(a) shows several other 'Event' nodes made available to the user in this specific context. The white connecting lines in Figure 2.7 represent the flow of execution in the script. When the event is fired as a result of the game player moving the game character over the Box, the execution moves to the Branch node. Branch node then evaluates the condition value that is fed into it. In this case, it checks if

[XI]Introduction to Blueprints. (n.d.). Retrieved March 2, 2021, from https://docs.unrealengine.com/en-US/ProgrammingAndScripting/Blueprints/GettingStarted/index.html.



Variable
Variable Name: Box
Tooltip:
Category: Default
Editable when I: ✓

Transform
Location: 0.0 0.0 200.
Rotation: 0.0 0.0 0.0
Scale: 1.23 1.25 9.75
Mobility: St St Mc

Sockets
Parent Socket: None

Shape
Box Extent: X 32 Y 32 Z 32
Line Thickness: 0.0

Navigation
Area Class: NavArea_
Dynamic Obsta:
Fill Collision Un:

Rendering
Visible: ✓
Hidden in Game: ✓

Physics
Simulate Physi:
MassInKg: 65.148582
Linear Damping: 0.01
Angular Dampi: 0.0
Enable Gravity: ✓
Constraints
Ignore Radial In:
Ignore Radial F:

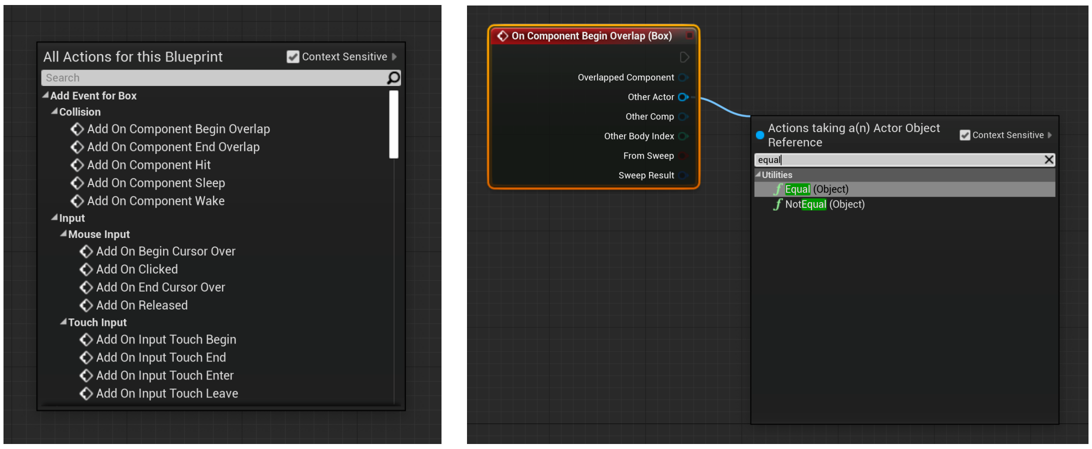
Figure 2.5 – The user interface of Unreal Engine Blueprints visual scripting system.

'Other Actor' that triggered the event is the Player Pawn (returned by the 'Get Player pawn' function node). If that evaluates to be true, the execution moves to the 'Cast To Character' node, which performs a cast operation on the value returned from 'Get Player Pawn', which is finally fed into the 'Launch Character' function node. It can be seen that most of the nodes have sockets for accepting input values and for cases those values are not fed from any external source, the values can be configured on the node itself. This can be seen with 'Launch Velocity' parameters in the 'Launch Character' node.

By default, Blueprint visual scripts get compiled and converted to an UnrealScript VM bytecode before they are used in-game. The Blueprints system also provides the option for the user to generate C++ code out of a visual script[XII] if desired.

Drawing inspiration from the above discussed VPLs, we build two low fidelity prototypes based on blocks and nodes setups and evaluate which of the two setups is most preferred by the target users for our specific use case. These steps are discussed in detail in the following section.

[XII]Blueprint Compiler Overview. (n.d.). Retrieved March 2, 2021, from https://docs.unrealengine.com/en-US/ProgrammingAndScripting/Blueprints/TechnicalGuide/Compiler/index.html.



((a)) New nodes can be created on the canvas by choosing them from the menu accessible by right-clicking on an empty area on the canvas.

((b)) Dragging out a line from any socket and releasing the mouse provides a menu that has all the contextually filtered node options that could possibly connect.

Figure 2.6 – Blueprints menu for creating new node.

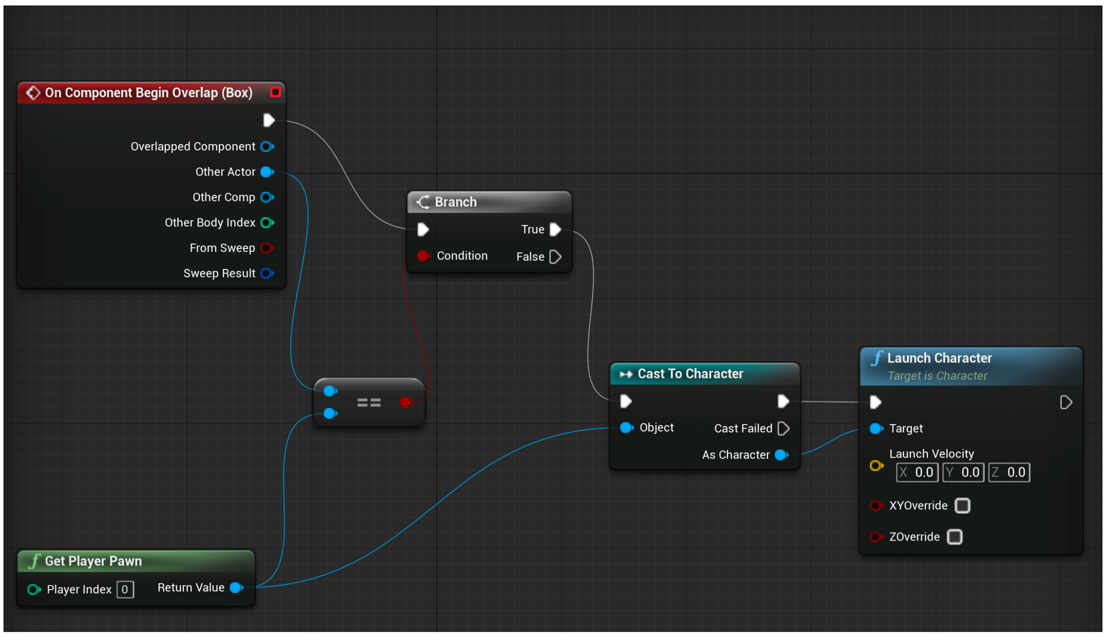


Figure 2.7 – An example Blueprint program.

3 Methodology

In this section, we discuss the methodology followed in exploring visual programming solutions to improve the user reach out of the G HUB Lua scripting feature. The project intended to reach out only to the existing user base of Logitech G HUB software and the requirement was to create a visual programming solution by obtaining an understanding of the related needs, desires and experiences of the target user base so that the final outcome will be perceptually, cognitively and emotionally intuitive. Accordingly, a User Centered Design process was followed from the very beginning. This practice helped us identify and address usability issues in the design of the product from early on, saving both time and effort and ultimately enabling us to achieve an acceptable level of usability.

A typical User Centered Design process for designing web applications goes through the following phases[I] in an iterative fashion.

1. Analysis
2. Design
3. Evaluation
4. Implementation

The process iterates among the design, evaluation and optionally implementation phases until the expected level of usability and quality of user experience is achieved. Figure 3.1 illustrates this idea. This four step iterative process was employed in carrying out this project. Chapter 4 discusses in detail the analysis of the problem at hand and target user base. Chapter 5 goes into detail on the design and implementation of two low fidelity prototypes, one of which follows a blocks based setup and the other, which follows a nodes based setup. Then, Chapter 6 discusses the first iteration of evaluations carried out on the two low fidelity prototypes with

[I] Notes on User Centered Design Process (UCD). (n.d.). Retrieved March 2, 2021, from https://www.w3.org/WAI/redesign/ucd.

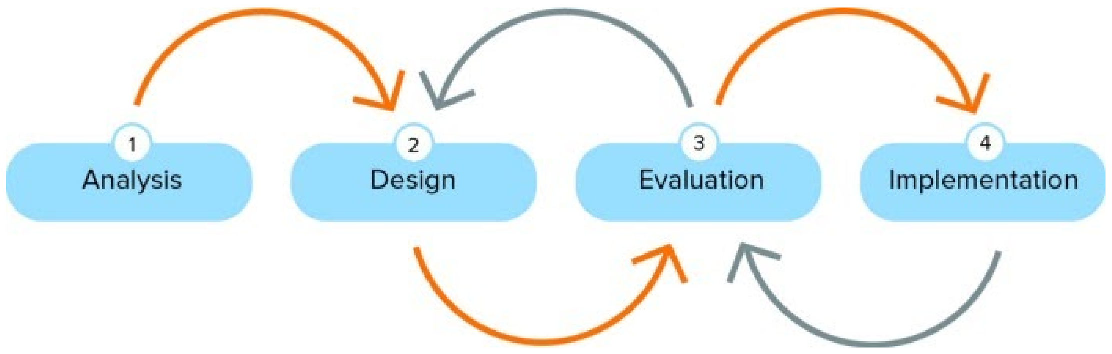


Figure 3.1 – User Centered Design process (Havik, 2017)

user tests. Drawing from the learnings of the evaluation carried out, a high-fidelity blocks based prototype was built and Chapter 7 discusses in detail the specifics of its implementation. Finally, as a means of verifying the usability of the high fidelity prototype developed, another iteration of user tests were carried as a second evaluation iteration.

Further usability issues were uncovered by the second evaluation iteration and it was clear that few more iterations between implementation and evaluation stages were necessary to achieve a high level of usability. Considering the limited time frame the project was carried out in, it was not feasible to proceed with any further iterations and hence those identified possible improvements were left as future work.

4 Analysis

4.1 Audience analysis

As the project targeted the existing user base of Logitech G HUB software, and the G HUB software team at Logitech already had a clear understanding on the goals and motivations of those users, it was decided that there is no necessity to carry out interviews to empathize with the users. Accordingly, the identified user task, user pain points, user goal and user behaviour patterns are discussed below.

The identified user task was to make advanced customizations on Logitech gaming gear that cannot otherwise be made with the general G HUB device configuration interface or using the ‘Macros’ functionality provided in G HUB.

Several user pain points were identified with the existing textual Lua scripting system. First, users had to be comfortable with the Lua programming language syntax and concepts to make the customizations they wanted. The script editor feature in G HUB provided for making those advanced customizations was placed quite hidden in the sophisticated G HUB UI and it looked out of place with the rest of the application in terms of look and feel. The editor had only very basic support for writing code and there was no automatic code completion functionality to assist the users in writing the code. Users had to refer to a lengthy API documentation[I] to figure out the supported G HUB Lua functions they can use in the code and there was minimum support for code debugging.

The identified main user goal for the proposed visual programming tool was to make advanced automations to Logitech gear to assist them in games or other applications they use in an intuitive, easy to use way.

The significant behaviour patterns of the targeted users of our visual programming tool were identified to be, being PC gamers who either do or do not have previous programming

[I] G-series lua api - overview and reference. (n.d.). Retrieved March 2, 2021, from https://douile.github.io/logitech-toggle-keys/APIDocs.pdf.

experience.

Following 2 personas characterizes the above discussed behaviours and traits of the target users. Persona 1 was chosen to be the Primary Persona, i.e. the persona that represents the primary target for the design of the system simply due to the fact that it mostly satisfies the scope of Persona 2 as well. Accordingly, Persona 2 was chosen to be the Secondary Persona with the idea behind being: 'designing the solution first for the primary, and then adjusting the design to accommodate the secondary' (Cooper et al., 2007).

4.1.1 Persona 1 (Primary Persona)

Stephan Willan is a 19 year old, living with his parents. He is awaiting to enter university to start his bachelor's degree in architecture soon. He loves gaming and spends most of his weekends and weekday evenings in front of his PC, playing Fortnite, an online multiplayer game.

He has a Logitech RGB gaming keyboard and an RGB mouse that he has been using for gaming for several years now and he finds the ability to customize and personalize them using G HUB very useful. While he has created some macros in G HUB and has assigned them to different keys in his mouse to automate some moves in the games he plays, he knows that the macros feature is just not expressive enough to create certain automations he wanted done. He knows about the Lua script editor of G HUB that gives that additional expressivity as he has seen Lua scripts shared in the internet gaming communities by various users to make various automations for the games, but with his very limited experience in programming, he has no clue at all on how to write a similar script to address his needs by himself.

He wishes there was a more intuitive and non-cryptic way to make the customizations he needs.

4.1.2 Persona 2 (Secondary Persona)

Seth Colbert is a 35 year old father of 2 kids. He is a Software Engineer by profession and has been working in the software industry for more than 10 years. He used to be an avid PC gamer before he got married, but now with more responsibilities in life, he does not get to play as much as he did before. Yet, he still has with him his gaming PC with his favourite Logitech RGB keyboard and Logitech RGB mouse and enjoys playing games every now and then.

Being a technical expert himself, he likes to customize his gaming gear to assist him in both gaming as well as when he is working. He maintains two different profiles in G HUB, one for gaming and the other for work related applications and has written Lua scripts to customize the behaviours of his devices differently in each of those profiles. Although, with his experience as a developer, he was able to convert his customization needs into Lua code and get the job done, he found it frustrating that he had to first familiarize himself with the Lua language syntax the first time he tried to use the textual script editor. Every time he wanted to add a new functionality to the script he had to go through the G HUB Lua API documentation to figure out the correct supported G HUB functions to use. Debugging the code was not straightforward either.

He expects to be able to make such customizations faster and easier without having to spend time on such mundane tasks like reading through documentations.

4.2 Problem statement

The user reach out of the Logitech G HUB Lua scripting feature is quite narrow as it does not provide an easy to use intuitive way of performing advanced customizations to Logitech gaming gear for the less tech savvy as well as expert level users to meet their goals of automating repetitive tasks in games or other applications they work with.

4.3 Vision statement

The new design of the Logitech G HUB scripting feature with visual programming will help even less tech savvy users achieve their goals of automating repetitive tasks in games or other applications they work with by giving them the ability to create scripts graphically in an intuitive, playful and easy to use environment, without them needing to have any prior knowledge in programming or the G HUB Lua API. This will significantly increase the user reach out of the scripting based advanced device customization feature of Logitech G HUB and lead to an overall better user experience of the application.

4.4 Context scenario

After having a long day at work, Stephen comes home in the evening. After taking a shower, to clear his mind and relax a bit, he decides to play an online multiplayer shooting game that he recently started playing. As he plays, he notices that as the player shoots bursts in the video game, the in-game gun recoil simulation causes the cross hair of the gun to move away from the target. He notices that this recoil movement of the gun can be cancelled out by moving the mouse tactfully with the right speed in the opposite direction of recoil movement, but he is not skilled enough to do that mouse movement precisely while shooting.

He figures out that this can easily be achieved by automating the mouse movement using G HUB software. He minimizes the game, opens G HUB and opens the script editor. As he is in a hurry to play the game and does not want to spend time learning Lua language syntax and concepts, he chooses to create the script graphically.

He immediately sees the list of components available for him to use to create the script graphically. He chooses the components that let him detect the left mouse button press, simulate relative mouse movements and designate the execution flow of the script to start with. He then associates those components together in a way that reads out the requirement he has in his mind.

After saving the completed graphical script, he also finds the option to view the corresponding generated Lua script. He feels empowered by the fact that he could produce that code without having to know a single thing about the Lua language.

He returns back to the game and tests how good his script is and realizes that he has to make some adjustments on the amounts of the relative mouse movements to perfectly match and counter the in-game gun recoil movement. So he switches back to G HUB, makes those changes in the graphical script, returns back to the game and tests again. This time, the script perfectly works and this drastically increases his shooting accuracy.

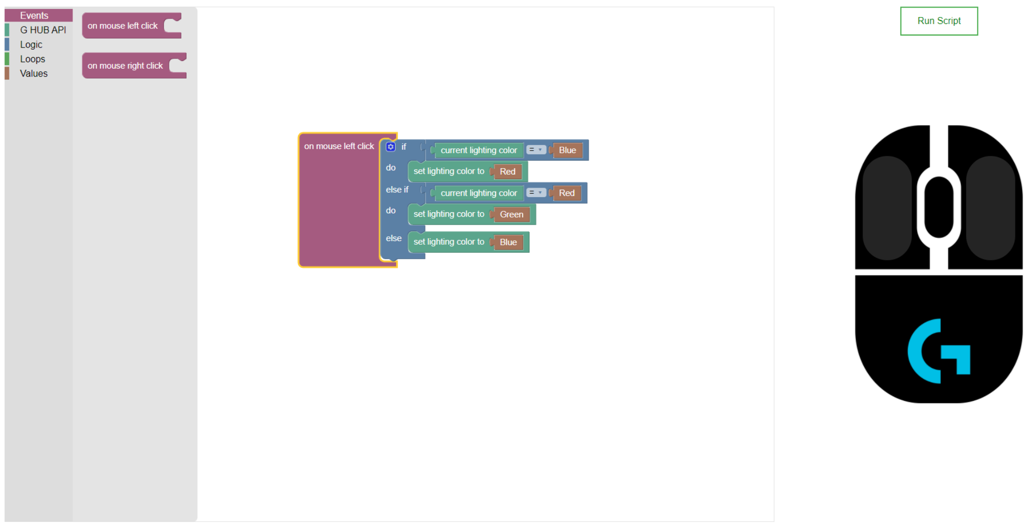
5 Design

The initial design decision that we were faced with was to decide on the kind of visual programming setup to use. As was described in Chapter 2, we observed that we have two main candidate setups for our use case.

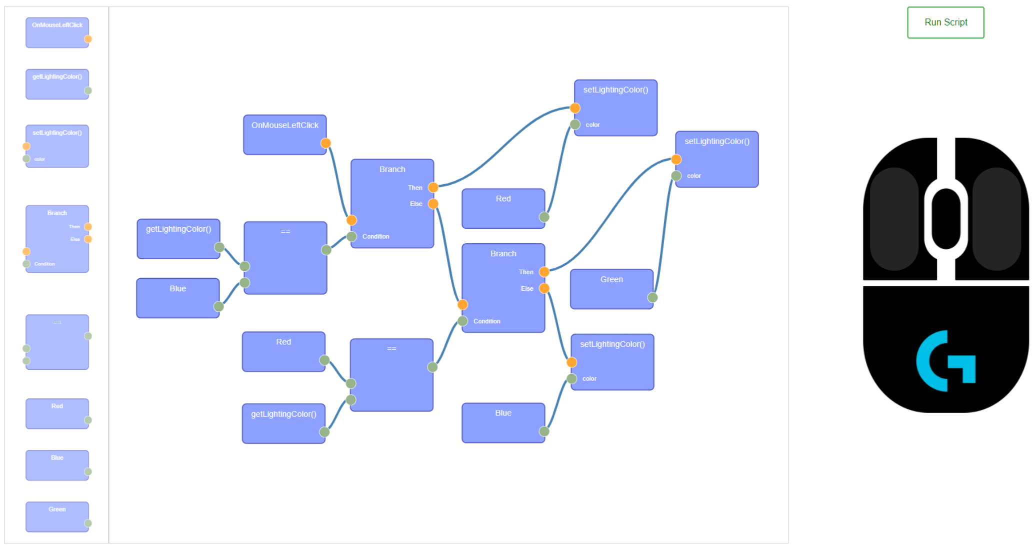
The first option was to have the components of the script represented by blocks that would fit together like puzzle pieces. We refer to this as a blocks based setup. Section 2.1 in Chapter 2 dives into the details of a famous visual programming tool called Scratch that uses exactly this notion. Someone familiar with programming and writing code in general would quickly notice that this notion of blocks closely resemble the way a chunk of code is written. What makes it different from writing the code itself is that the user here does not need to worry about using the correct keywords, having proper indentations or statement separators and getting the syntax right. All that complexity is abstracted away by the use of graphical blocks that fit each other like pieces of a puzzle.

The second option uses a notion of nodes to represent the components of the script. We refer to this as a nodes based setup. Section 2.2 in Chapter 2 describes in detail a tool that has a similar setup called the Blueprint visual scripting system, which is used in Unreal Engine 4. The general idea of this concept is that nodes are connected to each other by wires and these wires can specify either the flow of control or the flow of data from one node to another within the script. Unlike the blocks based option, scripts created with this setup do not directly resemble a block of code at a glance, yet each node would always correspond to a chunk or a full line of code.

To make sure the choice is made with the end users in mind, it was decided to carry out the first round of user tests. The primary target of this round of user tests was to understand which setup gave the users the best experience and to gain any additional insights from the users as to what they think can be improved in the prototypes in general.



((a)) The interface of Block based prototype with the visual script that performs the user assigned task.



((b)) The interface of Nodes based prototype with the visual script that performs the user assigned task.

Figure 5.1 – Block based and Node based low fidelity VP prototypes developed for the first iteration of user tests.

Figure 5.1(a) and Figure 5.1(b) shows the interfaces of the two low fidelity prototypes developed for the study. Due to the ongoing COVID-19 pandemic and social distancing concerns, it was decided to conduct all the user tests completely virtually via Zoom. As a result, a virtual representation of a Logitech Gaming mouse was included in the prototype interface so that the effects of running the created visual scripts can be observed by the users real time as it would have been with a real mouse, if the interview was carried out in person. Both prototypes have a set of provided graphical elements on the left that can be dragged and dropped onto the canvas area in the middle to create visual scripts. After creating a script on the canvas, the participant has to click on the ‘Run Script’ button for the script to take effect.

In terms of implementation, both the prototypes were built as web applications that can run on a web browser. For implementing the blocks based visual programming canvas in the blocks based prototype, the Blockly[I] JavaScript library was used. Blockly provides a set of pre-built blocks that support commonly used programming constructs such as conditional statements and loops and also provides the ability for the developers to customize its functionality in a variety of ways. The library also comes with a framework that simplifies the generation of textual code from a visual script. For implementing the nodes based visual programming canvas, Rete.js[II] JavaScript library was used. Unlike Blockly, Rete.js had minimum off-the-shelf support for implementing a nodes based visual programming environment. As a result, functionality of all the nodes provided in the toolbox in the nodes based prototype had to be implemented from scratch. The functionality of the virtual mouse in both the prototypes was implemented using pure JavaScript, HTML and CSS.

[I]Blockly. (n.d.). Retrieved March 12, 2021, from https://developers.google.com/blockly.
[II]Rete.js. (n.d.). Retrieved March 12, 2021, from https://rete.js.org/#/.

6 Evaluation - Iteration 1

The Nielsen Norman Group in their report ‘234 Tips and Tricks for Recruiting Users as Participants in Usability Studies’ (Sova & Nielsen, 2010) suggests the following as the three main rules for simplified user testing.

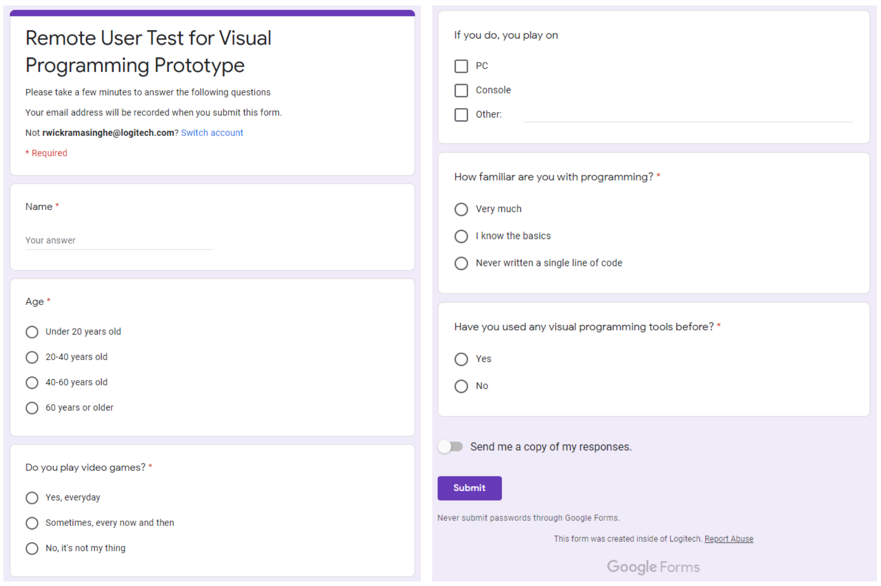
1. Get representative users
2. Ask them to perform a representative task with the design
3. Let the users do the talking

6.1 Recruiting users

Participant recruiting lays the foundation for all user testing as without it there is no way to conduct any user test (Sova & Nielsen, 2010). For our requirement, it was decided to recruit users from within the company due to cost concerns and information non disclosure concerns. Since all the participants were from within the company, there was neither a necessity to pay incentives nor to have participants agree with any terms of nondisclosure.

The aim was to reach out to some internal employees who happen to be PC gamers themselves and who do not have direct involvement with the G HUB software as part of their work at Logitech. This was to have the participants’ profiles as close as possible to the target end user group. We also wanted to balance the study group in terms of gender and programming experience. Accordingly we planned to have 50% representation of males and females and programmers and non-programmers. This makes it possible to rule out any possibility that any imbalance in those factors influenced the final results of the study.

Once the recruiting criteria was prepared, the next task was to decide on the number of participants to recruit for the test. Based on various research carried out on the field, it has been found that there are severely diminishing returns from usability testing a given design as the number of participants increase. In fact, from a large number of projects surveyed by the



Remote User Test for Visual Programming Prototype

Please take a few minutes to answer the following questions

Your email address will be recorded when you submit this form.

Not **rwickramasinghe@logitech.com**? Switch account

* Required

Name *

Your answer

Age *

- ○ Under 20 years old
- ○ 20-40 years old
- ○ 40-60 years old
- ○ 60 years or older

Do you play video games? *

- ○ Yes, everyday
- ○ Sometimes, every now and then
- ○ No, it's not my thing

If you do, you play on

- ☐ PC
- ☐ Console
- ☐ Other:

How familiar are you with programming? *

- ○ Very much
- ○ I know the basics
- ○ Never written a single line of code

Have you used any visual programming tools before? *

- ○ Yes
- ○ No

Send me a copy of my responses.

Submit

Never submit passwords through Google Forms.

This form was created inside of Logitech. Report Abuse

Google Forms

Figure 6.1 – Participant screening questionnaire

Nielsen Norman Group, almost 80% of the usability problems of the system subjected to the testing were found, after testing with four users (Sova & Nielsen, 2010). Since the intention of the study was to get qualitative insights and not to obtain statistically significant results, it was decided to recruit five participants per each distinctly different user group of interest, i.e programmers and non-programmers, and males and females. Having an odd number of participants in each user group also made sure that there will not be ties within a group in terms of the preferred visual programming setup out of the two options.

The next step in the process was to prepare a screening questionnaire that reflects the identified recruiting criteria. The questionnaire was designed so that the provided answers would help us easily screen out the responders that do not meet our recruitment criteria. The questions were carefully crafted in a way that avoids 'giving away' the profile we were targeting so that in case even if for some reason, someone really wanted to get into the study by giving false answers, they still would not know which right answers to give. The questionnaire was sent out as a Google Form via some internal company communication channels to reach around 1500 Logitech employees all over the world. Figure 6.1 contains the complete questionnaire.

6.2 Experiment design

The experiment was carried out in a within-subjects fashion where each participant would interact with both the prototypes built[I]. This choice was made based on time related constraints and the fact that we were only targeting for qualitative results. Recruitment of participants

[I]Between-Subjects vs. Within-Subjects Study Design. (n.d.). Retrieved March 2, 2021, from https://www.nngroup.com/articles/between-within-subjects/.

were done so that the group of participants are balanced in terms of gender as well as programming experience. As we were targeting 10 regular participants only, it was not feasible to flip a coin at the beginning of the user test to determine which prototype the user would test first as in the end it might leave us with a very skewed distribution of the testing orders; for example only one or two participants testing the nodes based prototype first and everyone else testing the blocks based prototype first. So, to counteract the possible order effects and effects of transfer and learning across the two conditions, it was decided to manually pre-assign randomly chosen five participants to first try the nodes based prototype and the rest to first try the blocks based prototype. Then, to avoid any effects on the user test results by the date, the time, or the context the experiments are executed, the order of conducting the user tests with the 10 participants was also randomized.

The expectations of the experiment were three fold. 1) The primary target of the experiment was to identify the preferred setup (blocks based setup vs. nodes based setup) among the 10 participants. We arrive at this decision assuming that our user sample is a representation of the Logitech G HUB user base and the fact that we balanced the user sample in terms of gender, programming expertise and learning transfer gives us confidence in the result obtained. 2) The second objective was to verify the hypothesis “Programmers prefer to use the Block based prototype and the non-programmers prefer to use the Node based prototype”. This hypothesis was formed based on the fact that the Block based setup closely resembles actual coding than the Node based setup. The fact that we have an odd number of participants from each of the groups guarantees that we will obtain a final preferred choice for each group. 3) Finally, the experiment also targeted at getting to know users’ judgement on visual programming in general, qualitatively measuring how well the users were able to understand each setup and identifying any critical usability issues in the prototypes that can be improved on in later iterations. This information can also give insights on how appropriate visual programming is, as a general solution to the problem being addressed.

6.3 User interview and user task

An initial interview guide was created with the aforementioned expectations as the basis to make sure each participant gets exposed to the same instructions and same set of information. A dry-run of the interview was carried out with an internal team member to get feedback mainly on the interview guide, the protocol, the timing, and the working of the user task in order to fine tune the study system. Appendix A.1 contains the final version of the interview guide used for conducting the user tests.

Each participant was asked to complete a task with each of the prototypes. The task was to create a visual script so that when executed, each time the left mouse button of the virtual mouse is pressed, the color of the G logo on it changes once, cycling through the colors red, green and blue. In other words, on the event of mouse left click, the script should read the current lighting color and depending on what color it is, set the appropriate lighting color, i.e.

if the current color is red, set it to green, if the current color is green, set it to blue and if the current color is blue, set it to red. The visual scripts in the canvas area of Figure 5.1(a) and Figure 5.1(b) shows how this can be achieved with each prototype. Users were asked to think out loud as they interact with the prototype and the Zoom sessions were recorded for later analysis.

Table 6.1 shows the details of all the participants of the first iteration of the user study. Real names of the participants are omitted for privacy reasons.

Table 6.1 – Participants of the first round of user tests.

	Gender	Age	Programmer	First test	Location	Date/time
P1	Male	40-60	Yes	Nodes	Lausanne, CH	19/11/2020 13:00
P2	Female	20-40	Yes	Blocks	Lausanne, CH	19/11/2020 14:00
P3	Male	40-60	No	Nodes	Lausanne, CH	19/11/2020 18:00
P4	Male	20-40	Yes	Nodes	Newark, US	20/11/2020 19:00
P5	Female	20-40	Yes	Blocks	Lausanne, CH	24/11/2020 15:30
P6	Male	20-40	No	Blocks	Newark, US	24/11/2020 20:00
P7	Female	20-40	No	Nodes	Lausanne, CH	25/11/2020 14:00
P8	Female	20-40	No	Blocks	San Francisco, US	03/12/2020 23:00
P9	Male	20-40	No	Nodes	Lausanne, CH	19/01/2021 11:00
P10	Female	20-40	Yes	Blocks	Newark, US	18/01/2021 20:00

6.4 Results

6.4.1 General impression on visual programming

During the user tests, before they were exposed to the prototypes, participants were asked to remember the last time they used a visual programming tool and recall what their impression was in general about it. User sentiment on visual programming in general can be a strong deciding factor on how much the users will adopt this kind of a new feature in G HUB. Hence, this was an important opinion to be collected from each of the participants.

A majority of the participants held a positive impression towards visual programming tools based on their previous experience. Figure 6.2 depicts this.

Participant P1 stated

> "I think for certain use cases it is just a lot better to have these kind of tools than having to write code out. It just allows a lot more kind of creativity and flexibility. It just depends on the use case I guess. So sometimes those kind of tools can be too inflexible and just don't give you enough flexibility to do the things that you want to do and other times for other types of tasks they allow you work a lot quicker and be more creative, in my experience."

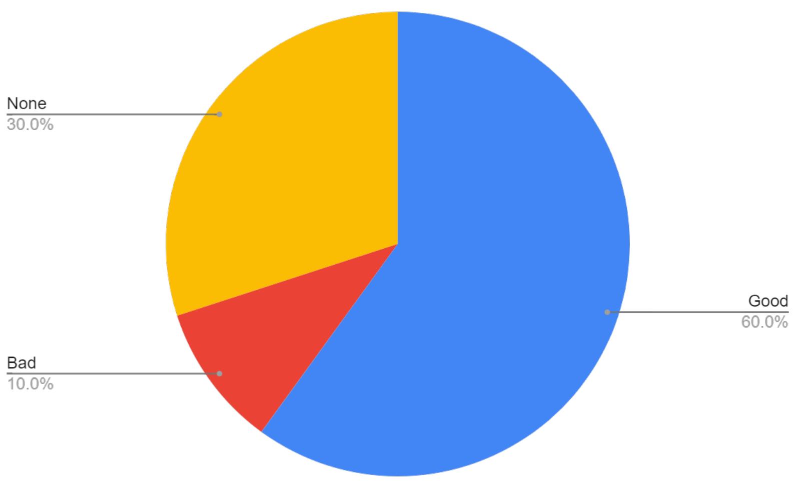


Figure 6.2 – Participants' impression on visual programming in general.

6.4.2 Preferred visual programming setup

General preference

Out of the 10 participants, 6 preferred the blocks based prototype. Figure 6.3 depicts this in a pie chart. The most common positive comment for the blocks based prototype was the fact that it provides a compact narrative like view of the program that can be read from left to right, top to bottom making the comprehension easier. Participant P9 stated

> "It's a bit reassuring because I can almost read like a sentence... like a paragraph... Because my dream will be like (saying) "I left click, each time I left click, change the color from red to blue to green and that in a loop or endlessly". And then I select run the script and it does it. So this is closer to what I'd love."

Participant P1 appreciated how compact looking the block based script he created is.

> "This one (block based prototype) seems a little more concise and a little more easy to do complex things... I guess... in the long run because it's just visually smaller."

Participant P8 also expressed a similar opinion.

> "The other one on the other hand (block based prototype), like you said, it was a whole puzzle piece... so it was kind of like, ok... you start reading it just like a story... you start from left to right to top to bottom kind of thing. So that made it easier to understand."

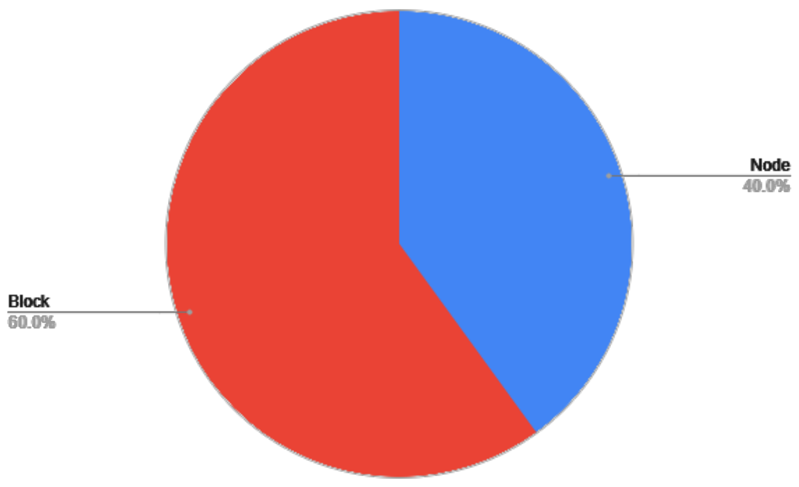


Figure 6.3 – Preferred visual programming prototype among the 10 test participants in general.

A common negative comment on the same was that differences in the sizes of blocks and the sockets made it difficult to identify whether a certain block piece would fit in another without moving it and making an attempt to fit them. When asked for what participant P1 did not like in the blocks based prototype he stated

> “I really like the puzzle piece idea because it gives another kind of nudge in terms of what should be fitting where. It helps narrow your options. However the fact that there are things that aren’t visually obvious, like the sizes not matching or that you can expand certain things, whatever it is, that makes it a bit harder.”

Participant P2 expressed a similar opinion when asked.

> “It is not 100% what can fit and what can’t. So may be make it a bit easier and more fast to get understood coz I could not understand how to put the blocks together, this took me a while.”

Participant P7 mentioned what her thoughts were when trying to determine whether a certain block could fit in another one.

> “May be this is me being a bit slow... I’m kind of like... ‘But it’s a different size does it fit in? should i try it? no? Should I do something else?’...”

The most common complaint against the Node prototype was that the script quickly becomes convoluted with a lot of lines that span all over the canvas making it difficult to follow through the flow of execution. Participants P2, P5, P7 and P8 expressed following opinions on that regard.

> “This (nodes based prototype) is more complicated, you have a lot of lines, doesn’t give you the idea of clean work... something clean and organized.”

> “That one (nodes based prototype) is easier when you would like to do some simple steps, but if you have like multiples... like... if you have 3, 4 branches, it is a bit confusing to have again the link to the branch, you don’t know where it starts, where it ends... and with a ‘if-else-if’, it’s more structured.”

> “Once you do like a couple of branches, it is a bit difficult for my eye to follow where I was before and where I gotta go next.”

> “This one (nodes based prototype) definitely feels more convoluted. Again, just because of the flow of it, it was just so like all over. It was like from here to there to there to there.. I was kind of like ok.. hold on.. I gotta make sure I follow it accordingly.”

The Nodes setup being less like plain coding and the connecting lines acting as a guide on the flow of the graph when the graph is not so complicated were some positive traits the users found. Participant P6 stated

> “I feel like I like this (nodes based prototype) because it feels less like I’m programming... like I have... I can go into this kind of with a zero knowledge where I think in the previous one (blocks based prototype) it feels like maybe I should know a little bit more of the language before I can start to piece stuff together.”

Preference based on coding experience

In order to verify the stated hypothesis, the preferred choice of setup was analysed within each group. 3 out of the 5 programmers as well as the 5 non-programmers preferred the blocks based prototype. Figure 6.4 depicts these observations. Accordingly, this refutes our hypothesis “Programmers prefer to use the Block based prototype and the non-programmers prefer to use the Node based prototype”. Apparently, the results say both the user groups prefer the blocks based prototype more.

Preference based on order of prototypes

Since the experiment was carried out on a within-subject setup, even if the effect on the final result by the order of prototype exposure is carefully balanced out by managing the orders of

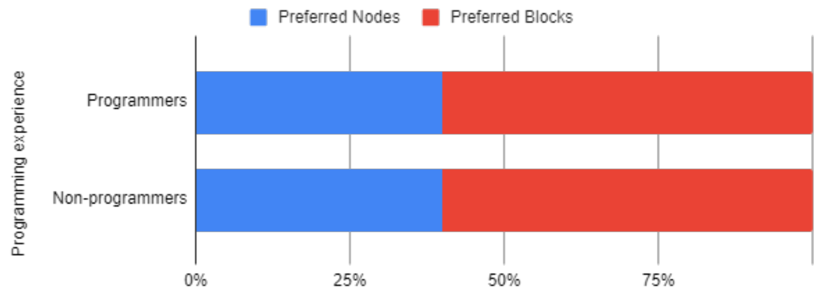


Figure 6.4 – Preferred visual programming prototype with respect to coding experience.

testing, it could be interesting to see if we can observe any patterns in the choices within each group in terms of the first prototype they were exposed to.

It could be seen that out of the 5 participants who first tried out the nodes based prototype, 3 preferred the blocks prototype in the end. The situation was exactly similar with those who first tried out the Blocks prototype as well. 3 out of the 5 preferred the blocks based prototype. Figure 6.5 depicts these findings.

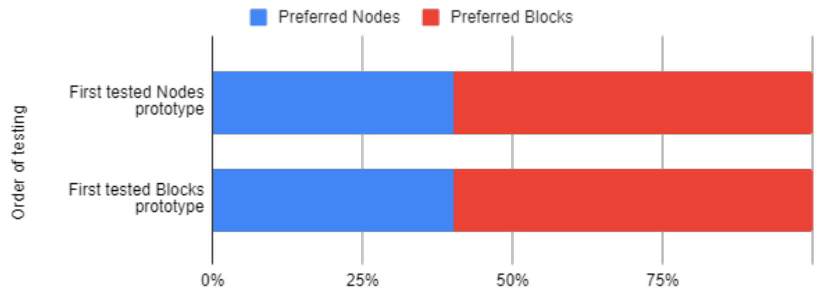


Figure 6.5 – Preferred visual programming prototype with respect to the order the prototypes were tested by the participant.

Preference based on gender

Traditionally, the gaming and tech savvy user base was believed to be dominated by males. But nowadays more and more women are moving into the tech and gaming sphere and Logitech as a company is making efforts to streamline their products and services to the growing female user base as well. Accordingly, the choice of setup within males and females is also an interesting observation one could make.

It could be observed that a majority of the males preferred the nodes based prototype where as a majority of the females preferred the blocks based prototype. Figure 6.6 depicts these observations.

Every female participant made a remark about the nodes based setup being less organized.

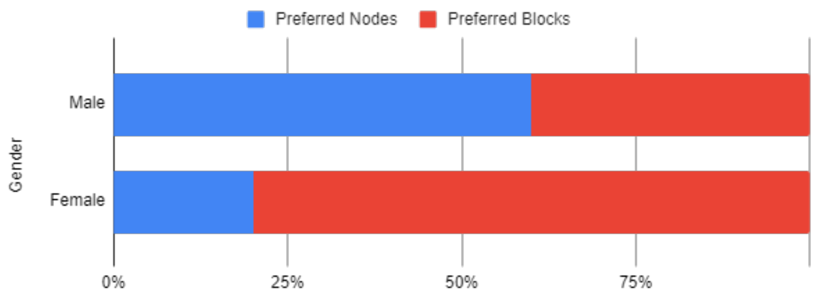


Figure 6.6 – Preferred visual programming prototype with respect to the gender of the participants.

This observation could be due to a tendency in females to prefer neat and tidy work. Following statements made by participants P2 and P5 supports this:

> “This (nodes) is more complicated, you have a lot of lines, doesn’t give you the idea of clean work, something clean and organized”

> “The connection is intuitive but it is less organized, it’s like a draft”

Moreover, participant P10 who preferred the nodes based setup, still made the remark that the setup looks messy.

> “You know I gotta say, even though I struggle... I think I like this interface better even though it looks like a spaghetti mess.”

6.4.3 Insights on usability

As mentioned in section 6.2, one of the objectives of the user study was to identify any usability issues in the low fidelity prototypes built so that they can be avoided or improved in the high fidelity prototype implemented in the next iteration. It was also useful to get feedback from the participants on certain design choices in order to decide whether they should be carried on to the next iteration prototype as is or whether they should be modified in any ways. As it was decided to proceed only with the blocks based setup, only the usability related input received with the blocks based low fidelity prototype are discussed.

With the Blocks prototype, many participants struggled to find the way to convert an ‘if’ block to an ‘if-elseif-else‘ block. Figure 6.7 shows how this could be achieved step by step with the ‘if’ block made available in the low fidelity prototype. The user first needs to click in the small blue button that shows a cog wheel icon. On the mini canvas that appear, user has to drag and drop the ‘else if’ and ‘else’ blocks under the ‘if’ block in the required order. As that is done, the

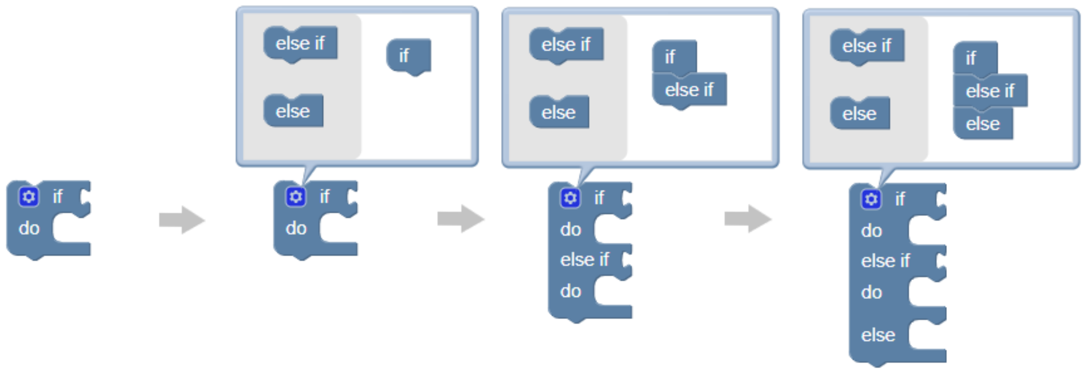


Figure 6.7 – Steps to convert an ‘if’ block to an ‘if-elseif-else’ ladder of any length.

changes get reflected on the original condition block. Only participant P2 was able to figure out how this configuration is done by herself without any assistance. Many of the other nine participants did not notice that it is a button that can be clicked on. Participant P6 stated:

> “I just thought... oh! there is a cool little logo there, but i didn’t think to click on it”

Even when after the mini canvas was shown, some participants still could not understand what they can do with it. Many tried clicking on the ‘else’ and ‘else if’ blocks on the left and gave up when nothing happened. Some tried to drag them out of the mini canvas to fit in to the original block. Only a few number of participants could figure out how to perform the configuration after the mini canvas was shown. When asked, participants P4 and P8 stated:

> “Oh, I would have never figured that out. I got that they are separated, I wanted to click it. I did not see a prompt that it was draggable in itself”

> “And I think with this part where you told me to click over here to do the whole else if, I would never have known to... that I needed to do that until you told me”

Another issue that was raised by multiple participants was the mismatching blocks and socket sizes confused them in determining whether a certain block could fit in a certain socket. Figure 6.8 shows an example depiction of this. On a first glance, due to the differences in the heights of the socket of ‘on mouse left click’ block and the ‘set lighting color to’ block, it gives an impression that they will not fit. But, as the ‘set lighting color to’ block is dragged and hovered over the ‘on mouse left click’ block socket, the socket expands to match the height of the incoming block. On this issue, participants P2, P7 and P8 stated:

> “It is not 100% clear what can fit and what can’t”

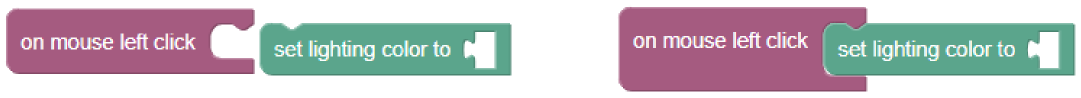


Figure 6.8 – In terms of sizes, the socket of the 'on mouse left click' block is smaller in height than the height of the 'set lighting color to' block. Yet, when the latter is fit into the former, the height of the socket changes to accommodate the incoming block.

> "It took me a second... just because it's not too dissimilar in shape and obviously because the size is very very different... may be this is me being a bit slow... I'm kind of like... 'but it's a different size does it fit in? should I try it? no? Should I do something else?'..."

> "Honestly the shape of it first of all did seem like it would fit and sizing itself also was like hold on that one is like a smaller piece and that one is like a larger piece"

Several participants mentioned that they would have performed the task easier and faster if they could first see some pre-build examples. Participant P1 stated:

> "...But again, like... if there was a visual reference where it showed me, like... if it showed me a pre-configured example of what it would look like, then I would probably very quickly be able to understand how the system generally works

Participant P10 expressed similar opinions:

> "One thing that I am a big proponent of is examples. Like... in tutorials. So if you give me an example of how it is supposed to look like... I mean that's what you do in StackOverflow too, when you look for something you look at examples"
>
> "It's almost like you need a little bit of tutorial to also show people in each one, how would you expect each shape to behave, because I didn't know this could expand (block sockets), I didn't know you can click into this (if block configuration button)"

The arrangement of the toolbox in the blocks based prototype was also something certain participants raised a concern on. Their opinion was that the fact that you can only see the blocks of one category at a time and the fact that you have to click on each category to see the blocks listed under that made it difficult to remember all the options made available for use. Figure 6.9 gives an idea of how the toolbox in the blocks based prototype functioned. To deal with that issue, some participants first tried to drag all the available blocks on to the canvas first so that they do not have to go to the toolbox and click on each category to see what options are made available

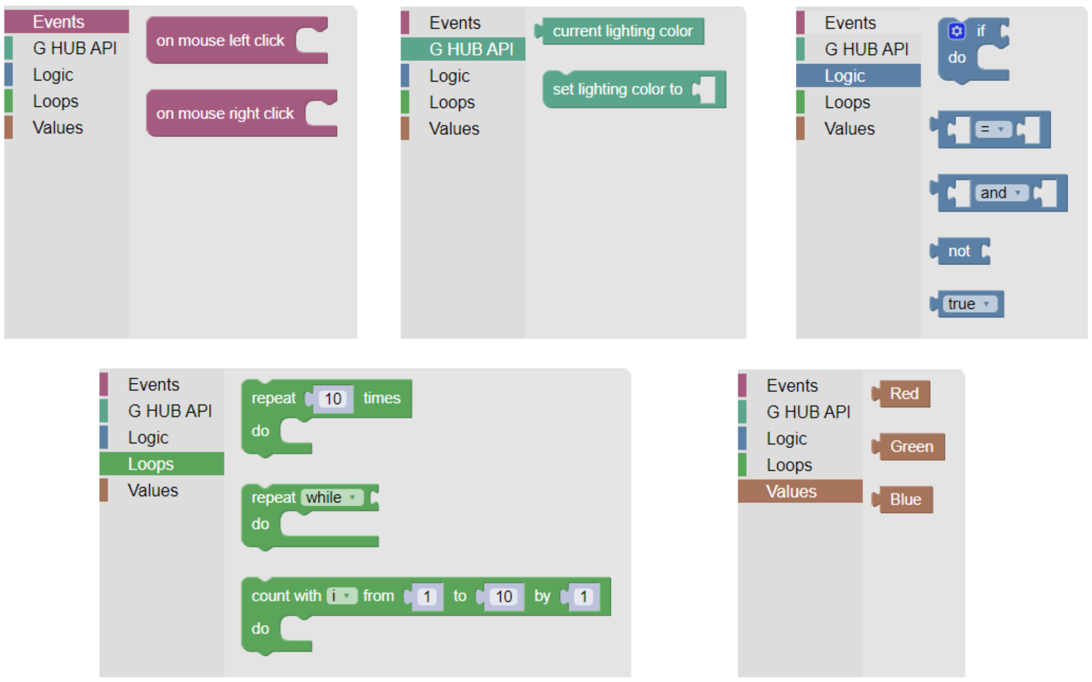


Figure 6.9 – Blocks were listed categorized into sections and clicking on a category shows the list of blocks that belongs to it.

On this regard, participant P6 and P8 said:

> "... you gotta go into the menus and then like... kind of drag everything out. So that made it... going through that and having to sit through and then like remember 'Oh!... where was everything again?'..."

> "So with this prototype (blocks based)... like... how those subsections that you have in the top (menu of the blocks), where it's just the events, the logic and everything... I felt just kind of like you have to click on it to kind of see all these pieces, but with the other one everything is already kind of laid out for you. And it's like I've always been a person that's more visual... if i see it... like... then I can kind of grasp it better, but then if... like... you put it in these little lists, I have to go through each list and if I can't see everything all at the same time it's harder to kind of visualize it"

The low fidelity blocks based prototype provided three separate blocks to represent the colors red, green and blue as values. Participants P4 and P9 expressed that they would prefer to see just one block for color which has some color palette like functionality allowing them to choose one color. P4 stated:

> “Here I would love to (have), if I right click, give me the options for the colors. I wanna change blue to green or red”

> “What could be nice is maybe for the color, you don’t have red, blue, green, but you have color, because you want to change the color and then you pick and therefore you don’t go back here (the toolbar) because here each time I can’t see whats behind (each category) like the loops or the thing... so either it would be nice to dispatch them all on top, or use arrows to have them directly, so.. I want to tweak the color, color is blue, red bla bla bla and so on...”

was something participant P9 mentioned during the user test.

When asked for possible improvements, participant P5 stated that she would like to have full support for keyboard shortcuts like undo, copy and paste.

6.4.4 User performance

Table 6.2 lists down the time it took for each participant to complete the given task with each prototype. Participant P1 did not manage to complete the task on the blocks based prototype and participant P3 did not complete the task with both the prototypes. Only a very few participants were able to complete the task all by themselves without any assistance. This can be expected due to the fact that the task requires a certain level of algorithmic thinking and problem solving skills and especially non-programmers can struggle at doing that. Yet, as these time values are influenced by the amount of help they received during the tasks, it would not be fair to derive conclusions from the duration values observed. Nevertheless, as shown in Figure 6.10, it is interesting to see how the time, 9 out of the 10 participants took in performing the task with the second prototype they tested, is lower than the time they took in doing the same task with the first prototype they tested. This can imply that the knowledge they acquired when performing the task with the first prototype helped them in performing the task with the second prototype faster.

6.4.5 User mental model

Before exposing to the users the two low fidelity prototypes, they were asked about what they think a visual programming tool to customize devices in G HUB would look like. While most answers seemed to stem from the existing device configuration interface in G HUB with some drag and drop functionality built on top, two participants expressed a mental model that closely resembles the two prototypes we had built. Participant P6 stated

> “...like a visual thing where I can like connect here to here and that something happens... that’s kind of like what I imagined... sort of like a little network or

Table 6.2 – Time duration taken by each participant to complete the assigned task with each prototype during the first round of user tests. Durations marked with a † imply that the participant failed to complete the task and the task was given up halfway.

Participant	Duration (mm:ss)		First tested
	Blocks prototype	Nodes prototype	
P1	†07:51	21:33	Nodes
P2	09:23	05:01	Blocks
P3	†10:14	†09:09	Nodes
P4	09:10	15:30	Nodes
P5	09:37	06:46	Blocks
P6	17:56	07:27	Blocks
P7	07:43	12:12	Nodes
P8	10:51	09:41	Blocks
P9	07:13	09:05	Nodes
P10	09:53	04:26	Blocks

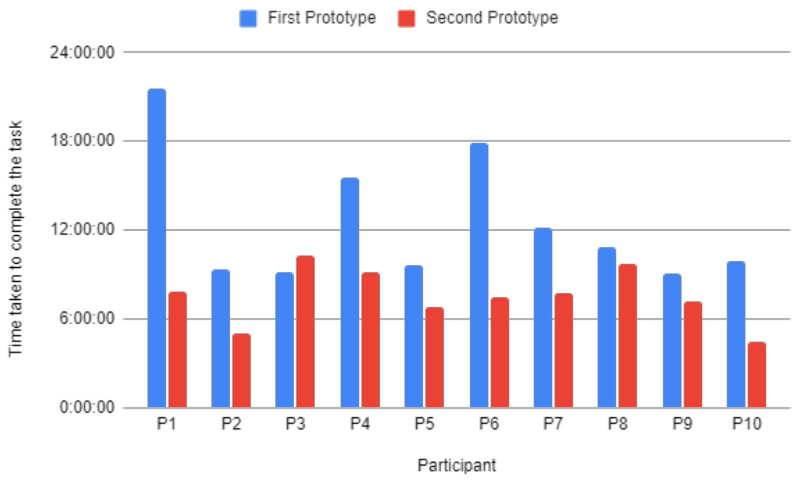


Figure 6.10 – Comparison of time taken by participants to complete the task with the first prototype and the second prototype they tested.

> framework of some sort... you have these modules... like all the ports, ins and outs... and you just connect one thing to another and that's kind of how I imagined it. Like it's in the sequence that you plug things in you'll get you know a certain effect."

where he talks about all the features seen in our nodes based prototype.

Participant P7 stated

> "Thinking back on the stuff I have done before, like on other programs I have

> worked on, it is usually a GUI with a number of buttons to... kind of like command buttons that you would use... that then in the background the code would (run)... it's like a GUI button that develops the code line."

Although her description does not exactly match any of our prototypes, her line of thinking matches with the fact that we use visual components, which in the background generates a code that can be executed.

6.4.6 Self understanding on the context at the beginning of user test

After showing the first assigned prototype to each participant, before they were given any explanation on how to use the tool or what it does, they were asked to play around with it and tell what they think the tool allows them to do. 8 out of the 10 participants were able to either explain that it allows them to program what each mouse button would do in terms of configuring some lighting or create by themselves a simple test script to set the lighting color of the virtual mouse without any help. Following are some statements made by the participants in response.

Participant P1, P2 and P3 stated

> "I see that it would be for helping me to define what different buttons do"

> "I think I can set the lights, I can say on mouse left click set lighting color to something"

> "I understand that this is a sequence of tasks and I guess that if I click for example on the left mouse button, then I can probably turn something in red or something like that."

As this measurement was done with the first prototype each user was exposed to, and since the order of prototypes was balanced among the participants, five users got to first test the blocks based prototype whereas the other five users got to first test the nodes based prototype. It was observed that regardless of the order, 80% of the participants in each sub group were able to correctly state what the tool lets them do.

6.4.7 G HUB use

Out of the 10 participants, 8 stated that they have experience using the G HUB software before. The most common task they have used it for was to configure the RGB lighting in their gaming devices. Yet none of them had any knowledge whatsoever about the Lua script editor feature in G HUB. When asked why, participant P3 said

> “I think I probably never really dig into that because I probably haven’t understood what I could be achieving with these scripting stuff.”

Participant P5 also stated

> “I didn’t find the benefits so rewarding to take time and invest time to code.”

This is an interesting observation that supports the fact that the existing text based Lua script editor functionality is rarely used by the user base, even though it provides powerful configuration capabilities.

6.4.8 Suggested use cases

In order to probe on which ways users might find a configuration tool like this useful, all the users were asked for an example situation in their day to day life that they might find advanced device configurations useful. Two common use cases emerged from all the responses. 1) One was task automation. Participants mentioned about programming keys to automate launching applications performing tasks inside applications or performing certain actions in games that would otherwise require multiple key presses. 2) The other use case was to configure the lighting in devices to provide real time feedback. They referred to configurations that allow changing device lighting based on events happening in the computer, either within applications or within games. For instance, have the keyboard light up in a certain way when there is new email or when the player gets shot in a shooting game.

7 Implementation

Based on the preference results observed in the first iteration of evaluations with the low fidelity prototypes, it was decided to proceed with the blocks based setup. This chapter discusses the work carried out in the implementation stage of the User Centered Design process.

The implementation of the high fidelity blocks based prototype was carried out making sure the usability issues discovered during the evaluation were addressed. For instance, it was observed in the first round of user tests that a majority of the participants struggled in understanding how to obtain an ‘if-elseif-else’ block by modifying the provided ‘if’ block. As a solution to this, in addition to the configurable ‘if’ block, it was decided to make available a pre-configured ‘if-else‘ block in the high fidelity prototype to see if users will utilize that to create ‘if-elseif-else’ ladders by nesting them. Figure 7.1 shows this pre-configured ‘if-else’ block.

Another complaint participants raised in the first round of evaluations was that the toolbox having a menu like design with closed categories made it difficult to remember which options are made available to them. To address this, an always open, fully scrollable toolbox was used in the high fidelity prototype with the categories still visible on the left for making search for a certain block easier. Figure 7.2 shows this toolbox.

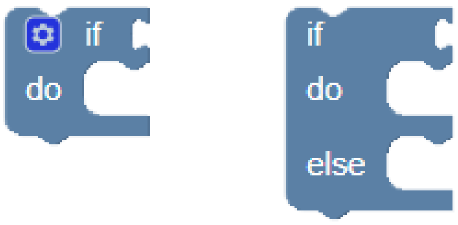
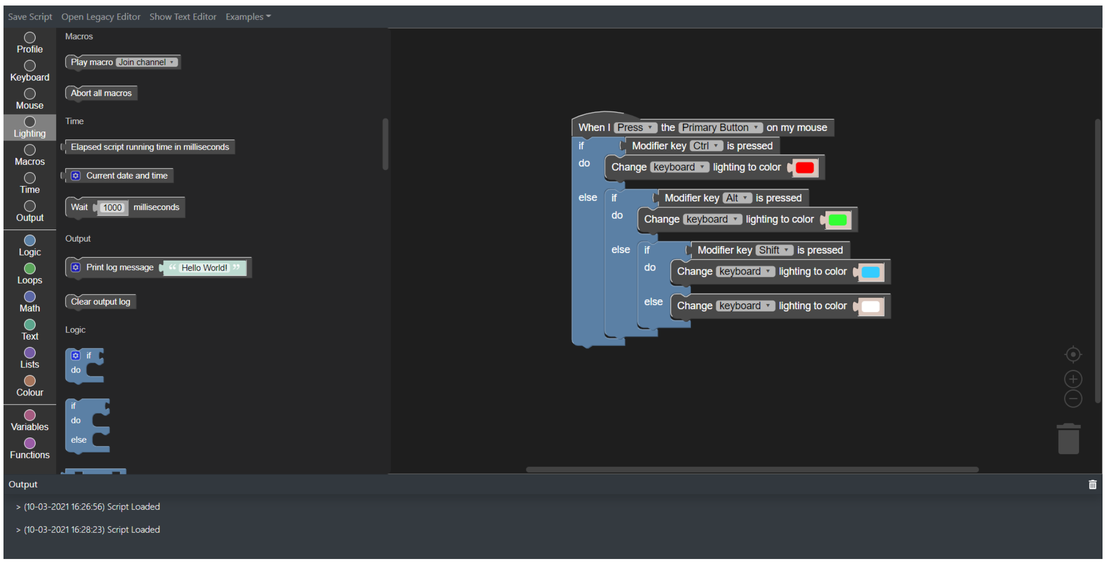


Figure 7.1 – On the left: a configurable ‘if’ block. On the right: a pre-configured ‘if-else’ block



```
When I Press the Primary Button on my mouse
if    Modifier key Ctrl is pressed
do    Change keyboard lighting to color 🟥
else  if    Modifier key Alt is pressed
      do    Change keyboard lighting to color 🟩
      else  if    Modifier key Shift is pressed
            do    Change keyboard lighting to color 🟦
            else  Change keyboard lighting to color ⬜
```

```
> (10-03-2021 16:26:56) Script Loaded
> (10-03-2021 16:28:23) Script Loaded
```

Figure 7.2 – The interface of the high fidelity blocks based prototype with the visual script that performs the user assigned task.

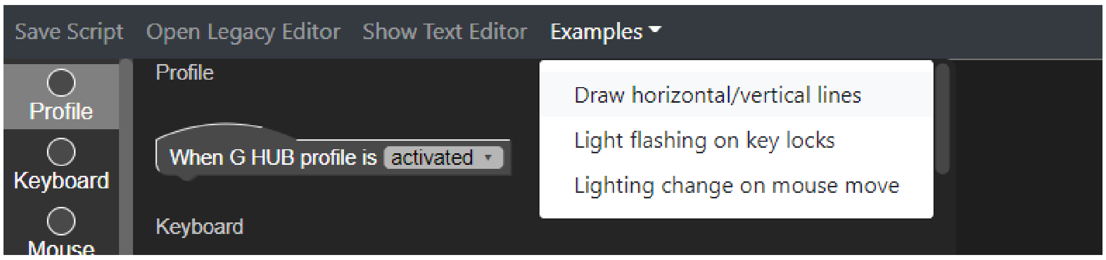

Save Script
Open Legacy Editor
Show Text Editor
Examples
Profile
Keyboard
Mouse
Profile
When G HUB profile is activated
Keyboard
Draw horizontal/vertical lines
Light flashing on key locks
Lighting change on mouse move

Figure 7.3 – A menu item that lets users access some pre-built example scripts.

Several participants also stated that having some example pre-configured scripts would have helped them understand how to use the tool easily. As a result, an option to view some example visual scripts was also included in the high fidelity prototype. Figure 7.3 shows a close up view of this menu in the interface. Figure 7.4 shows the three example scripts provided to help users understand the functionality of the tool better.

Some participants found that certain blocks and sockets having different sizes made it confusing for them to determine whether they would fit or not. To address this issue, as a first step, the enclosing socket shapes were removed from all the event listener blocks. To make them still look different from the rest of the blocks, a hat like shape was added to the block. This can be noted in the event listener blocks shown in Figure 7.5.

Support for commonly used keyboard shortcuts for actions like cut, copy, paste, undo and redo was also something that was requested by participants during the first iteration of evaluations and hence they were included in the high fidelity prototype.

Finally, the toolbox was equipped with a variety of new blocks that represent all the Logitech

G HUB Lua API functions, all varieties of programming constructs, data structures, variables, functions and literals. Figure 7.5 and Figure 7.6 shows all the blocks that were supported in the high fidelity prototype. These blocks allow visually representing any general textual Lua program functionality. This list also includes a block that provides a color palette to choose a color as was requested by some participants in the first iteration.

Figure 7.2 shows the interface of the high fidelity blocks based prototype developed. The prototype was made to work completely integrated with the G HUB software and any visual scripts created using this prototype can be executed in G HUB in the same way a textual script would execute in the existing textual script editor. The prototype is capable of making customizations to any gaming keyboard or mouse G HUB recognizes. Similar to the low fidelity blocks based prototype, this prototype has a toolbox with all the blocks that can be dragged and dropped on the canvas to create scripts. As the script is built on the canvas visually, the prototype generates the textual version of the graphical script in the background. A text editor was also integrated into the same prototype so that the user can view the generated textual script and modify it if necessary. Figure 7.7 shows this. Saving the script either by the 'Save Script' button in the interface or by hitting 'Ctrl+S' would instantly make the script come to effect.

Just like the low fidelity prototype, this high fidelity prototype was also implemented as a web application that runs on a web browser. To support the dynamic features the prototype needed to provide, the React[I] JavaScript library was used. Accordingly, following the React approach in building interfaces, the interface was developed as four separate modules: the top menu bar, the visual script editor, the textual script editor and the output log feed. React provides the required functionality to support switching between the textual script editor and the visual script editor. Redux[II] library was used for managing the application state and communicating state information between sibling modules. The visual programming editor was implemented using the Blockly[III] JavaScript library. The Monaco Editor[IV] library was used for implementing the textual script editor. Monaco editor is the library that powers the famous VS Code code editor and one reason to choose that library was that a VS Code user using the prototype would find its look and feel familiar. The pre-built HTML components provided by the Bootstrap[V] library were used for building the prototype UI. Finally, for the prototype to be able to communicate with the G HUB backend via web socket connections, changes had to be made to the G HUB backend as well which is implemented in the C++ programming language.

Implementation of some of the blocks that represent G HUB Lua API functions in Blockly required detailed attention and design. For instance, the `PressKey(keyname[,keyname])`

[I]React – A JavaScript library for building user interfaces. (n.d.). Retrieved March 12, 2021, from https://reactjs.org/.

[II]Redux - A predictable state container for JavaScript apps. | Redux. (n.d.). Retrieved March 12, 2021, from https://redux.js.org/.

[III]Blockly. (n.d.). Retrieved March 12, 2021, from https://developers.google.com/blockly.

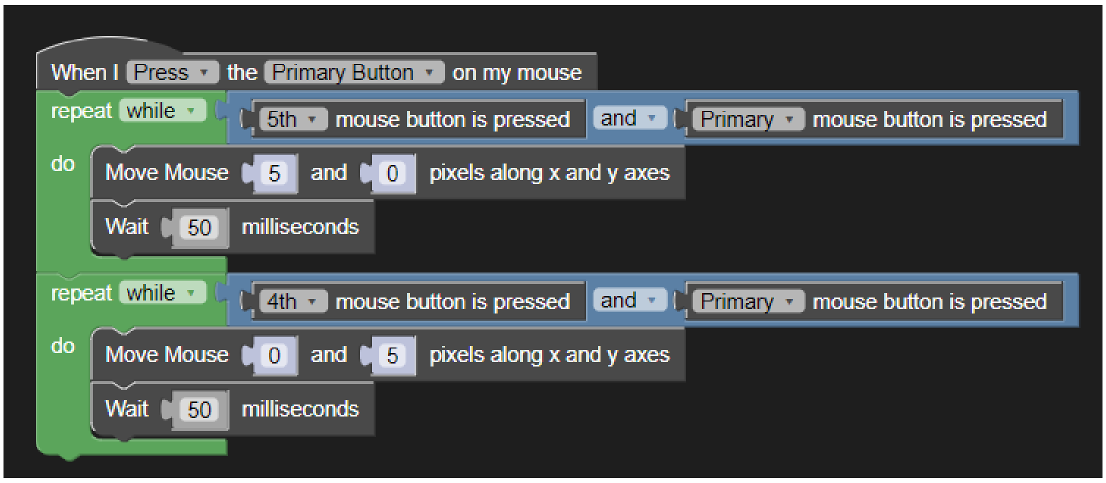
[IV]Monaco Editor. (n.d.). Retrieved March 12, 2021, from https://microsoft.github.io/monaco-editor/.

[V]Bootstrap. (n.d.). Retrieved March 12, 2021, from https://getbootstrap.com/.

G HUB Lua API function accepts a variable number of parameters to support simultaneous multiple key presses. Representing such a function as a block required additional effort in implementing a Blockly mutator[VI] for the block that enables dynamically configuring the block to have any number of input fields. Figure 7.8 shows how the configuration can be done with the implemented mutator mini canvas.

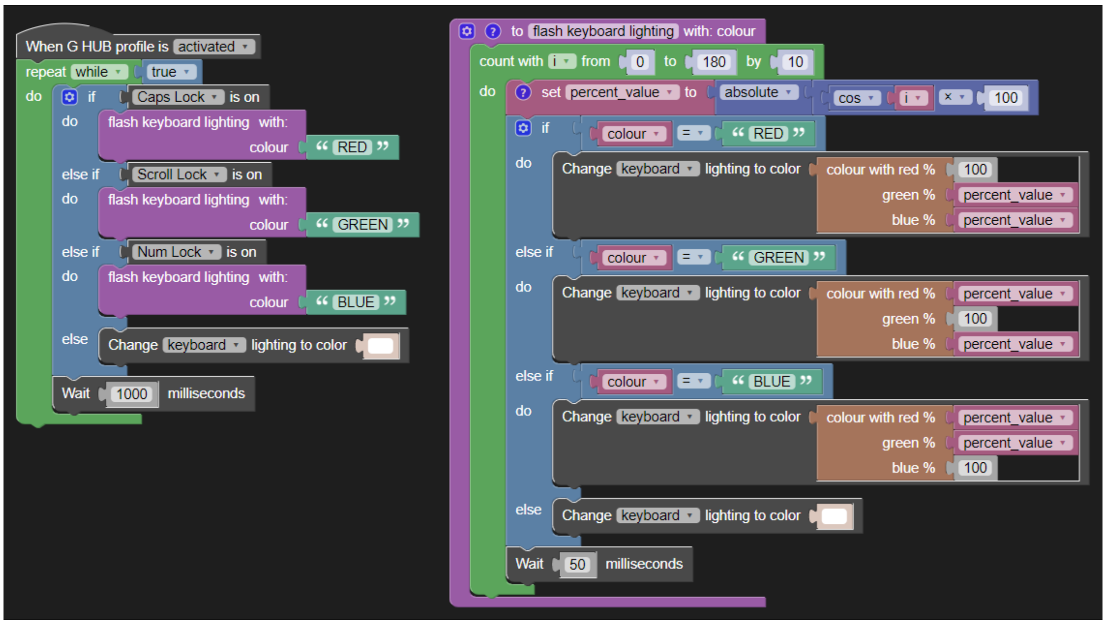
The implementation of the block for the `GetDate([format[,time]])` G HUB Lua API function brought even further complexities in implementation. In this situation, the mutator needed to restrict the additional inputs that can be configured, to a maximum of two, all the while making sure the first input is always a string input for the 'format' and the second 'time' input can be added only if the 'format' has already been added. To enforce these constraints, the blocks in the mini canvas had to be tactfully disabled depending on the configuration state. As shown in Figure 7.9, at first only the 'Format' block can be dragged into the 'Additional parameters' block. Once the 'Format' block is added, no more 'Format' blocks can be accessed and the 'Time' block becomes enabled. Once the 'Time' block is also stacked inside 'Additional parameters' block, no more 'Time' blocks can be accessed as well. To cover all further corner cases, block reordering inside the 'Additional parameters' block was disabled and the mutator was implemented in a way that any orphan blocks in the mini canvas are automatically deleted.

[VI]Extensions and Mutators | Blockly. (n.d.). Retrieved March 12, 2021, from https://developers.google.com/blockly/guides/create-custom-blocks/extensions.



```
When I Press the Primary Button on my mouse
repeat while   5th mouse button is pressed  and  Primary mouse button is pressed
do   Move Mouse 5 and 0 pixels along x and y axes
     Wait 50 milliseconds
repeat while   4th mouse button is pressed  and  Primary mouse button is pressed
do   Move Mouse 0 and 5 pixels along x and y axes
     Wait 50 milliseconds
```

((a)) Example script that configures the mouse arrow to move vertically/horizontally when left clicked while holding thumb mouse buttons.

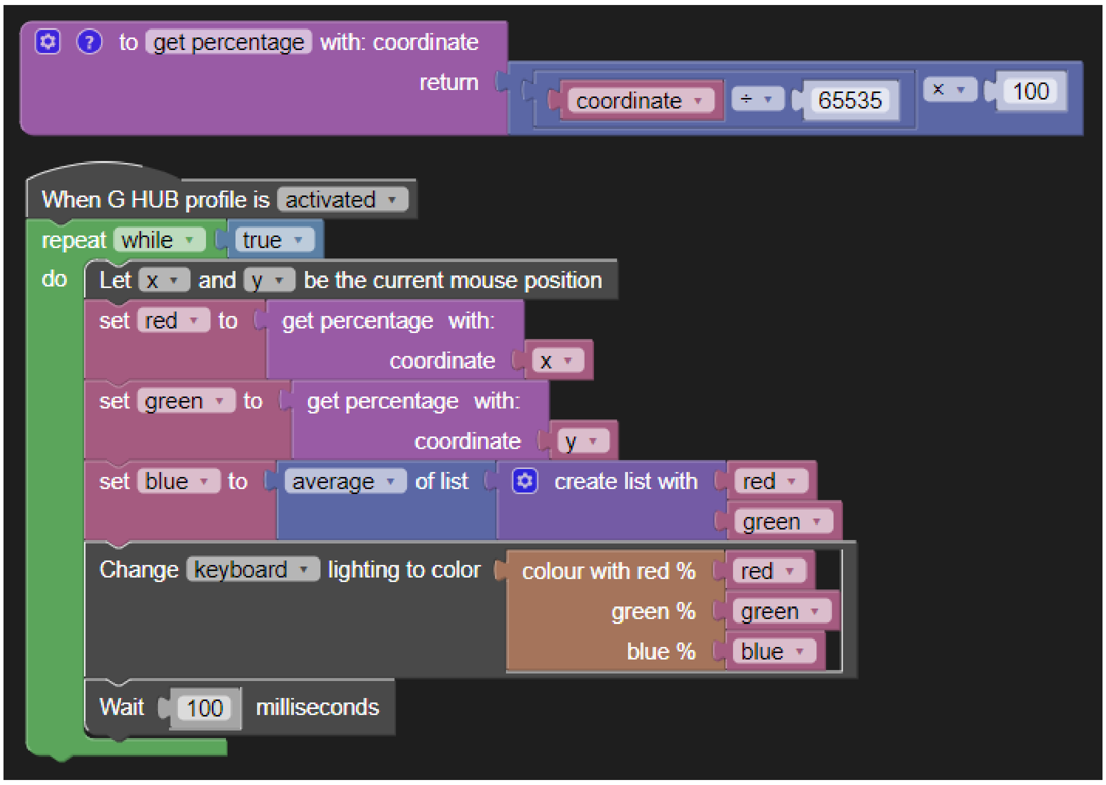


```
When G HUB profile is activated
repeat while true
do   if Caps Lock is on
     do   flash keyboard lighting with:
                                colour " RED "
     else if Scroll Lock is on
     do   flash keyboard lighting with:
                                colour " GREEN "
     else if Num Lock is on
     do   flash keyboard lighting with:
                                colour " BLUE "
     else Change keyboard lighting to color
     Wait 1000 milliseconds
```

```
to flash keyboard lighting with: colour
count with i from 0 to 180 by 10
do   set percent_value to absolute   cos i × 100
     if   colour = " RED "
     do   Change keyboard lighting to color   colour with red %  100
                                                      green %  percent_value
                                                       blue %  percent_value
     else if   colour = " GREEN "
     do   Change keyboard lighting to color   colour with red %  percent_value
                                                      green %  100
                                                       blue %  percent_value
     else if   colour = " BLUE "
     do   Change keyboard lighting to color   colour with red %  percent_value
                                                      green %  percent_value
                                                       blue %  100
     else Change keyboard lighting to color
     Wait 50 milliseconds
```

((b)) Example script that configures the keyboard to flash in different colors depending on whether the CapsLock, ScrollLock or the NumLock is turned on or off.

Figure 7.4 – Example scripts provided in the high fidelity prototype.



```
to get percentage with: coordinate
    return ((coordinate ÷ 65535) × 100)

When G HUB profile is activated
repeat while true
do
    Let x and y be the current mouse position
    set red to get percentage with: coordinate x
    set green to get percentage with: coordinate y
    set blue to average of list create list with red, green
    Change keyboard lighting to color colour with red % red
                                                green % green
                                                blue % blue
    Wait 100 milliseconds
```

((c)) Example script that configures the keyboard to change lighting color depending on the position of the mouse arrow on the screen.

Figure 7.4 – Example scripts provided in the high fidelity prototype.

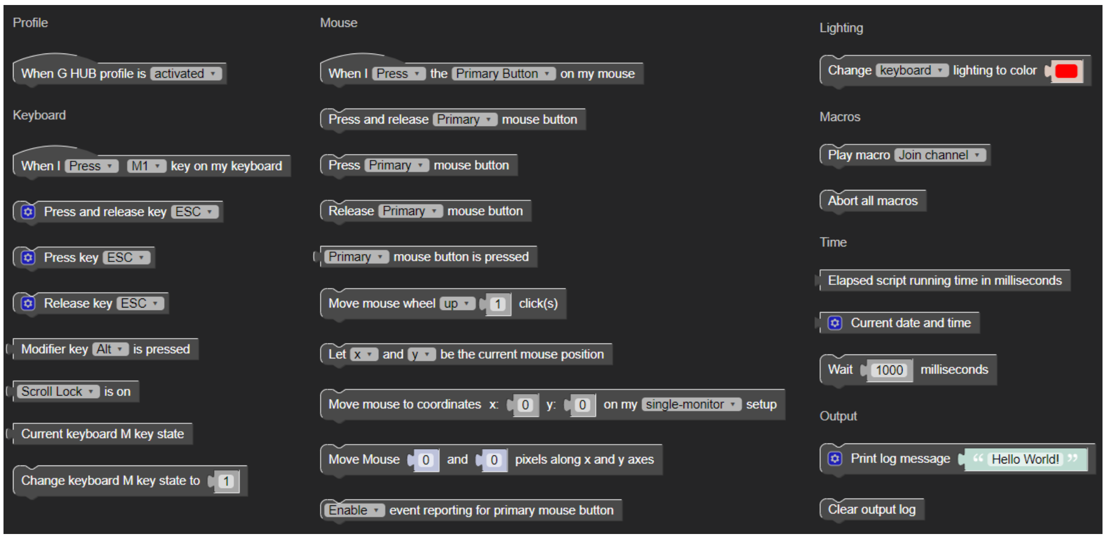

Profile
When G HUB profile is activated
Keyboard
When I Press M1 key on my keyboard
Press and release key ESC
Press key ESC
Release key ESC
Modifier key Alt is pressed
Scroll Lock is on
Current keyboard M key state
Change keyboard M key state to 1
Mouse
When I Press the Primary Button on my mouse
Press and release Primary mouse button
Press Primary mouse button
Release Primary mouse button
Primary mouse button is pressed
Move mouse wheel up 1 click(s)
Let x and y be the current mouse position
Move mouse to coordinates x: 0 y: 0 on my single-monitor setup
Move Mouse 0 and 0 pixels along x and y axes
Enable event reporting for primary mouse button
Lighting
Change keyboard lighting to color
Macros
Play macro Join channel
Abort all macros
Time
Elapsed script running time in milliseconds
Current date and time
Wait 1000 milliseconds
Output
Print log message "Hello World!"
Clear output log

Figure 7.5 – List of all the blocks created to represent the G HUB Lua api functions in the high fidelity prototype.

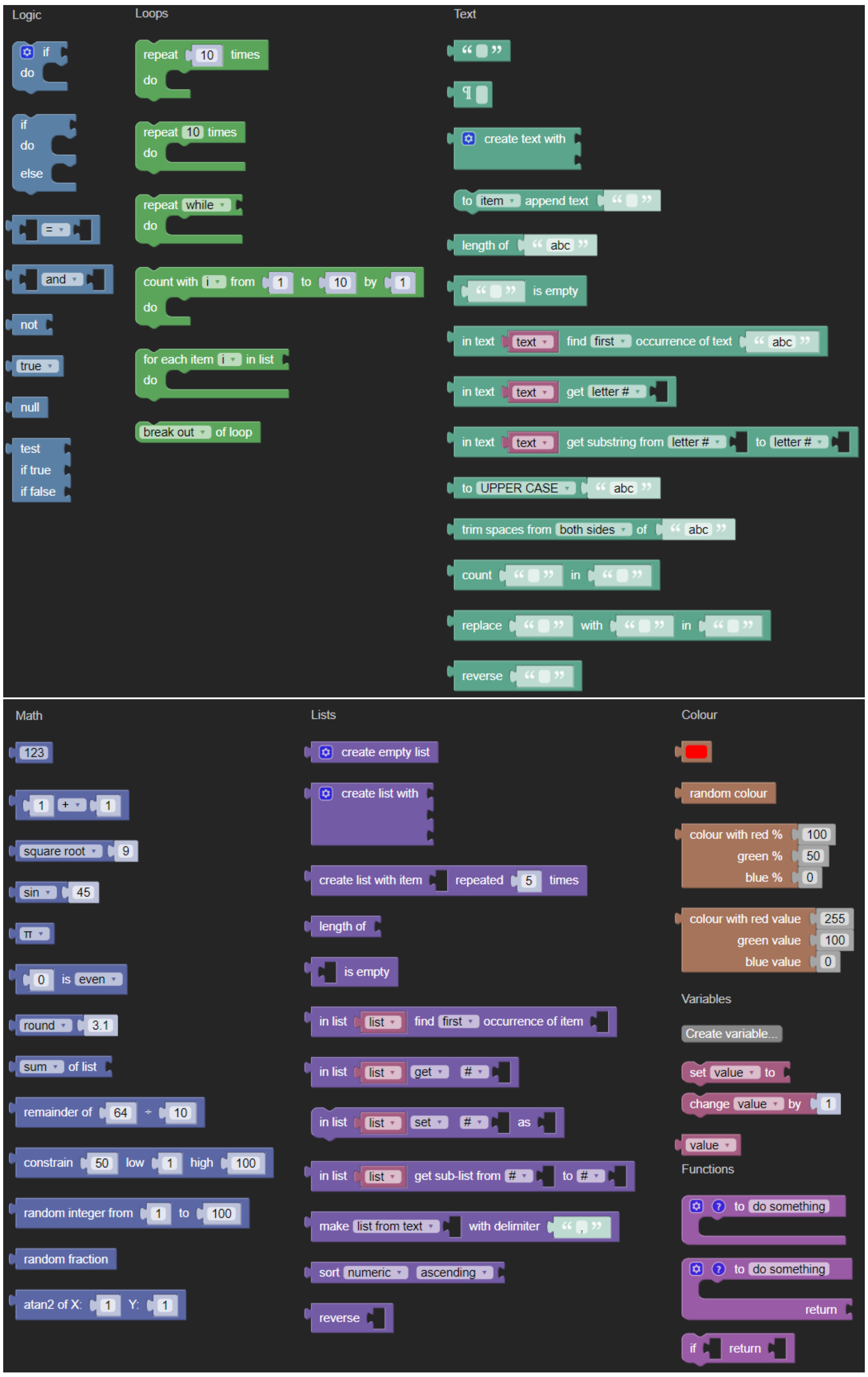
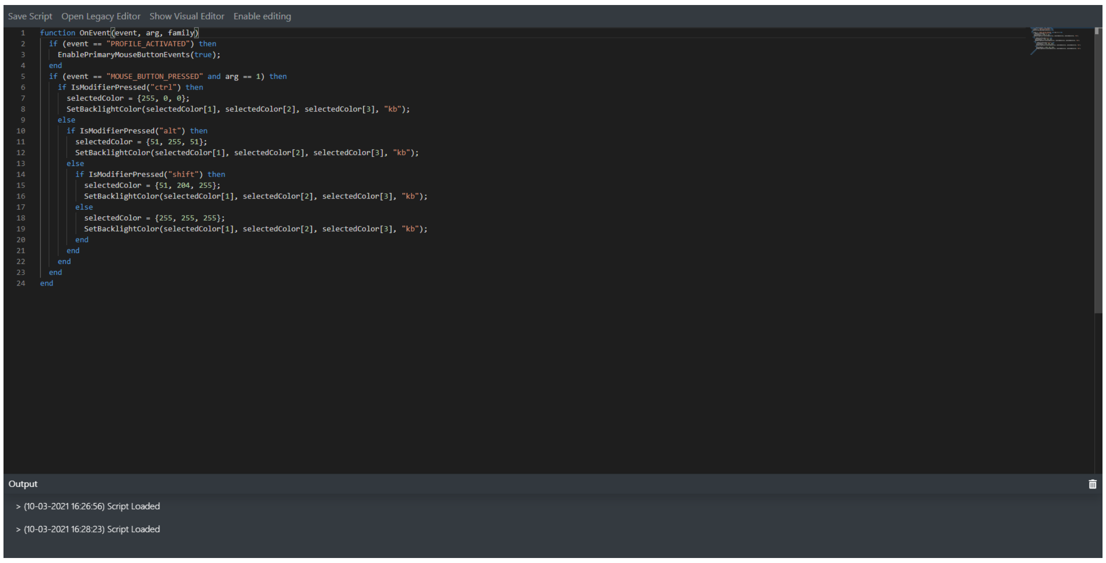


Figure 7.6 – List of the blocks created to represent programming constructs, data structures, functions, variables, literals and commonly used functions in the high fidelity prototype.



```lua
function OnEvent(event, arg, family)
  if (event == "PROFILE_ACTIVATED") then
    EnablePrimaryMouseButtonEvents(true);
  end
  if (event == "MOUSE_BUTTON_PRESSED" and arg == 1) then
    if IsModifierPressed("ctrl") then
      selectedColor = {255, 0, 0};
      SetBacklightColor(selectedColor[1], selectedColor[2], selectedColor[3], "kb");
    else
      if IsModifierPressed("alt") then
        selectedColor = {51, 255, 51};
        SetBacklightColor(selectedColor[1], selectedColor[2], selectedColor[3], "kb");
      else
        if IsModifierPressed("shift") then
          selectedColor = {51, 204, 255};
          SetBacklightColor(selectedColor[1], selectedColor[2], selectedColor[3], "kb");
        else
          selectedColor = {255, 255, 255};
          SetBacklightColor(selectedColor[1], selectedColor[2], selectedColor[3], "kb");
        end
      end
    end
  end
end
```

```
> (10-03-2021 16:26:56) Script Loaded
> (10-03-2021 16:28:23) Script Loaded
```

Figure 7.7 – The interface of the textual script editor implemented in the high fidelity blocks based prototype with the generated textual script that performs the user assigned task.

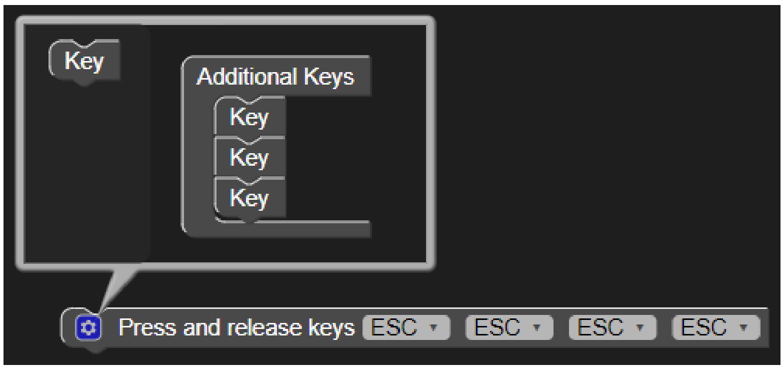


Figure 7.8 – The implemented mutator allows appending any number of additional key input fields to the block by stacking the same number of 'keys' blocks inside the 'Additional keys' block.

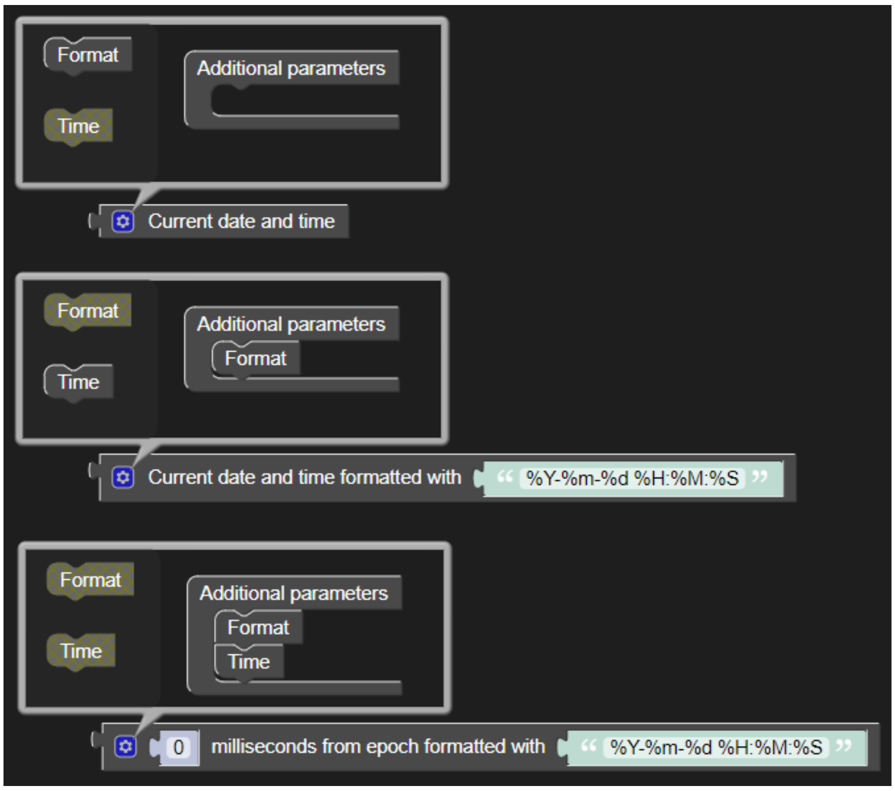


Figure 7.9 – Different configuration stages of the mutator implemented for the `GetDate()` G HUB Lua API function.

8 Evaluation - Iteration 2

8.1 Recruiting users

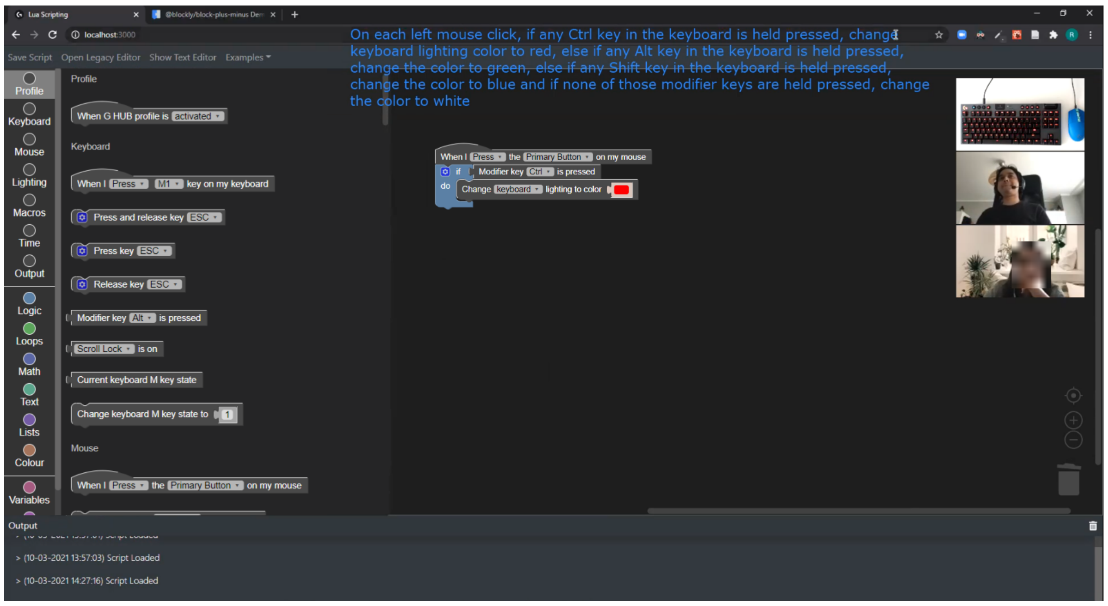
Similar to the procedure followed during iteration 1 and for the same reasons described in section 6.1, only Logitech internal employees were targeted for the user test. We reached out only to the employees whose work did not have a direct involvement with the G HUB software so that opinion biases can be minimized.

Taking into consideration the time constraints of the project as well as the fact that four participants in general can uncover almost 80% of the usability issues of a prototype (Sova & Nielsen, 2010), it was decided to limit the number of participants to four. Since this round of user tests did not involve any kind of A/B testing, there was no need to consider going for odd numbers for the sake of breaking ties.

8.2 Experiment design

As this experiment involved only one prototype, there was not need to handle effects of order and learning transfer as was the case with evaluation iteration 1. Nevertheless, recruitment of the participants were done maintaining a strict balance in the gender and the programming experience of the participants.

As was mentioned before, the expectations of this experiment was two fold. 1) One objective of the experiment was to verify from the users any improvements made to the prototype based on the usability issues found and improvements suggested by the participants in the previous iteration. 2) The other objective was to uncover any new usability issues users might face with the improved high fidelity version of the prototype.


Save Script
Open Legacy Editor
Show Text Editor
Examples
Profile
Keyboard
Mouse
Lighting
Macros
Time
Output
Logic
Loops
Math
Text
Lists
Colour
Variables
When G HUB profile is activated
When I Press M1 key on my keyboard
Press and release key ESC
Press key ESC
Release key ESC
Modifier key Alt is pressed
Scroll Lock is on
Current keyboard M key state
Change keyboard M key state to 1
When I Press the Primary Button on my mouse
if Modifier key Ctrl is pressed
do Change keyboard lighting to color

On each left mouse click, if any Ctrl key in the keyboard is held pressed, change keyboard lighting color to red, else if any Alt key in the keyboard is held pressed, change the color to green, else if any Shift key in the keyboard is held pressed, change the color to blue and if none of those modifier keys are held pressed, change the color to white

```
Output
> (10-03-2021 13:57:03) Script Loaded
> (10-03-2021 14:27:16) Script Loaded
```

Figure 8.1 – Iteration 2 user tests carried out over Zoom showed a real-time video feed of a keyboard and a mouse for the participant to see the effects of the scripts they make

8.3 Interview and user task

A similar interview guide to that which was used in the iteration 1 of evaluations, was used to make sure each participant gets exposed to the same set of instructions and information.

A Logitech G915 TKL RGB keyboard and a G102 LIGHTSYNC mouse was used in the user tests to have the effects of the executed visual scripts demonstrated to the participant real-time. Due to the ongoing COVID-19 pandemic and social distancing concerns, all the user tests were carried out remotely using Zoom and a real-time video feed of the keyboard and the mouse was provided in the Zoom call for the participant to see as can be seen in Figure 8.1.

Similar to the protocol followed in iteration 1, during the user test each participant was asked to perform a task with the high fidelity prototype. The task was to create a visual script so that when executed, each time the left mouse button is clicked on the gaming mouse, if any Ctrl key in the keyboard is held pressed, change keyboard back-light color to red, else if any Alt key in the keyboard is held pressed, change the keyboard back-light color to green, else if any Shift key in the keyboard is held pressed, change the keyboard back-light color to blue and if none of those modifier keys are held pressed, change the keyboard back-light color to white. Figure 7.2 shows how this task can be programmed using the blocks based setup in the high fidelity prototype. Figure 7.7 shows the generated textual version of the same visual script. participants were given remote access to the computer via Zoom to perform the task and the task description was added on screen as a Zoom annotation. As usual users were asked to think out loud as they work on the task with the prototype and the Zoom sessions were recorded for further analysis.

Table 8.1 shows the details of all the participants of the second iterations of the user study. Real names of the participants are omitted for privacy reasons.

Table 8.1 – Participants of the second round of user tests.

	Gender	Age	Programmer	Location	Date/time
P11	Male	20-40	Yes	Lausanne, CH	22/02/2021 15:00
P12	Female	20-40	Yes	Lausanne, CH	22/02/2021 18:00
P13	Male	20-40	No	Lausanne, CH	01/03/2021 17:00
P14	Female	20-40	No	Lausanne, CH	10/03/2021 14:00

8.4 Results

8.4.1 Insights on usability

As shown in Figure 7.6, in addition to the configurable 'if' block, an 'if-else' block was provided in the toolbox. It was interesting to observe that all the four participants ended up using this new 'if-else' block when performing the task. When inquired why, participant P12 said:

> "It's intriguing to me because the other blocks didn't have that icon (cogwheel button). But just looking at the icon, I didn't expect that it would give me necessarily more options. And once I clicked it I was like 'okay, there are few blocks here, what does that mean...? where should I click...?' But when I saw them connecting because they had connections... then you start seeing the differences here (on the original block).. And you are like... 'Oh! this is a configurator for this block'..."

Participants were also asked about an alternative configuration mechanism for the 'if' block as shown in Figure 8.2. All the four participants confirmed that they think this alternative configuration mechanism is more intuitive for them. Participant P12 confirmed it saying:

> "Yeah this is more intuitive for sure. Maybe instead of having just the + and - sign, I would have it inside a circle or something... just to not get in the way of this is part of the block or anything... just that to make clear that it's a expansion or contraction of the block"

Participant P13 summed up the same idea with his statement:

> "Intuitively i would think there is a +, it means i can do something... so i would have clicked just to test. But the other one (configuration with cog wheel button) I thought that I just select one instead of reorganizing them."

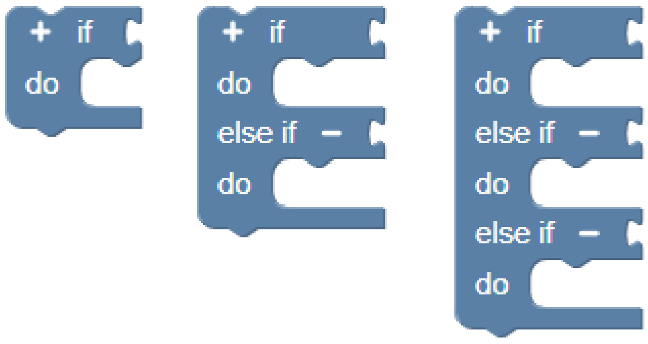


Figure 8.2 – Alternative configuration mechanism for if block

Another interesting observation was that the use of this new ‘if-else’ block forced the users to use them in a nested fashion to build ‘if-elseif-else’ like conditional ladders. This seemed to make comprehension of the program they created more difficult for them. For instance, participant P11 was confused whether or not the nested ‘if-else’ will get executed in the program he created. He went on to say

> “To me when you code, you have the indentation that is fairly important. I see that for me it’s like this function is embedded in this one and this is embedded in this one. I would prefer to have something like this (stacking the ‘if-else’ blocks one after the other), that would be much cleaner, so when I press this (referring to the event listener block) I have my 3 conditions... it’s almost like I could use it like a switch and the case functions in JS (Javascript)”

Figure 7.2 shows the interface of the high fidelity prototype and on the left we can see the always open continuous toolbox that allows scrolling through all the block categories. Contrary to the user input received in the first iteration, three of the 4 participants in this iteration found the new toolbox difficult to use. When shown the previous menu style toolbox, Participants P12 and P14 stated that they prefer that more. Both of them did not understand how the categories allow them to quickly scroll to a specific section in the toolbox. While working on the task participant P12 said:

> “The other thing is... like... I didn’t quite see those categories until you said.”

Participant P14 also said at the end of the task:

> “To be honest just now I started reading the titles. Earlier the different colors, I thought like it is a color palette. At first I though this were gonna be the colors that we were gonna change the keyboard to”

Participant P12 and P14 went on to further elaborate their opinion:

> “I think I like this (menu style toolbox) because then it is very clear... like... ‘OK, you have the functions, you have the logic, the keyboard...’ because when I was going through the other one (scroll list toolbox), and I was scrolling here, I was not necessarily seeing that this (current category shown highlighted) was changing based on this (list being scrolling). And then I got lost with all the options because its like... ‘Okay, this is a bit overwhelming with all these things...’, but this one here (menu style toolbox), I know I wanted to get to the logic one, it would be... like... easier for me to navigate.”

> “Just in terms that it (menu style toolbox) is easier to access, I know I need a variable so I’d just go to the variable rather than just scrolling... because the list is long... scrolling all the way to the bottom... all the way to the top...”

Participant P11 preferred neither styles of the toolboxes. He preferred to see something like a contextually filtered menu appearing on the canvas that lets him type what he wants to do and the menu shows the filtered list of blocks that matches the search query. He also suggested greying out blocks in the toolbox that would not fit any existing blocks in the canvas so that the number of options are narrowed down. These were his words:

> “I would like... press black here (on the canvas), no options there (as a toolbox), I type a sentence and say ‘When...’, and then you give me options - ‘When I press what, the keyboard, the mouse whatever...’, ‘ok, the mouse...’, ‘what on the mouse?...’, ‘The primary button...’, ‘ok, what do you wanna do... Do you wanna add a condition?...’, ‘Yes I wanna add a condition If...’, and then I complete my sentence and in the end I have only one big sentence and I can change the parameters. As soon as I finish typing a part of the sentence, I need to be asked or proposed some logical way, because here I guess as soon as I add that (the event listener block), I cant probably add some other stuff here (on the toolbox). So maybe those should be grayed out”

Although several participants in the first iteration stated they would have preferred to look at some examples, none of the participants in this iteration paid any attention to the examples menu that was made available in the interface.

It could also be noticed that although the participants did not explicitly mention anything about keyboard shortcuts, as they worked on the task, they used them to copy and paste or delete blocks naturally.

It was also interesting to hear from the participants their general impression on the high fidelity prototype. Participants P13 and P14 who were non-programmers as well as participant

P12 who had some programming skills stated that they would prefer to use this tool to create a program rather than write the code textually. Participant P13 said:

> "I think it just tells me that I could try to code and its not that difficult in fact. It kind of breaks the first barrier that you have. Most of the time you see people coding and its like crazy complicated, but its only logic in the end"

8.4.2 User performance

Table 8.2 lists down the time it took for each participant to complete the given task with the high fidelity prototype. Participant P13 got stuck with the logic he followed in doing the task and did not manage to complete it. All the participants, regardless of coding experience needed different levels of assistance in completing the task. So , just as it was the case in the iteration 1 as well, these duration values are influenced by the amount of help they received during the tasks and deriving conclusions from them would not mean anything significant.

Table 8.2 – Time duration taken by each participant to complete the assigned task with each prototype during the second round of user tests. Durations marked with a † imply that the participant failed to complete the task and the task was given up halfway.

Participant	Duration (mm:ss)
P11	19:56
P12	12:12
P13	†13:23
P14	12:37

9 Discussion

The primary objective of the iteration 1 of the user tests was to decide on which visual programming setup to proceed with between blocks based setup and nodes based setup. Both of these visual programming setups have been successfully used in various visual programming tools and environments that have been built. Yet, as the results showed, in this specific use case, a majority of the participants preferred the blocks based setup. The nodes based setup is commonly seen utilized in professional development environments especially in the graphics industry. Many of the 3D and 2D graphic creation software provides a nodes based editor for creating textures and materials for the models where the texture can be enhanced step by step in a sequence with each node adding some visual effect to it. What we noticed is that these texture generation processes inherently follow a strict sequential flow and never have conditional flow paths. For our use case, representing a program using such a nodes based graph will not result in a strict sequential flow of execution when programming constructs like conditional statements and loops are used. As a result, the execution path of the visual script along the nodes and connecting lines can go back and forth following different nodes in the graph and this makes interpreting a nodes based visual program difficult. The observations we made with the users indicate that this is the reason why most participants did not prefer the nodes based setup. Even some of the participants that said they preferred the nodes based setup mentioned that they prefer it because it looks 'visually cool'.

Due to the time constraints involved with a master thesis project, we limited the number of participants we recruit for the first iteration of user tests to 10. While we could gather a lot of useful inputs from the 10 participants, some concern was raised on the confidence of the choice made with respect to the visual program setup. As the results show, the distribution of the preference was 60% and 40% for the blocks based setup and the nodes based setup respectively. This choice percentage of blocks setup cannot be considered a strong majority and one can argue that the decision could have easily flipped if, for instance, five more participants were included in the user test. This situation has an even stronger effect on the results obtained within user groups. For instance, Figure 6.4 shows the preferred choice of visual programming setup within the user groups of programmers and non-programmers.

Here, we can see 3 out of the 5 programmers preferred the blocks based setup. Yet, adding just one more programmer to the group can make the votes tie. This lack of confidence could have been minimized by going for a larger number of participants that included both internal employees as well as external users hired via some agency. In retrospect, a better approach would have been to conduct a quantitative study rather than a qualitative study so that we can be confident that the difference in preferences is significant.

As was described in Section 6.1, a screening questionnaire was used to filter out participants that do not match the expected target user base of the proposed tool. In the questionnaire, a required question was included to state how familiar the participant is with programming. Three options were provided: ‘Very much’, ‘I know the basics’ and ‘Never written a single line of code’ (refer Figure 6.1). Depending on the answers provided on the form, participants were recruited for the user tests in a way that balances the programming experience among the total 10 participants. Yet, when the participants were interviewed during the user test, some participants who had answered on the form that they had never written a single line of code, spoke of some brief previous coding experience they have had. All of them made it clear that they were really bad at what they tried to do when they made those attempts at coding or learning how to code. So it was clear that some participants had answered this particular question based on the self judgement they had about their coding skills, rather than based on the real situation. So it should be highlighted that when balancing the participants in terms of coding experience, their self judgment on their skill level was taking into consideration. As a result some participants who were categorized as non-programmers might have had some basic level of programming skills this could have influenced the set of participants to be unbalanced with respect to coding experience.

Another concern that became clear as the user tests were conducted was that some participants have never had in them the need to personalize the devices they use. These participants sometimes struggled to give a personal opinion on certain things simply due to the fact that they personally have no real preference. This also could be seen as a contributing factor that hinders the confidence of the choice made on the visual programming setup in the first iteration. So in retrospect, this information should have been something that was demanded in the screening questionnaire so that the participants will have stronger choices and opinions.

Section 8.4.1 states how conflicting observations were made in the second iteration and the first iteration with regard to the setup used for the toolbox. The most probable reason behind this could be the fact that the low fidelity prototype used in the first iteration supported only a handful of blocks. As a result, participants could have felt that they could remember all the blocks available if they were laid out openly. But with the high fidelity prototype, more than 50 blocks were provided in the tool box and the ability have all of them in the memory becomes an impossible task nobody would attempt to do. When that is the case, having them hidden under categories would have forced the participant to think first in terms of categories and then in terms of the exact block, there by making the search for a block more efficient than scrolling through the whole list.

10 Future work

Chapter 8 goes into detail in describing the features of the implemented high fidelity blocks based prototype. One feature that was discussed there was the ability access the textual script generated from a created visual script. This feature can prove useful for advanced users with programming experience by enabling them to further fine tune a program with textual code that was initially created using the visual scripting tool. At the moment, the tool only support generating the textual code from a visual script. As a result, if the user makes any change to the generated code in the textual script editor, the canvas of the visual scripting environment is cleared out. Implementing a mechanism to generate a visual script from a given textual script could add a lot of value to the user experience of the tool. This would enable users to move back and forth between the textual and visual setups, there by continuing the work from the point they left it off in the other setup. One possible way to implement this feature would be to traverse through the abstract syntax tree of the textual code and try to map the programming elements to visual programming blocks.

Another interesting feature that could help users comprehend a certain visual program would be to have a mechanism that lets them step through the blocks in the program in the order each block in the program will be executed. This could be something similar to a debugger that we see in Integrated Development Environments that lets you step from one line of code to the other. As execution reaches a certain block, the block can be shown visually highlighted in a certain color. Some controllers need to be provided that allow the user to specify when to proceed to the next step in the execution.

Going by the it's commitment to inclusivity and diversity in gaming, Logitech introduced the Logitech G Adaptive Gaming Kit for users with disabilities and those with a wide variety of accessibility needs[I]. It would be an interesting avenue to explore how this visual programming prototype can also be tailored to help such people with special needs. One straight forward improvement on this regard would be to provide full accessibility to all the features of the tool only using the keyboard. More insights can be gained by interviewing some users from the

[I]When Everyone Plays, We all Win! | logi BLOG. (n.d.). Retrieved March 10, 2021, from https://blog.logitech.com/2019/11/18/logitech-g-adaptive-gaming-kit/.

disabled gaming community.

As was stated in Section 8.4.1, none of the participants in the second iteration of user tests noticed that they had the option to refer some example scripts to get some idea on how to use the tool. This implies that, to have impact, the tool needs more work in terms of guiding the user to become familiar with the visual programming environment. A possible solution would be to have some interactive tutorials designed to make the user accustomed to the setup when they first open it. These tutorials could take the form of a game where the user is first shown a sample script that they can test by themselves and then they are shown a script with missing pieces where they have to figure out what block should go where. Users can also be given marks based on how fast they complete each step. The tasks can be made to increase in difficulty in each level and the complete suite of tasks can be designed to cover all the available functionality provided by the tool.

The results obtained by the second iteration of the user tests show that the prototype needs further improvement and this calls for several more iterations of user tests. One avenue that should be worked upon in the immediate next iteration would be to explore ways of bringing the represented model of the prototype closer to the target users' mental model. As described in the book titled 'About face: the essentials of interaction design' by Cooper et al.(2007), providing the users with an overwhelming number of blocks that maps 1-to-1 for every function will more reflect the infrastructure of engineering efforts, but will bring little value a user to assist him in achieving his goals. The represented model of the high fidelity prototype built in the second iteration can be seen to be placed closer to the implementation model rather than the mental model. Users will use the tool with some end goal in mind and their mental model of the setup will be to interact with the tool in the same flow as they would narrate their requirement in natural language. The closer the represented model can be brought towards the user's mental model, the easier users will find the application to use and understand. One way to make this move would be to explore ways of combining multiple blocks that represent certain G HUB Lua API functions in to a single block in some meaningful way. This single block could provide configuration options to provide the functionality of each of the G HUB Lua API functions it represents, yet it would hide the users from having to worry about that complexity. Another possibility would be to explore alternate solutions to using a toolbox. This could avoid the need for the user to move back and forth between the canvas and the toolbox to find the programming elements he want. As was suggested by participant P11, this can possibly be achieved by using a contextual menu that can be opened by right-clicking on any empty space on the canvas and the user can then start typing his requirement in natural language to search for blocks that matches his need.

11 Conclusion

Logitech G HUB software lets users personalize their Logitech Gaming gear. To cater for advanced device customization requirements of the users, G HUB provides a Lua scripting environment and a set of Lua API functions that can be used within this scripting environment. This facilitates performing actions such as simulating hardware events, manipulating device lighting settings, playing pre-configured macros and reading hardware and software states of the connected gaming devices. In this project we investigated how visual programming programming solutions can be used to make this existing Lua scripting environment more approachable and intuitive to use for users without any programming skills.

From initial research, two potential visual programming setups were chosen as candidates. One used a setup of blocks that fit each other and the other used a notion of nodes that are connected to each other using lines to specify flow of control and data. Low fidelity prototypes of each setup were developed and a round of user tests were carried out with the primary target of identifying which setup to proceed with. 10 internal Logitech employees were recruited for the study while making sure the genders and the levels of programming experience in the user group stay balanced. All the participants were given a task to complete with each of the prototype and the order they test the two prototypes was also balanced.

The results showed that 60% of the participants preferred the blocks based setup. Accordingly, a high fidelity prototype following the blocks based setup was developed. This prototype was made fully integrated with the G HUB back-end so that the textual scripts generated by it from a visual script can be executed on the back-end to have its effects on any connected devices. Finally, a second iteration of user tests were carried out to evaluate the usability issues this prototype attempted to solve and discover any new usability issues that were introduced in the new design.

A Appendix

A.1 Interview Guide

Participant Name :
Email :
Gender :
Age :
Position :
Time/Date :
Prototype order :

Note: Timebox for max 40 mins

A.1.1 Introduction and Setup

- Thank for the participation
- Self introductions
- Intro on the user study
  - Some questions, no right wrong answers
  - Task with prototype, to learn from you what works and what doesn't.
  - Think out loud. What you like, don't like
- Zoom recording - "This material will only be used internally and never shared with anyone else. Will be disposed of at the end of the project"
- Start the recording.

A.1.2 Demographics and Background

Observe the gender and age group of the participant.

- Play video games? If yes
    - The last game? How often?
    - PC or console?
- Logitech gaming devices? If yes,
    - Familiarity with the Logitech G HUB Software? If yes
        - What have you used it for?
        - Lua Script editor of G HUB? If has used
            - Liked it? why?
- Coding experience? If yes
    - Started when?
- Visual programming?
  If yes
    - The last VP tool used?
    - Impression? Liked? Disliked? Why?
    - What would a VP tool for configuring devices in G HUB be like? (probe for users mental model)

  If no
    - Say it is something that allows you to create code graphically. Thoughts on what it would be like? (probe for users mental model)

Notes:

- *Try to make it more like a conversation and less like a list of formal questions*
- *Try to refer to experiences eg: last time they used it*

A.1.3 Task on the prototype

Start with (node/block) prototype

Share screen

Provide remote access to the user.

- How do you think this tool works? You can play around and try out

Mention

- Low fidelity prototype visual scripting tools
  - meaning its not at all complete
  - not necessarily what the end product would look like
- 2 versions in 2 different fashions
  - blocks and nodes
  - illustration of a mouse used to represent a real Logitech mouse only for the purpose of feedback
- Task description
  - task not representative of how it's used in real life, just a dummy
  - "Create a script on the canvas such that when it is run, every time you click on the left click button of the virtual mouse, the color of the G logo changes once, sequentially going through the colors Red, Green and Blue. For instance, if you click when the color is Red, the color should change to Green. If you click while the color is Green, it should change to Blue and finally if you click while the color is Blue, it should change to Red."
- Any questions?

Time taken to complete the task

- With blocks:
- With nodes:

Notes:

- *Do not describe how it works, **remind them to think out loud**, see how well they figure it on their own*
- *If they dont think out loud, as the user starts interacting with the interface, ask questions like 'how do you think you can use this tool'?*
- *Give answers only to the questions the user voices out, ask if they want to know the answer or want to figure it out on their own*
- *When the user seems to have no more feedback to give, try to ask a new question or more about what they mentioned to avoid moments of silence. Try to keep it as a conversation*

A.1.4 Follow up questions

- Which prototype should we build? Why? Anything negative? why?
- Anything positive with the other? Why?
- Any improvements you suggest?
- Anything this sort of interface would help you with in real life?

A.1.5 Wrap up

- Questions?
- Thanks!

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