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[PROTOTYPE OF SLURTLES FOR KIDS]

[Deliverable 5.2]

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ER4STEM - EDUCATIONAL ROBOTICS FOR STEM

The ER4STEM project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No. 665972

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1 EXECUTIVE SUMMARY

1.1 ROLE/PURPOSE/OBJECTIVE OF THE DELIVERABLE

This documents presents the SLurtles prototype for kids. SLurtles, having never previously been implemented with young learners will be used for the first time using the ER4STEM framework. To realise the potential of SLurtles with young people they need to be redesigned and implemented in a secure virtual world environment. Once created, SLurtle-based learning activities which follow the ER4STEM Framework will be designed and packaged for teachers working with young learners in a variety STEM contexts. This deliverable reports on the redevelopment of SLurtles and the creation of the virtual environment in which they are used, which has resulted in a prototype ready for piloting with end users.

1.2 RELATIONSHIP TO OTHER ER4STEM DELIVERABLES

The SLurtles prototype will be implemented in workshops by CU and reported in D2.2 and D2.3. During this time, a range of SLurtle-based activities will be designed and piloted with teachers and students, which will be made available to other teachers via the ER4STEM repository (D5.4). These workshops will be informed by the ER4STEM Framework as it develops (WP1).

1.3 STRUCTURE OF THE DOCUMENT

This document begins by providing the background, purpose and scope of the SLurtle prototype, before presenting an overview of the SLurtle prototype and the virtual environment in which it is used. Finally the current testing schedule is presented.

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2 INTRODUCTION

2.1 BACKGROUND

In Mindstorms, Seymour Papert advocated “the construction of educationally powerful computational environments that will provide alternatives to traditional classrooms and traditional instruction.” [1] While he accepted that the tool he was using, Logo, was limited by the capabilities and functionality of the technology of the 1970s, it nevertheless went on to give rise to a rich vein of research based on the notion of “objects-to-think-with”, with Scratch [2] and ToonTalk [3] prominent examples. These “objects-to-think-with” provide the learner with an easy to access, or “low floor”, entry to programming, whilst allowing the more experienced user create highly complex algorithms, resulting in a “high ceiling” [4].

A virtual world, such as Second Life, provides a three-dimensional, persistent and flexible environment which operates in real-time. It is not a game but an always-on, immersive virtual environment where users can meet, collaborate, create, share and discuss. While the automatic reaction to replicate what has gone before in a new technology (Winn, 2005) has been observed in virtual worlds with the creation of in-world lecture theatres, etc., some educators have begun to explore the potential of this technology and the new educational opportunities it can support.

Much like the Lego/Logo “behaving machines” that could be created in the real world [5], artefacts which are interactive and exhibit behaviours can be created in the virtual world. Content creation in the virtual world of Second Life, for example, begins with a simple object (prim), which can be manipulated in numerous ways and combined with others to create sophisticated structures. However the skills required to create even a simple artefact, such as a staircase, results in a high step barrier to entry. Furthermore, in order for this simple artefact to exhibit behaviours requires the object to be programmed. Programming within Second Life requires the use of Linden Scripting Language (LSL), a high floor, high ceiling programming language with C style syntax. Based on Scratch [2], Eric Rosenbaum [6] developed Scratch for Second Life (S4SL) as a low floor programming environment for Second Life. S4SL provides the learner with an opportunity to programme and introduce behaviours to otherwise static objects in Second Life, much like the Lego/Logo “behaving machines”.

SLurtles are robots programmed using S4SL and are designed for use with adults to introduce them to basic programming concepts through collaborative and distributed activities [7]. Once programmed, SLurtles can respond to actors within the virtual world and be programmed to create complex artefacts which can be shared with and explored by others. Based in the online 3D virtual world Second Life, research has demonstrated that by engaging with SLurtles, learners have been enabled to engage in increasingly complex problem solving as they explore, test and extend their understanding of programming through the construction of personally meaningful artefacts by programming SLurtles [8]. To realise the potential of SLurtles with young people they need to be redesigned and implemented in a secure, purpose built virtual world environment.

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3 SLURTLE REQUIREMENTS

3.1 SLURTLE TOOL

Based on SLurtles in Second Life (Girvan, Tangney and Savage, 2013), the SLurtles created for ER4STEM must fulfil these requirements:

- Graphic representation
  - 3D
  - Provide a position and heading
- Features
  - Construction as a process to engage learners in programming
    - Be progammable
    - Call/create instances of 3D objects
  - Sharable
  - Easy-to-use (this will be dependent on the client user-interface of the virtual world platform)
  - Persistent (relies on platform)
  - Creates simple building blocks
  - Support complex constructions
  - Support a wide variety of constructions
  - Support collaboration

3.2 VIRTUAL WORLD

Based on the perceived educational affordances of the original SLurtles, the research literature on education in virtual worlds, the aims of the ER4STEM project, and user requirements identified through discussions with teachers, the following requirements for the virtual world were identified:

- Platform
  - 3D
  - Multiple users represented as avatars
  - Communication between users
  - User-generated programmable content
  - Persistent
  - Sharing content between users
  - Operate in real-time
  - Flexible with no existing rules or objectives
  - Easy-to-use client
- Server/Grid
  - Stable – no unexpected interruptions, especially during workshops.
  - Secure
  - Easy to connect to - not reliant on technical knowledge or time of teachers.
  - Access restricted to teachers and researchers.
  - No personally identifying information held.
  - Regular backups.
  - Sustainable after the project has ended.

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- Virtual space
  - Access restricted to researchers, teachers and students.
  - Multiple user levels for researchers, teachers and students with different roles and rights.
  - Opportunities for collaboration between project schools but no contact unless agreed.
  - Age appropriate content.
  - Options to customise avatars.
  - No tasks that need to be completed before learning can commence.
  - Orientation space for users to familiarise themselves with the technology.
  - Ability for teachers and possibly students to modify the environment as workshops progress.

4 SLURTLE PROTOTYPE

4.1 SLURTLES

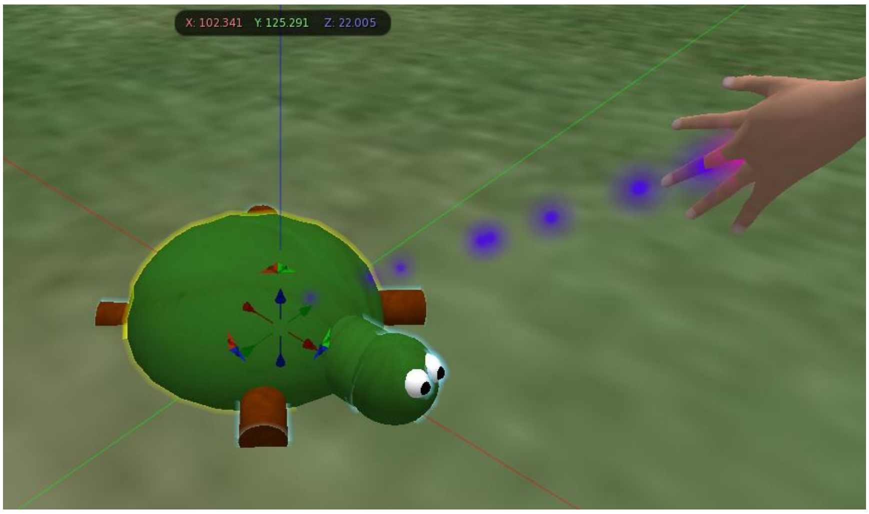

Figure 1 Avatar interacting with SLurtle for kids

Figure 1 shows the SLurtle tool created for ER4STEM. With many of the same requirements of the original SLurtle, a similar looking tool was created. The head provides a clear heading, whilst the body provides a clear indication of the position of the SLurtle. When selected (as shown in Figure 1) the precise X Y Z coordinates appear providing the precise location of the SLurtle on the grid island.

The original SLurtles were provided for users from a SLurtle collection point. This showed images of the types of objects that each SLurtle would create, from which the user could select a SLurtle. Initial user test showed that whilst it was useful to see the types of blocks created by each SLurtle, requiring the user to visit this point for each SLurtle used was inconvenient. Therefore the ER4STEM SLurtles are all provided in a user's inventory when their account is first created.

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Each SLurtle contains a lineSegment (Figure 2). An instance of the lineSegment is created starting at the center of the SLurtle's body when the 'pen down' command is given. The shape, width and height of the lineSegment are predetermined. The length is determined by the distance travelled forward by the SLurtle in a single move when the 'pen down' command is used.

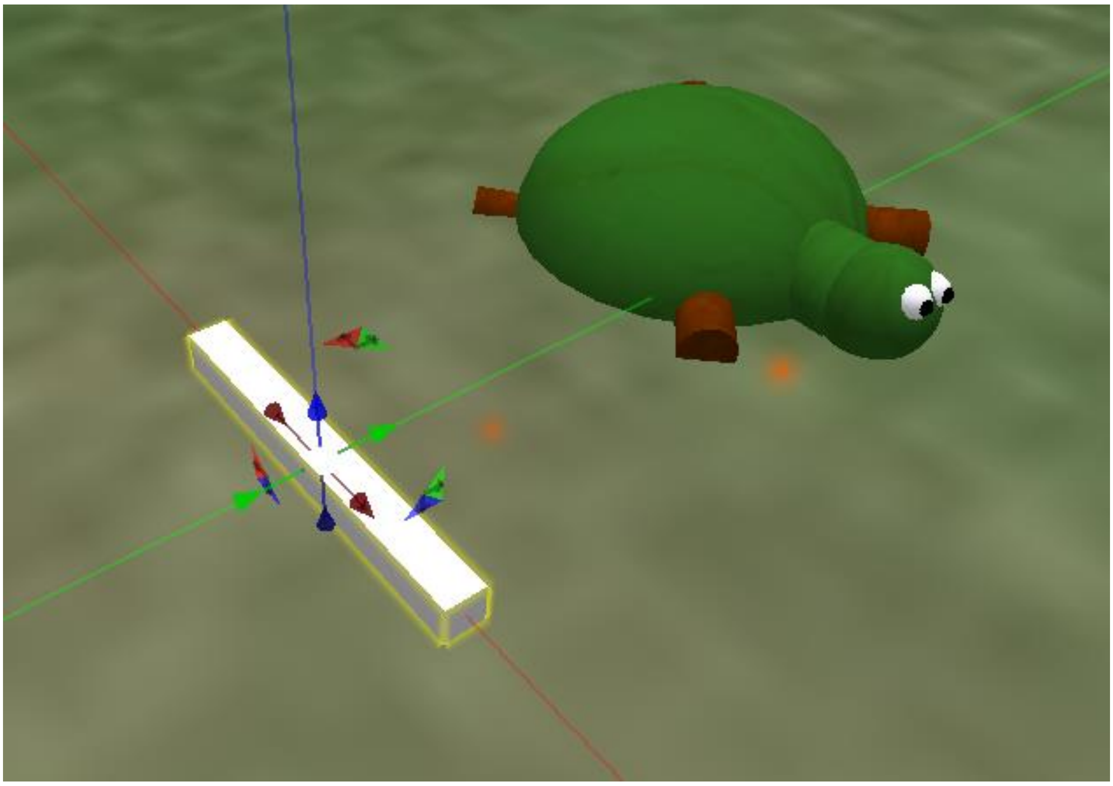

Figure 2 Instance of a 1 meter lineSegment in white

The position, colour and length of each lineSegment created is determined by a script in the SLurtle. Users have two options to achieve this. 1) Create a new script in the SLurtle and use a text editor in the virtual world to write the script. 2) Use Scratch for OpenSim (Figure 3) which provides a block-based programming environment which automatically generates the text-based script, which can be copied into a new script in the SLurtle. It is anticipated that most users will use Scratch4OpenSim but as they gain familiarity they may change the script in the virtual world text editor, providing teachers with an opportunity to develop lessons which support learners transitioning between block and text-based languages. The particular advantage for students who are collaborating or transitioning is that scripts in SLurtles can be copied into Scratch4OpenSim to be represented as graphical blocks.

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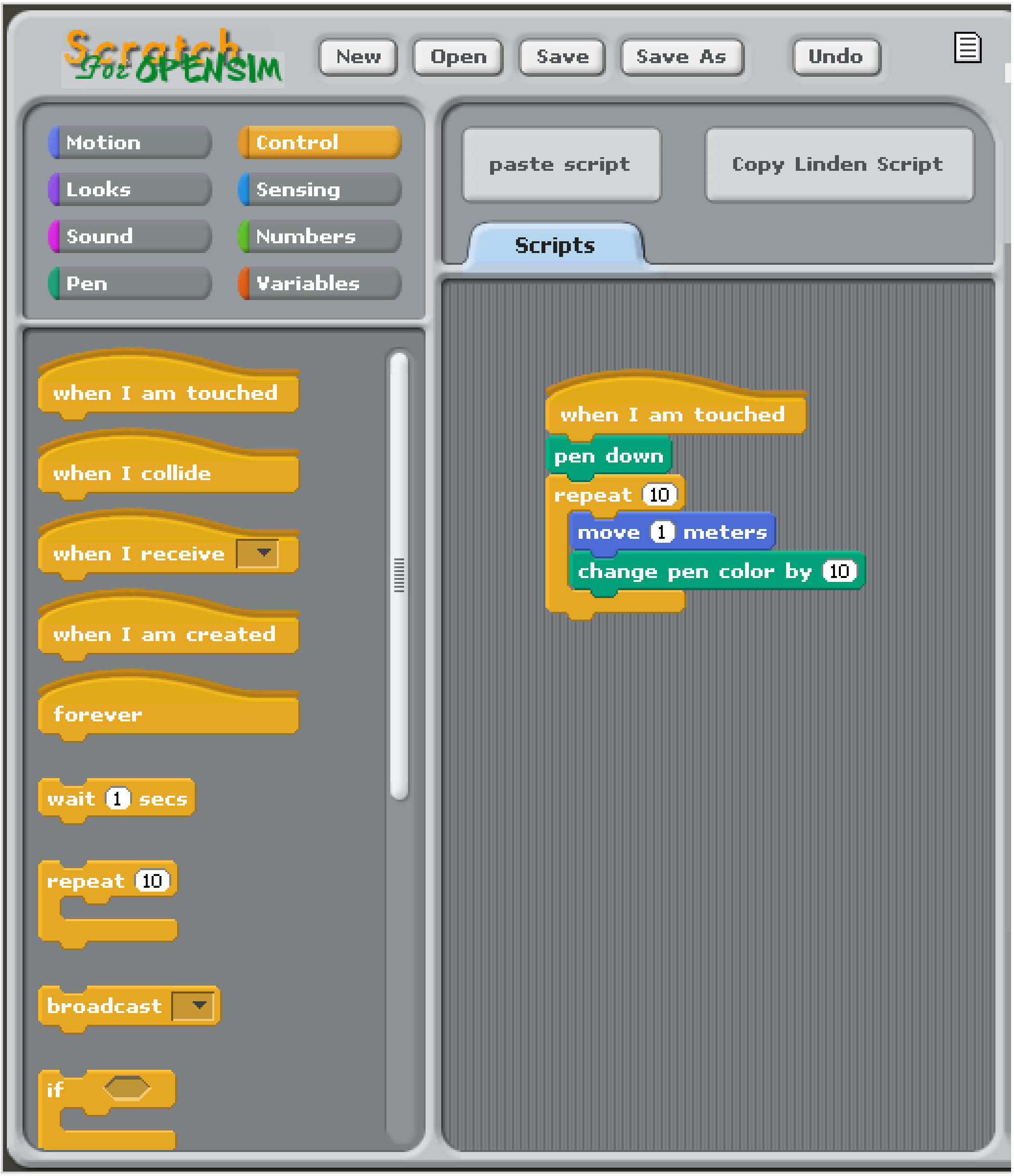

Figure 3 Scratch for OpenSim programming interface

Attributes assigned in the script placed in the SLurtle are passed to a script within each lineSegment instance. From the original SLurtles, this lineSegment script had to be adapted to operate on the OpenSim platform.

4.2 VIRTUAL WORLD

In the context of this report, the term ‘virtual world’ is used to refer to a persistent, simulated and immersive environment, facilitated by networked computers, providing multiple users with avatars and communication tools with which to act and interact in-world and in real-time.

The term ‘virtual world’ is used in subtly different ways across the research literature and as a result there can be confusion by what is meant. While the lack of a clear and common understanding of a

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term is not uncommon in a developing area such as virtual worlds, there are implications. The variety of terms used by authors can cause confusion, such as MUVE and virtual world both used to label Second Life in one article [9] while Ghanbarzadeh et al. [10] consider virtual worlds to be a subset of MUVEs. Others have labelled Second Life an immersive virtual world [11], a social virtual world [12], and a virtual environment [13], yet virtual environment is in turn used by Minocha et al. [14] to label Facebook. Thus it is perhaps unsurprising to find a common blurring of the boundaries between terms and the ways in which they are used.

In this section of the report, a rationale for the platform and server/grid choices is given, followed by an overview of the virtual world design.

4.2.1 PLATFORM

While Minecraft is an increasingly popular virtual world technology with young people, it is primarily designed for entertainment and only allows content creation within the boundaries of the game, or game grammar. There are different forms of primitive objects, each with its own set of features, for example glass and wood.

Unity 3D is an increasingly popular game engine used to power 3D virtual worlds. Again, these virtual worlds are typically limited by game grammar and those which support user-generated content, require this to be developed in separate software and uploaded to the environment, thus reducing opportunities for collaboration.

The appeal of virtual worlds such as Second Life over Minecraft or those that use Unity 3D is that there are no pre-defined goals and Second Life allows users to create their own content. Everything can be created from scratch, within the environment and in real-time allowing groups of people to come together and create from the bottom up. Changes to the environment can also be done rapidly and in real-time, allowing teachers to make modifications to the learning environment as the lesson unfolds.

However, Second Life is designed for use by adults and learners can easily leave their own learning environment and explore the rest of the Second Life grid. On the wider grid they may find adult content and meet other users of the virtual world. Therefore Second Life is not a suitable virtual world for use with young people.

OpenSim (http://opensimworld.com/) is an open source virtual world server based on the Second Life platform. It shares most of the same features as Second Life but allows users to create their own virtual worlds (grids) which may or may not be linked to other virtual worlds.

DECISION: OpenSim provides all of the features needed for SLurtles and SLurtle-based activities.

4.2.2 SERVER/GRID

There are three main options on type of OpenSim server that could be used: Sim-On-A-Stick (SOAS); a private server hosted on your own computer; or a paid-for service.

SOAS is a very simple version of OpenSim on a memory stick. It is designed to host one sim (or island) for a single user. Although it is possible to connect others on the same network, the host computer

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needs sufficient memory and to be linked to other users via an Ethernet connection. This is the most secure and simplest form on OpenSim, however it is no longer actively updated and will require some configuration for each workshop by teachers.

While a server hosted on a computer within the school, which is not connected to the internet, on a school's own network is also a secure solution, it has similar limitations. It requires the workshop tutor and/or class teacher to have access to the school's network, configure the server and class computers. It would also require researchers to have ongoing access to the school's network from outside the school to provide technical support.

The most stable option is to use a hosting service which can provide the technical support to maintain the virtual world grid. This also reduces the technical knowledge required of teachers. Using a hosted service to create a virtual world also has additional benefits, such as importing items which are available on other virtual world grids. While this can reduce the personnel time involved in the creation and programming of objects for the virtual world from scratch, by allowing people to move between grids there are increased security risks, however there are controls that can be put in place to mitigate these risks. The other disadvantage of a hosted service is the increase in cost but again it reduces personnel and teacher time, also providing a familiar platform for teachers to use without additional knowledge following the end of the project, thus they are not reliant on the researcher to be able to continue to engage in ER4STEM activities with their students. Importantly, unlike the server within the school's own network or SOAS, it is easy to create a grid on an externally hosted server which supports collaboration between schools, within a highly access controlled environment.

DECISION: The decision was made to use an externally hosted service for the second year of the project and first pilot year for SLurtles. During the testing of SLurtles and the activity plans, it is important that all other factors remain stable. The hosted server provides the most reliable and easy to set up solution for both researchers and teachers.

The hosted server allows for the creation of user accounts without storing any personally identifying information on the hosted server.

The hosting service makes back-ups of the grid on a regular basis.

Only CU has super-user access. All access requests must be made through CU.

There are a number of controls that can be put in place to mitigate the security risks identified above. Hypergrid access is only available to administrator accounts (user level above 100) created on the grid. Therefore administrators can get out and back but no one else can leave or enter, so students cannot leave and visit other grids and the grid will be invisible and inaccessible to those on other grids.

4.2.3 VIRTUAL SPACE

As highlighted in the developing ER4STEM Framework (WP1), space is an important factor in the design and implementation of robotics learning activities. In the case of SLurtle-based activities, this includes both the physical and virtual space. As the majority of all learning activities will happen within the virtual space, this was an important part of the prototype design.

The virtual grid, known as SLurtle Space (SLurtleS for short) can be accessed through any OpenSim viewer, also known as client. Following initial testing, Firestorm was identified as the preferred

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viewer and will be used during prototype testing as it provides the most user-friendly user-interface when using SLurtles. This principally relates to the pie-menu interface.

The grid is currently comprised of four island, as shown in Figure 1 below. On their first log into SLurtle Space, users will arrive on 'hello_world' island. Figure 2 shows the layout of this island which is designed to provide both structured (Figure 3) and unstructured orientation to interacting in the virtual world. It also provides a space for learners to customise their avatars.

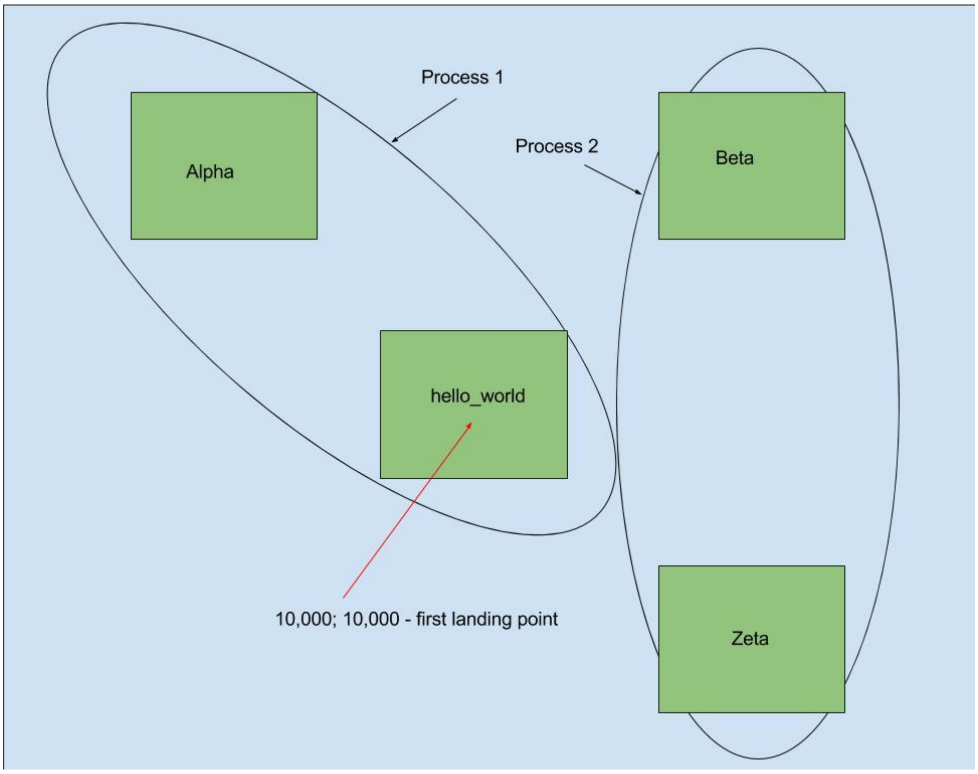

Figure 4 SLurtle Space grid layout

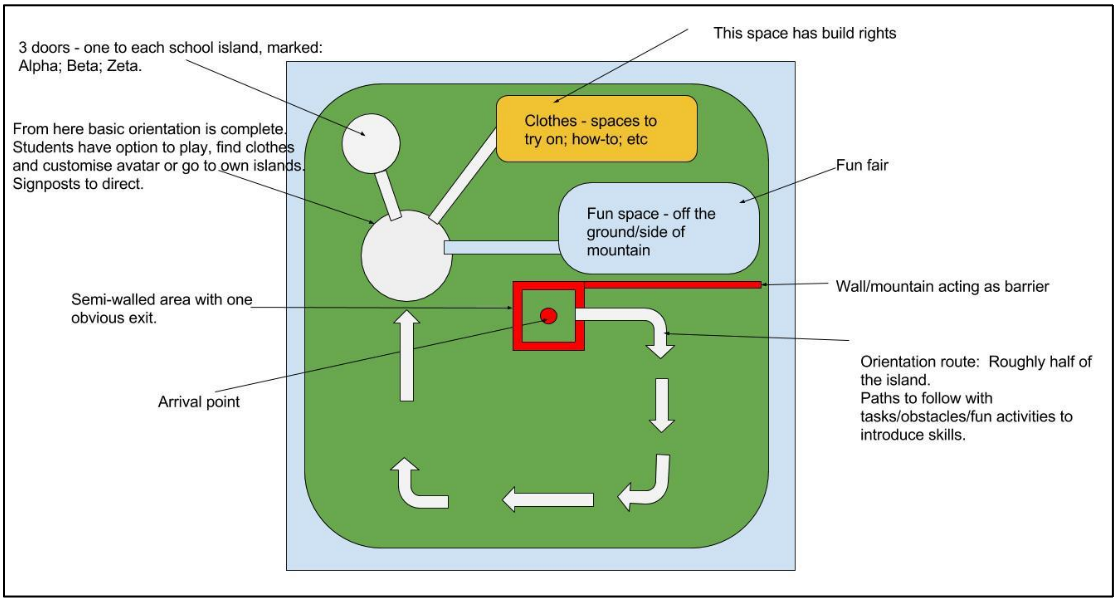

Figure 5 hello_world island layout

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Figure 6 Part of the structured orientation space

Once ready to leave hello_world, students move to their own school's island 'alpha', 'beta' or 'zeta through a door which acts as a portal. Three islands were created for schools to allow multiple classes or schools to use the SLurtle prototype space at the same time. Access to each of these islands is limited to the teacher and their pupils. However at a future point, access may be granted to another class, allowing for collaboration between schools on the same island.

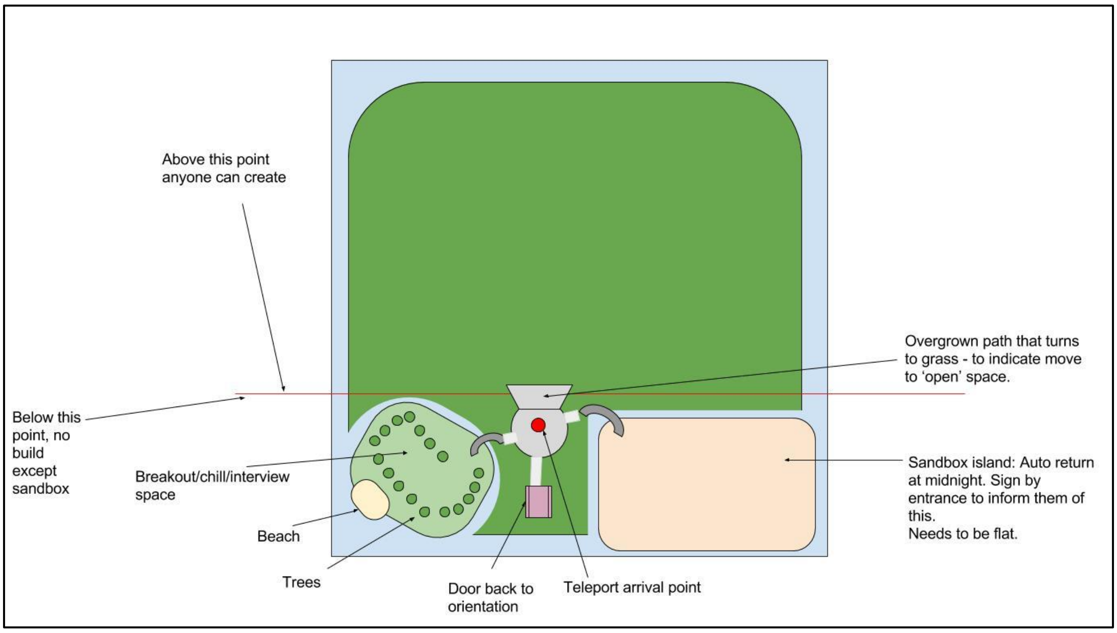

Figure 7 Schools island layout

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Each of the school islands has the same layout to start (shown in Figure 3). They include an informal space which can be used for whole class discussions, time-out, small-group discussions and research interviews. They also include a sandbox which provides a testing space for users to use their SLurtles. Any objects in the sandbox at the end of the day will be returned to the user.

The rest of the island is flat land, allowing it to be configured to suit the designed learning activity. This draws on the flexibility, persistence and in-situ content creation afforded by the virtual world, allowing the teacher to design and implement any suitable learning activity, using the most appropriate pedagogical approaches. Platforms or working spaces have been pre-made and can be placed on the island at any time to provide groups of learners with their own spaces (Figure 4). Alternatively the space can be left open to promote exploration and sharing. As content is developed with teachers for specific workshops, this will create a repository of resources for all teachers to draw from in their design of SLurtle-based learning activities.

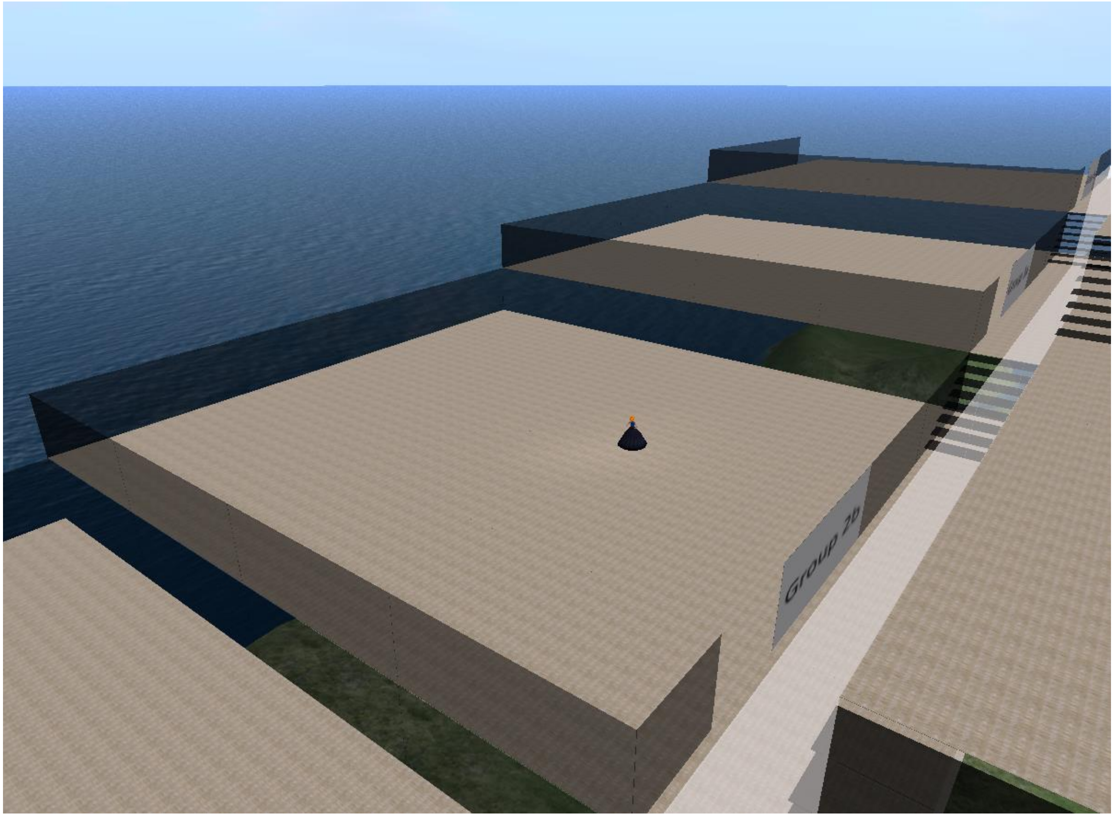

Figure 8 Empty platform with avatar.

5 SUMMARY

This deliverable has presented the SLurtle prototype for kids, including the tool and the virtual world in which the SLurtles are used.

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6 CONCLUSION / OUTLOOK

The next step is for SLurtle-based activity plans (WP4) to be developed, in-line with the ER4STEM framework (WP1) and piloted with teachers and students in workshops in project years 2 and 3 (WP3). The evaluation (WP6) of these workshops will include additional data gathering to collect feedback on SLurtles and the virtual world for ongoing development. Once the SLurtle prototype has been demonstrated to work effectively in schools on a stable hosted platform, all files and materials for schools to host their own SLurtles server on their own network will be made available through the repository (WP5).

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7 GLOSSARY / ABBREVIATIONS

EC	European Commission
ER4STEM	Educational Robotics for STEM
REA	Research Executive Agency
STEM	Science, Technology, Engineering, and Mathematics
SOAS	Sim-on-a-Stick

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