

Learner-tutor interaction design and learning scenarios

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Short abstract	Initial studies to inform the design of the learning platform and the tutors' prototypes. Overview of the learning scenarios designed for the tutor.	
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Table of Contents

1. Executive Summary.....	1
2. Introduction	3
3. Showcase of Curriculum-driven Learning Scenarios.....	5
3.1. Teaching Topic	5
3.2. Target Users	5
4. User-centered Design Activities.....	7
4.1. Tutor-centered design activities	7
4.1.1. Initial informal pilot interviews.....	8
4.1.2. Structured Interviews	8
4.1.3. Wizard-of-Oz study	13
4.2. Learner-centered Activities	15
4.2.1. Mock-up study 1	15
4.2.2. Wizard-of-Oz Study.....	18
4.2.3. Mock-up study 2	20
4.2.4. Mock-up study 3	22
5. Scenario Design	25
5.1. Tutor Embodiment.....	25
5.2. Technical considerations	25
5.3. Multi-touch tables in learning	27
6. Learning Scenarios in EMOTE	29
6.1. Scenario 1	29
6.2. Scenario 2	29
7. Conclusions and Future Work.....	33
8. References.....	34
9. Appendix	36
9.1. Appendix 1 WoZ Instructions.....	37
9.2. Appendix 2 Mock-up study 3 tutorial	44
9.3. Appendix 3 Mock-up study 1 Instructions UK	48
9.4. Appendix 4 Mock-up study 1 Instructions Sweden	50
9.5. Appendix 5 Mock-up study 2 Instructions	52

1. Executive Summary

The main purpose of EMOTE project is to design, develop and evaluate a new generation of artificial embodied tutors that have perceptive capabilities to engage in empathic interactions with learners in a shared physical space. The overall objective of WP2 is to perform user-centered design activities in order to develop the learning scenarios for EMOTE. In this document, we provide a description of the work done in this workpackage (WP2) during the first year within the EMOTE project, providing a set of user requirements, and adopting a learner-centric approach to the creation of learning scenarios. These requirements were gathered through design activities within two user groups: learners and teachers (tutor). The activities developed during this year were designed to provide requirements from a student perspective, and a tutor-centered view, thus taking into account the views and activities of the two types of stakeholders.

The requirements for the construction of the preliminary versions of the learning scenarios are arranged in three main spheres: a presentation of the showcase of curriculum-driven learning scenarios, a set of user-centered design activities carried out along this first year, and technical requirements for the scenarios design and development.

Showcase of Curriculum-driven Learning Scenarios

In the EMOTE project a learner-centric approach is adopted and applied to the design of curriculum-driven learning scenarios. This way, in *Section 3* we discuss the teaching topics established in EMOTE project, in particular the geography curriculum and place the EMOTE objectives into an educational context, setting the target group of the learner's population (early-secondary students).

User-centered Design Activities

In order to develop the learning scenarios for EMOTE and to perform further analysis regarding indicators of users experience in the learning process, several user-centered activities were designed. In *Section 4* we discuss both the tutor-centered activities with teachers developed accordingly to several objectives (e.g., define a user experience scenario that outlines the role of the tutor) and the Learner-centered activities with students designed in order to develop artificial empathic tutors and maximize the enjoyment and the performance outcomes of the user's learning experience.

Scenario Design

In *Section 5* of this document, the technical requirements about the scenario design are discussed. The topics of these discussions concerned:

- The tutor embodiment, where literature among the theme and the embodiment of the EMOTE tutor is addressed;
- Technical considerations about the student's interaction with the system are considered, being the nature of this interaction through a carefully designed multi-touch screen interface;
- A multi-touch table as a learning tool in an educational context is considerate, highlighting its benefits in different (e.g., collaborative) learning scenarios.

Learning Scenarios in EMOTE

Finally, and taking into account all of the requirements mentioned in the previous Sections, two learning scenarios in EMOTE were established and are described in *Section 6*:

- Scenario 1 focuses on local map reading as an individual activity;
- Scenario 2 is a collaborative scenario based on Enercities game (a game chosen as the most appropriate for the learning goals established).

2. Introduction

Aiming to achieve fruitful empathic interactions with learners, the EMOTE project will aim at the construction of a new generation of artificial embodied tutors that enrich learning experiences and learning progress in a physical way. This will be done by monitoring the learner's abilities and difficulties throughout the learning process, modelling affect-related states experienced by the learner during the learning task and the interaction with the embodied tutor, by providing appropriate feedback to the learner by means of contextualised empathic reactions, adaptive dialogues and personalised learning strategies.

Overall, the EMOTE project aims to:

- Research the role of pedagogical and empathic interventions in the process of engaging the learner and facilitating their learning progress;
- Explore if and how the exchange of socio-emotional cues with an embodied tutor in a shared physical space can create a sense of connection and social bonding and act as a facilitator of the learning experience;
- Investigate how to adapt tutor interaction abilities to different tutor embodiments.

EMOTE will adopt a learner-centric approach environment (McLoughlin, & Luca, 2002). This approach is applied to teaching and the curriculum outcomes and tasks are aligned and foster cognitive skills and deepen learning. This can be achieved by enabling students to take an active role in learning. Also, there is an emphasis to on the process rather than the content to promote active learning (McLoughlin, & Luca, 2002). This approach will be applied to the design of curriculum-driven learning scenarios, where personalised and pedagogical learning strategies will be employed by the tutor in order to successfully adapt to the learner's engagement and progress in the learning task. To ground the research in a concrete classroom scenario, the EMOTE project will develop a showcase in the area of geography, focusing on the processes associated with the dynamically changing world (e.g., greenhouse effect). Indeed, a variety of teaching strategies are used nowadays to foster learning, in particular in areas such as sustainable living. These areas require learners to have a deep understanding of physical processes, ways to shift perception, taking perspective of different stakeholders, and empathise with different populations' points of view. EMOTE will create a concrete empathic tutor that will engage with the learners in the exploration of these areas, but will contrast with "drill and practice" applications, by implementing different learning approaches.

In order to achieve its objectives, EMOTE will integrate interdisciplinary research on affect recognition, learner models, adaptive behaviour and embodiment for human-robot interaction in learning environments, grounded in psychological theories of emotion in social interaction and pedagogical models for learning facilitation.

To achieve these goals, this WP will inform the design of the components to be developed in WP4, WP5 and WP6, and specifically the perceptive abilities of the tutor, the tutor's adaptive empathic behaviour and the learning platform. The WP objectives of Year 1 and of this particular deliverable are related to the first two tasks in this WP, which are described below.

Task 2.1: Design of the learning technology

Task 2.1 aims to design a learning technology for teaching geography-related topics. Although from a researcher perspective there may be a clear role for embodied robotic tutors in the classroom, Russell and Schneiderheinze (2005), point out that once such an innovation enters the classroom it becomes part of a complex system of social and pedagogical interactions, involving both teachers and students. Therefore, it is pertinent to investigate the perspective of the potential learner-users as well as the social and contextual structures inherent in the environment.

In EMOTE an approach was adopted in which the primary context is the geography classroom, where the students were defined as the primary users for the embodied tutors. The teachers were considered as important secondary users (by receiving progress data from the tutor), stakeholders (as the people whose working environment is affected), and adopters (as the people having a major say in which technologies are being used with students). Different activities were conducted with both students and teachers along learner-centered and tutor-centered design activities. The results of these activities were combined with several technical considerations and requirements.

Task 2.2: Design of the learning scenarios

Task 2.2 aims to create curriculum-driven learning scenarios grounded in educational theory that connect with the experiences of the target user group (input from Task 2.1). Scenarios will be designed to support teachers teaching geography-related topics to students by means of an embodied tutor. The tutor will interact with the students in a shared physical space with the support of maps and charts on a multi-touch table. Personalised, adaptive scenarios will be built around the concepts of guided and discovery learning approaches. The tutor will adapt its approach to being more or less guiding depending on the topic that is taught and each student's needs. Based on the results of the activities in Task 2.1 scenarios will be designed so as to gradually encourage students to take a self-directed approach to learning and become more proactive and engaged in the learning process. Finally, this task will explore how to adapt learning scenarios to the different tutor's embodiments investigated in EMOTE.

3. Showcase of Curriculum-driven Learning Scenarios

EMOTE will adopt an approach where curriculum outcomes and tasks are aligned and foster cognitive skills and deepen learning (McLoughlin, & Luca, 2002). Thereafter, this approach will be applied to the design of curriculum-driven learning scenarios. For this, the target group and the teaching topic for the EMOTE project are described below.

3.1. Teaching Topic

The teaching topic established for the EMOTE project concerns geography-related topics taught with the support of maps and charts on a multi-touch table. To ground the research in a classroom scenario, the EMOTE project showcases will be divided into two different scenarios, both related to the geography curriculum. These scenarios will be centered around map reading and environmental issues, such as processes associated with the dynamically changing world (e.g., the greenhouse effect, acid rain, and global warming) and are explained in *Section 6*. EMOTE aims to create a concrete empathic tutor that will engage with the learners in the exploration of these topics.

In order to define the content for the showcases, the syllabuses for the relevant topics in this area within the participating countries of EMOTE project were compared. **Figure 1** shows which syllabuses were considered relevant given the target group. It can be seen that the syllabuses for geography in the different countries do have much in common although expressing key concepts and processes in different ways. It should also be noted that both the curricula of Portugal and England will be adapted soon (2013/2014) as some changes in the Educational system are under way.

In order for the showcases to be useful in schools in all the participating countries it was thus decided to focus on two high-level concepts that are common for all curricula: “**Map Reading Skills**”, and “**Sustainable Development**”. These two concepts will be target domain in one scenario each. **Figure 1** also provides an overview of how these topics are presented in the relevant syllabuses for the different countries.

3.2. Target Users

To place the EMOTE objectives into an educational context, a target learner group was set. The target group was established accordingly to EMOTE participating countries' syllabuses for grades of geography curriculum-driven. This way the target users/learners for EMOTE project are early-secondary students with age ranging between 11 and 13 years old. **Figure 1** shows the target groups in each country respectively to their grades.

EMOTE Partners	Syllabuses for grades	Ages	Map reading skills as mentioned in syllabuses	Sustainable development as mentioned in syllabuses
University of Gothenburg Sweden ¹	Years 4-6, Years 7-9	10-12, 13-15	Maps, how they are constructed using colours, symbols and scales	<p>How choices and priorities in everyday life can impact the environment and contribute to sustainable development.</p> <p>The importance of Earth's natural resources (e.g., water, land available for cultivation, forests and fossil fuels).</p> <p>Where different resources exist and what they are used for.</p>
INESC-ID Portugal ²	Class 5-6, Class 7-9	10-11, 12-14	Reading maps using its components and identifying topics such as names/locations, topographic and hypsometric terms, and climate characteristics.	Establish comprehension regarding natural resource exploration impact (renewable versus non-renewable energy resources) and human political and economic activities (e.g., transportation networks, industry, and construction). Understand the relation between population growth and resource consumption.
University of Birmingham England ³	Year 7-9 (Key Stage 3)	11-14	The use of atlases, globes, maps at a range of scales, photographs, satellite images and other geographical data	Understanding that the physical and human dimensions of the environment are interrelated and together influence environmental change. Exploring sustainable development and its impact on environmental interaction and climate change.
Heriot Watt University Scotland ⁴	First Year	11-13	The use of a range of maps, atlases, Ordnance Survey maps, satellite imagery and other graphic and digital material, including the use of Geographical Information Systems to obtain, illustrate, analyse, and evaluate geographic information.	Resource management and biodiversity: How humans use, modify and change natural ecosystems in ways that may be sustainable or unsustainable. Specific examples at local and regional scales should be chosen to illustrate how this may lead to beneficial (e.g., agriculture and food production, identifying new energy resources) and/or detrimental outcomes (e.g., desertification, loss of biodiversity, soil degradation) for human well being.

Figure 1. Target group & teaching topic in EMOTE

¹The Swedish syllabuses can be downloaded at: <http://www.skolverket.se/laroplaner-amnen-och-kurser/grundskoleutbildning/grundskola/geografi>

²The Portuguese syllabus can be downloaded at:
<http://dge.mec.pt/metasculturariales/index.php?s=directorio&pid=20>

³The English syllabus can be downloaded at
<http://media.education.gov.uk/assets/files/pdf/g/geography%202007%20programme%20of%20study%20for%20key%20stage%203.pdf>

⁴The Scottish syllabus can be downloaded at:
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/206145/GCSE_Geography.pdf

4. User-centered Design Activities

In EMOTE a learner-centric approach is adopted and applied to the design of curriculum-driven learning scenario mentioned above, where personalized pedagogically learning strategies are employed by the tutor in order to successfully adapt to the learner's engagement and progress in the learning task. In order to achieve these goals, a set of user requirements is needed.

These requirements were gathered in activities within two user groups: learners and tutors.

The learner-centered activities are designed to provide requirements from the student perspective, and the tutor-centered activities provide requirements from human teachers. In order to achieve its objectives, EMOTE integrates an interdisciplinary research (affect recognition, learner models, adaptive behaviour and embodiment for human-robot interaction in learning environments), grounded in psychological theories of emotion in social interaction describe broadly in Deliverable 3.1, and pedagogical models for learning facilitation.

User-centered activities were designed to gather information and to perform further analysis regarding indicators of users experience in the learning process. The user-centered activities are detailed below.

4.1. Tutor-centered design activities

Tutor-centered activities were performed with teachers. These activities had several objectives, namely to define a user experience scenario that outlines the role of the tutor, and to have a deep understanding of students' learning difficulties and learning enablers. These activities are described below, and some teachers participated in more than one activity.

Figure 2 displays a brief description of them.

Tutor-centered Activities	Teachers Sample	Total number of teachers per country
Structured interviews	Initial informal pilot interviews	3 teachers from Sweden
	Difficulty levels	1 teacher from England 1 teacher from Sweden
	Back-stories	6 teachers from Sweden
	Teachers' views on the use of empathic robotic tutors in the classroom	3 teachers from England 1 teacher from Scotland 3 teachers from Portugal 3 teachers from Sweden
	Participatory design workshop	3 teachers from Sweden
Comments on videos from Wizard-of-Oz study		11 teachers from Sweden
Total number of teachers		23 teachers

Figure 2. Brief description of tutor-centered activities.

4.1.1. Initial informal pilot interviews

Based on the general analysis of the syllabi and the possible showcase for the two scenarios, initial informal pilot interviews with teachers were held. These interviews were held with 3 teachers in Sweden (UGOT) and provided a general sense of possible activities within geography and sustainable development, based on the type of learning that is perceived as important in the modern classroom, namely authentic learning where students can relate the content of the learning situation to their everyday life. In addition, the importance of the active role of the students in their own learning process was emphasized by the teachers, as well as the construction of students' own knowledge integrating new knowledge with pre-existing constructs and learning through a meaning making process. These views on learning and education are similar to the central idea of constructivism theory in the context of education (Kanselaar, 2002). Relating this to authentic learning, teachers pointed out the highly motivational and meaningful process of this approach for students, which they argued could potentially increase the learning outcome. It was evident from the interviews that the teachers valued the ability for students to practice complex reasoning, where reflection is important. Complex reasoning was also said to pose a common difficulty for students in general, so teacher support is crucial.

Based on the interviews, it was concluded that both an individual as well as a collaborative tasks where two or more students can participate, would be necessary. In order to evaluate learning outcomes for research purposes, it will be necessary to be able to determine each individual student's performance according to the scenarios' task goals. However, it is also important to be able to provide teachers with an added value of the project, i.e., that there is also a contribution with learning opportunities that teachers feel comfortable implementing within the existing geography education. Teachers often stressed the importance of collaborative activities, both from a practical and a pedagogical perspective. Therefore, a collaborative task needs to complement the individual ones so that the EMOTE project meets teachers' expectations, and that subsequently longitudinal studies in schools can be performed.

4.1.2. Structured Interviews

The structured interviews with teachers were conducted to receive teachers' input concerning difficulty levels regarding geography-related tasks, and back-stories for the scenarios. , Other interviews were aimed at understanding teachers' views on the use of empathic robotic tutors in the classroom. Furthermore, participatory workshop activities were performed with the teachers.

Difficulty levels

Geography teachers in both in Sweden and England participated (UGOT and UoB). The first part of the interviews concerned if and how one could rate the difficulty of specific map reading skills, such as using a compass, measuring distances, understanding latitude and longitude, reading map symbols, features, contours, etc. The second part of the interviews concerned ways in which teachers might vary the difficulty to adapt to different student's needs in general, as well as in relation to each specific skill.

Specifically, the following three key methods for varying difficulty emerged from the interviews:

1. First, reduce or increase the amount of information presented adjusting to student's needs and capabilities to solve the task, so that they will have to sift through and discover the key aspects needed to succeed. For example:
 - a. Instructions or directions can be made more or less complex by containing several pieces of information.
 - b. Include more or less disruptive elements, such as several map symbols irrelevant for solving the task.
 - c. Increase the amount of steps required to solve the task.
2. Second, specific map reading skills can be made more or less complex. For example:
 - a. Traveling North vs. North-North-West.
 - b. Traveling 500 m vs. 0.5 km.
 - c. Measuring a straight road vs. a curved road.
3. Third, some map reading skills are generally more difficult than others. Therefore, a task can be simplified by e.g.:
 - a. Utilizing a compass rather than coordinates.
 - b. Asking the student to identify map symbols or features rather than topographical contours.

Back-stories

A number of potential back-stories that will work with the activity structure were presented to six teachers across Sweden (UGOT). These ranged from game like back-stories involving aliens, to more realistic or serious activities such as town planning.

The response to the back-stories varied between the teachers but there were several common themes. For example, some of the more fun back-stories were deemed to be too childish, too scary, or too close to play to be used for serious learning. The more realistic or serious activities had the benefit that they could lead to discussion in the classroom but some effort would have to be made to ensure the content is accurate. It was also a worry that the content could be less engaging.

As the back-story does not impact the structure of the activity there's still no final decision on which back-story to use. Yet, the possibilities collected will be further analysed in future studies. For initial studies (that were done in this first year) a simple fun activity was considered sufficient to teach map reading skills. However, a more serious back-story may be required regarding long term studies and to convince teachers of the added value of the system (e.g., further discussion in class about the activity) in the classroom.

Teachers' views on the use of empathic robotic tutors in classroom

In the context of interviews, it was explored how teachers' would approach their teaching roles if unhindered by time constraints, investigating possible benefits for teachers and students of implementing the robotic assistants.

Therefore, semi-structured interview were performed with teachers in Sweden, England, and Portugal. The teachers' sample description is described in **Figure 3**. There were several themes regarding the tutor role that emerged from the interviews:

	England	Scotland	Portugal			Sweden			Average
Gender	M	F	F	F	M	F	M	M	4M/4F
Age (Y)	54	48	47	44	38	29	25	38	40,4
Teaching experience (Y)	32	26	17	19	13	5	1	13	15,8

Figure 3. Sample description of teachers participating in user experience scenarios.

Pragmatic realities and ways of working

Teachers' workload

There were general concerns that the presence of robotic tutors might introduce competition between students who would want to interact with the robot. This would result in increased administrative and “conflict resolution” workload for the teacher who would have to keep track of each student’s time spent working with the robot, which can be a practical disadvantage due to time constrains facing teachers today. Nevertheless it was also pointed out that competition would probably decrease in step with the novelty effect wearing off and even might, eventually, result in a loss of interest.

If robots could work autonomously, teachers recognize that they could prove beneficial tools for their teaching practice reducing their workload in terms of teaching and administrative tasks. In other words, if robots could function without much interference from the teacher in a separate room, they seem to view robotic tutors as a solution to the issues of time constrains mentioned.

Delivering personalized education

As teachers valued providing personalized responses to students, they thought the robot could become a resource if it would be able to encourage students to think an extra step during the activity when teachers would not have time to do so themselves, because they would need to give equal attention to all students.

Adapting the robotic tutor to classroom practise

Teachers envisioned these situations working in practice using the educational material conveyed by the robots as an activity within a larger class project, for example through station rotation. Teachers also expressed the importance of developing a robot that would manage small group work, since strictly having individual sessions could become extremely difficult to manage with lessons time assigned to geography. They also discussed some potentials issues

that could arise during group work or when students were left alone with the robot (e.g., group dynamics).

The role of the robot

Teachers pointed out that they wanted the robot to contain an automated assessment database, where teachers could check each student's process. However, it was made clear that they did not want to grant the application freedom to actually grade their students, stressing the importance of the teacher being in control. In addition, students would need to be aware of exactly what is documented about them in order to preserve their identity (e.g., grades feedback). Most teachers conceive robotic tutors as peers (in relation to students) that can guide and motivate students through several learning tasks. It was also highlighted the fact that robots in educational settings can promote independent learning.

Robots as social entities

Unlike other ubiquitous technologies, when discussing humanoid robots aimed for educational settings, fears are induced regarding the risk of robots replacing human-human interaction (McQuiggan, et al., 2008). This is an interesting phenomenon that hardly occurs for other intelligent tutoring system projects. Namely the mere physical embodiment of the tutor seems to provoke fears. Some of these concerns were noted expressed by the teachers interviewed. At first, they seemed inclined to carefully assess whether or not we were working on robots intended to replace them. When researchers informed them that this was not the case, they went on to question if a social connection was even possible, partly due to lack of faith in or knowledge about the recent technology advances. Both teachers' and students' perceptions of the interaction between the tutor and the students thus need to be evaluated in a later stage of the project.

Overall, the teachers thought that having a robot/touchable set-up as part of the teaching system in their lessons was plausible as long as it would adjust to the school settings and relevance for the aspects of the program. As it occurs that during the academic year teachers develop group activities due to class size, time and workload, they would perceive having a supportive system as this one as valuable. With this, the expectations of teachers relate to a robot-tutor that could create motivation in students, improve their creative process and promote student independence in the discovery learning process. Teachers imagined that the engagement with the robot would be smooth due to the novelty that it constitutes but they also required that the system should prompt feedback to the teacher (e.g., if the student is not making progress) so they could have an indication of how the student is doing. Regarding levels of difficulties, teachers claimed that it would be important to be able to adapt them but that this should be done in an implicit way rather than an explicit. Although having a system like these might improve learning, teachers were concerned about some technical aspects of this set-up, depending on the school conditions. Nevertheless they seemed satisfied with and curious about this approach and to its possible results.

Participatory design workshop

An important ability for the robotic tutor is to adapt to different students' needs. As such, a thorough understanding of learning difficulties and learning enablers in this area is required. In the geography syllabuses examined as well as previous research, it has not been made evident how different skills in map reading vary in difficulty, although there have been attempts to gather insights in the area. Therefore, it was decided that 3 geography teachers in Sweden (UGOT) would be consulted through a participatory design workshop, in order to utilize their experience and expertise in this regard.

In the participatory design workshop the teachers were provided with a preliminary version of Scenario 1, and were asked to contribute to the design (see **Figure 4**). In this version of the scenario the learner was asked to follow a route on a local map, based on information from the embodied tutor. The teachers' contribution comprised ideas for technical content, as well as pedagogical strategies adopted by the robotic assistant. In order to elicit appropriate responses, the teachers were asked to envision a more and less capable student as a basis for their pedagogical strategy. Thereafter they were asked to write down the verbal formulations they would use for these two different students within the same task. It was specifically urged them to think of changing their approach from more guided to discovery learning depending on the student's need for support.



Figure 4. Participatory design workshop with teachers in Sweden.

The results suggested a general trend in how directions and instructions are framed, according to student's needs and different capabilities. This way, the less capable student can be provided with rather simple and clearly formulated pieces of information at a time, while the

more capable student can be provided with one or several complex pieces of information. However, it seemed to be rather difficult for the teachers to provide a description of how they would adjust to different students' needs from a fictive perspective. Instead of adapting the route-following task's difficulty level by providing more or less scaffolding they broke down the actual route into pieces, which in itself may not provide more or less support to the student to understand the different map-reading concepts. This indicates that these interactions need to be observed in practice rather than theory. In order to study teachers' pedagogical strategies in practice, these workshops were thus followed up by mock-up studies at a later time. These mock-ups are presented in *Section 4.2* related to learner-centered activities.

4.1.3. Wizard-of-Oz study

Wizard-of-Oz (WoZ) is an effective technique in human computer interaction studies where an interactive agent, which is not yet fully autonomous, is fully or partially controlled by a human wizard (Dahlbäck, Jönsson, & Ahrenberg, 1993). A WoZ study was performed and is widely described in *Section 4.2.2* as a learner-centered activity. However, the focus of this WoZ study was mainly on testing the WoZ environment in combination with the robotic tutor and a multi-touch application, not on the pedagogical role of the robot tutor or the educational value of the application. Furthermore, the experimenter performing the Wizard-role was not a teacher. In order to receive teacher input about the pedagogical approach of the robot tutor and the educational application we performed a Wizard-of-Oz comments study as described below.

Wizard-of-Oz comments

In the WoZ comments study the videotaped materials of the WoZ study were shown to three focus groups of teachers from three schools in Sweden; the first one with three teachers, the second one with two teachers, and a final one with six teachers. The teachers themselves were filmed when commenting on the materials (see **Figure 5**) in order to facilitate later analysis.

They were first given the scenario used in the WoZ study (see **Appendix 1**) and then watched the first part of one of the videos containing the instruction to the student. Thereafter they watched the WoZ videos of all students and commented on them. The teachers seldom showed any gestures or gave direct examples of what they would say while they were watching the videos, but they had numerous reflections afterwards. Those comments were related to the user interface, the pedagogical approach, and the way the tutor generally behaves towards students. However, one has to keep in mind that the WoZ environment was still rather limited, thereby restricting the wizard considerably in the types of actions possible. Some comments of the teachers are therefore more related to the possibilities shown, than to the real scenario that will be implemented later. The teachers' feedback is described below.



Figure 5. Teachers discussing the Wizard-of-Oz study

Teacher feedback: User interface

The teachers commented about the students' struggling with the user interface and recommended the use of a robust detailed map of the local area containing details about the terrain on which the route taken is clearly displayed. Basic map reading skills, such as using a compass, should first be practiced in a separate activity before using it in the map reading activity. The back-story for the map reading activity should play a more prominent role in order to motivate the children.

Teacher feedback: Pedagogical approach

The scenario as presented in the WoZ study was perceived to be much more like a test than a learning scenario. The teachers were not convinced that students would actually learn from it, except how to zoom in and scroll, which they thought is an important map reading skill nowadays as well. The main suggestions to improve this was by making the robot encourage students to explain more, let them think aloud and asking why-questions, even if it would not be able to understand these explanations. Instead of asking questions like "What is the name of the road?" the student should get the opportunity to show that s/he understands the concept (e.g., North-east). Since the concept should be in focus, not the correct answer, the system should be able to recognize plausible alternative answers that show this understanding. These important recommendations are our main concerns in the further development of the scenario and the design of the tutor behaviour. However, it is important to note that they are partially caused by the limited technical possibilities for the wizard to ask more questions and be responsive.

Furthermore, the teachers recommended not giving too many instructions at once, making a clear distinction between instructions and other kinds of information. The system should also detect wrong and insecure behaviours sooner and intervene rather quickly, not necessarily by guiding the student directly, but by asking whether help is needed, helping the student to return to a familiar place on the map, and assuring that the student has understood the question or instruction. Finally, whenever the student has reached a sub goal as well as the final goal, the application should provide clear feedback and reward this properly.

Teacher feedback: Robot's behaviour

Concerning the robot's behaviour, the teachers felt that much more effort should be put into creating a bond with the child, for example by having a jokingly off-topic conversation before the actual task, behaving more like a companion than a teacher, acknowledging when a student is trying to make eye-contact or says something in a questioning way, as well as having a broader repertoire of utterances to say similar things. Help should be provided in a personal way, and not too much as instructions.

4.2. Learner-centered Activities

The learner-centered activities were developed with students of the target ages in different countries. These activities served to the design of artificial empathic tutors in order to maximize the enjoyment and the performance outcomes of the user's learning experience, endowing the tutor to react to the learner's skills, difficulties and affective states experienced during the learning process and the interaction with the tutor. These activities are described below, and **Figure 6** displays a summary of the different activities that were carried out.

4.2.1. Mock-up study 1

Mock-up study 1 | UGOT

Goals

A mock-up is a prototype that enables testing and design of some functionalities of a system (Bartneck, & Hu, 2004). The first mock-up study was performed with an initial version of the map reading scenario in England (UoB) and in Sweden (UGOT) (see **Appendices 3 and 4**). The mock-ups were adapted to the local area of the school in which the mock-up sessions were held. In each participating country the mock-up was used by a teacher together with students with different capability levels (two in Sweden and three in England).

The aim of the mock-ups was to study how teachers adapt their pedagogical strategies in a learning situation to respond to students' needs. A side aim was to determine the teacher's and student's general use of eye-gaze during the activity. The sessions in both Sweden and England were filmed, transcribed, and annotated. Results of the annotations concerning eye-gaze are described in more detail in D5.1 (given its role in creating behaviours for our robotic tutors).

Participants

The sample of the mock-up study in Sweden (UGOT) consisted of 2 students and one teacher and concerned a map reading activity. As it concerned an individual activity scenario, each two sessions were held with one student and one teacher.

Conditions

The activity was run with one very capable and one less capable student.

Material

The following material was used: Instructions for the teacher (see **Appendix 4**); a local map; a topographical map; a compass; a ruler; a string (for measuring non-straight distances, and comparing to ruler); coloring pencils; a grid overlay, 2 cameras, one capturing the overall situation and one focusing on the participants' faces; and an external table microphone

Initial findings

The present study led to the following initial findings:

- Using the local area makes the activity easier, because both the student and the teacher can use pre-existing knowledge. Difficulty levels could be increased by placing the activity in an unfamiliar location.
- The teacher challenged the more capable student by asking her to explain her actions, i.e., “Why did you choose that road?” or “Can you explain what tools you can use here?” The teacher also asked the student to transfer her knowledge of one map to the other, i.e., “Can you find the same place on this other map?”
- Hesitation and vocal intonation indicated uncertainty and were used as a way to seek confirmation. Sometimes a smile was also used to indicate uncertainty.
- The teacher usually responded to the student’s uncertainty by reminding the student of previous locations, as well as possible tools.
- The teacher always observed the same place on the map as the student and indicated approval through empathic sounds, such as “Mmm. Good” while the student was ‘thinking out loud’.
- The map scale should be placed in clear sight.
- Using maps with different scales simultaneously is very difficult.
- Satellite maps without street names are hard to use.
- The practical hands-on approach with the maps was particularly motivating for the less capable student.
- The teacher broke down the more complex questions into manageable components targeting specific map-reading skills.
- The teacher’s use of hands to illustrate (e.g., how topographical lines would look in reality was very prominent).
- The teacher performed oral transfer tests by posing questions such as “What if you had gone here instead?”

Mock-up study 1 | UoB

Goals

The mock-up study in England (UoB) concerned the same activity as in Sweden (UGOT) and had the same goal. Therefore, the main goal was to study how teachers adapt their pedagogical strategies in a learning situation to respond to students' needs.

Participants

The participants of this study were three students of varying ability and one teacher. The sessions were organized similarly as in Sweden, in an individual setting.

Conditions

The activity was run with one very capable and one less capable student.

Material

The material used in this study, was the following: Instructions for the teacher (see **Appendix 3**); a map key that explains the map symbols (e.g., roads); three maps of the local area at different scales: 2500m; 10000; 20000; a transparent compass; three map scale transparencies, one scaled appropriately for each map, used to measure distances. There were 2 cameras, one capturing the overall situation and one focusing on the participants' faces.

Initial findings

The study led to the following additional findings:

- Teacher ensured that the student understood the question. By prompting them to read the question in more detail. Also, they would ask the student to explain the question back.
- Teacher did not give the answer, but would keep probing until the student understood the question and would keep guiding towards the answer.
- The teacher would try to make the task more engaging by adding context and bringing the map to life.
- The teacher would relate the map to objects in the world, possibly features that the student could see from the window, or was familiar with.
- The teacher would give tutorials (e.g., about the use of a compass), seamlessly in the exercise if needed.

	Mock-up 1	WoZ	Mock-up 2	Mock-up 3	Total
Partner	Birmingham University, Birmingham University of Gothenburg, Sweden	Heriot Watt University, Scotland	University of Gothenburg, Sweden	INESC-ID, Portugal	
Main Goals	Study how teachers adapt their pedagogical strategies in a learning situation to respond to students needs.	Investigate the limitations of the technologies.	Test the influence of the positioning of the tutor and the student in relation to each other.	Analyse the group interaction.	
Student Sample	2 students from Sweden 3 Students from Birmingham	3 students from Scotland	12 students from Sweden	31 students from Portugal	51 students
Teacher Sample	1 teacher from Sweden 1 teacher from Birmingham	1 teacher from Scotland	2 teachers from Sweden	1 teacher	6 teachers
Number of Session	5 sessions	3 sessions	12 sessions	11 sessions	20 sessions
Sessions Duration	30 minutes per session. Total of 150 minutes.	20 minutes per session. Total of 60 minutes.	20 minutes per session. Total of 240 minutes.	60 minutes per session. Total of 660 minutes	1110 minutes of recorded sessions.

Figure 6. Brief description of learner-centered activities.

4.2.2. Wizard-of-Oz Study

Goals

When designing interactive technologies, formative evaluations are carried out using partially functional products. Especially when the technology is particularly novel, as in the case of robotic tutors, it is beneficial to carry out evaluations using a simulation before any large investments of money and time are made. In human–computer interaction, evaluations using such simulations have become synonymous with the term Wizard-of-Oz. In a Wizard-of-Oz evaluation some or all of the interactivity that would normally be controlled by computer technology is imitated, or manipulated by a human being.

Based on the first mock-up study, a WoZ environment was developed to test the WoZ environment and interface, evaluating the learning scenario in combination with the robotic tutor behavior (see Figure 7).

Participants

Three students were asked to play out the scenario (see **Appendix 1**) and one adult subject played the human-wizard, who controls the robot.

Conditions

One study played the map reading task in a multi-touch table with one Nao Robot, performing an individual setting.

Material

The WoZ environment consisted of the wizard's desk, the interactive touch table, sensors, and the robotic embodiment as shown in **Figure 3**. The wizard, steering the Nao robot's verbal and non-verbal behaviour was seated in a different room away from the student.

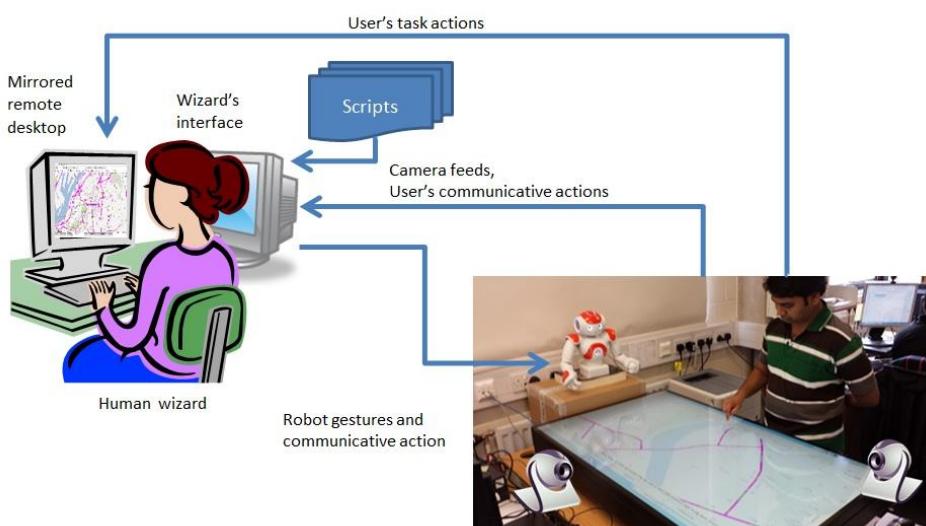


Figure 7. The WoZ environment

Wizard's desk: The wizard's desk consisted of two display screens. The touch table display at the user end was mirrored on to one of the displays at the wizard's desk using which the wizard can observe the learner's activities related to the educational application. Another display contained the Wizard Interface, a software application that allowed the wizard to interact with the learner.

Application: The educational application was displayed on an interactive touch table surface. A map based application was developed to teach learners basic and advanced map reading skills. The touch interface allowed the learner to use touch to click, drag and zoom the map.

Sensors: The environment had an array of sensors such as two video cameras and a Kinect sensor. A Kinect sensor and a video camera were placed in front the learner. Another camera was placed in front of the robot

Embodied robot: The robotic embodiment was a Nao robot (torso version) that sat on the long side of the touch table. It was capable of head, arm and body gestures in addition to synthesized speech. The robot received the text and gestures selected by the wizard through the Wizard Interface. Tutor's utterances were synthesized into speech using the in-built text to speech (TTS) engine while the gestures were realized using appropriate head, arm and body motions.

Initial findings

Their interactions were filmed from two sides (from the side and the front). In a later phase, these interactions were shown to teachers that provided their feedback about the activity. Comments are stated in *Section 4*, in the tutor-centered activities.

4.2.3. Mock-up study 2

Goals

Based on the individual scenario 1 presented above, a second mock-up study was performed in Sweden (UGOT). This mock-up study had a threefold purpose:

1. To test the scenario with teachers and students in order to adapt it in terms of technical design and appropriate difficulty levels.
2. To gather utterances and behavioural data from the teachers and students in order to adapt the robotic tutor's perceptive capabilities as well as pedagogical approach.
3. To test the influence of the positioning of the tutor and the student in relation to each other (at two sides of the table opposite each other, or two adjacent sides) concerning its potential effect on engagement (see **Figure 8**).

Conditions

A simplified paper-based version of the final version of Scenario 1 (see **Appendix 5**) was performed in 12 separate sessions comprising one-to-one interaction between a student and a teacher. In contrast to the first mock-ups, the participants were seated. The location of the map was the local area around the participants' school. Half of the students were placed on the teacher's right side and half in front of the teacher (see **Figure 8**).

Participants

12 students and two teachers participated in the mock-up study. The sessions were filmed with three cameras and will be transcribed and translated from Swedish to English for detailed analysis.

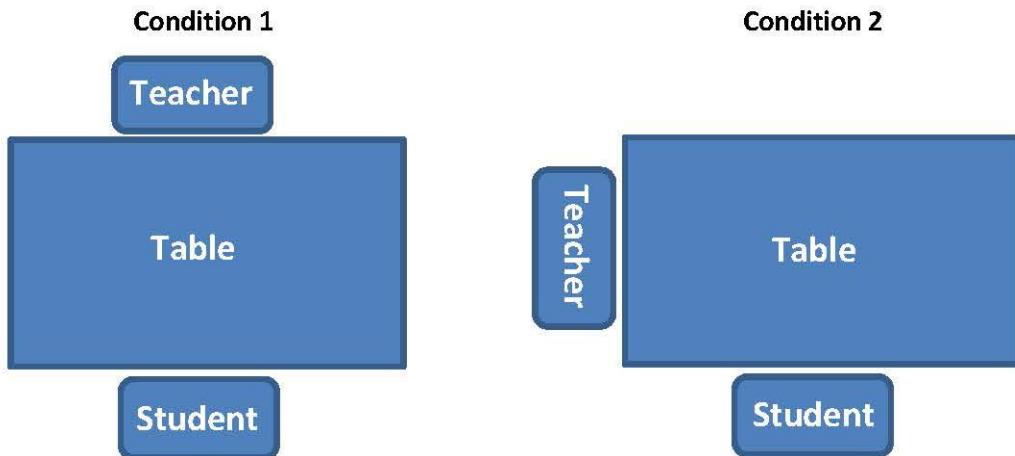


Figure 8. Positioning conditions of mock-up study 2

Initial findings

Preliminary findings of this study are the following:

1. The application: Back-stories, difficulty levels, map reading, user experience.
 - a. There was positive feedback from both teachers and students regarding the design of the scenario. The teachers said that they usually did not do this kind of activity, and that they felt that the students responded well. The students said that they found the activity fun, and that they would like to do something similar on a multi-touch table. Although this might sound contrary to the teachers in the WoZ study commenting that the students would not learn anything beyond e.g. zooming in and zooming out, we have to keep in mind that here the teachers and students were not hindered by any technical limitations of the WoZ environment. The activity in itself thus seems appropriate, but the robotic tutor's role should be developed more.
 - b. The concept of having a practice phase followed by a testing phase in Scenario 1 proved to be efficient, i.e., the students could use the knowledge gained in the first phase, and utilize that for the second phase.
 - c. The trivial back-story of the thief did not seem age appropriate for the target group.
 - d. The students responded well to the difficulty levels. The different tasks required a bit of initial scaffolding from the teachers in varying degrees. Thereafter, the students were capable of working through the tasks on their own in most cases. In general, the level of difficulty seemed to be appropriate for the age group.
2. A corpus of teacher and student behaviours was gathered. A detailed analysis concerning eye gaze, movement of hands and body posture still needs to be performed, but some key commonalities are the following:
 - a. The teachers would begin the activity by asking the students whether or not they recognized what the map depicted.

- b. Thereafter, they asked the students to locate their school. When the students struggled, the teachers would ask if they could try to find surrounding landmarks on the map, and try to find their way based on their previous knowledge of these surroundings.
 - c. When students received directions, they would often confirm that they had heard correctly by repeating the directions, whereby the teachers would confirm by responding yes, or repeating the directions.
 - d. The teachers provided scaffolding in a chronological set of phases, where if the student seemed confused or navigated in the wrong direction, the teachers would (1) repeat the directions placing emphasis on the key words, or just repeat the key words with emphasis in isolation; (2) suggest a map reading tool through oral or physical recommendation (i.e., by handing over the appropriate tool, e.g., the ruler, or pointing/gesturing towards); (3) explain how a tool or feature is used (lecture); and (4) return to the task at hand.
 - e. In some sessions there was rarely any silence, while in others the student worked for a while independently. This seems to suggest that teachers have an intrinsic understanding of when it is appropriate to speak and when not to, perhaps due to the fact that they know the students well.
 - f. The teachers gestured frequently towards the map when explaining concepts and discussing with the students.
 - g. When the students had placed their game piece in a certain location, and this was incorrect, the teachers would rather quickly refrain from addressing the student as "you". Instead, they would say, "Hmm.. Are we really in the right place here?", "Perhaps we went a bit too far here...", etc.
 - h. The teachers provided calm and supportive positive feedback when the student succeeded (e.g., "Good job!", "That's right.").
 - i. The teachers made assessments by asking the students to explain their line of thinking, and often times asking what the students were thinking when they were, e.g., contemplating which tool to use.
3. Regarding the positioning of the teacher, the teachers said that they felt that they established more eye-contact when seated in front of the student which can possibly lead to higher engagement. However, a closer analysis of the video material will have to be performed in order to corroborate this intuition. This analysis will be done before the end of the reporting year and will inform the setup of our system for further mock up studies as well as the final evaluations.

4.2.4. Mock-up study 3

Goals

A mock-up study with scenario 2 was held in Portugal (INESC-ID) (see **Figure 9**). Being the first mock-up performed with the collaborative scenario, the formulated objectives were the following:

- Analyse the group interaction;
- Analyse possible curriculum links within the activity;
- Analyse emerging issues about the game.

Participants

This mock-up sample concerned one teacher and thirty-one students and was focused on the topic of sustainable development, using the Enercities game task⁵ in a multi-touch table.

Conditions

Two conditions were established for the present study: in Condition 1 three students played the Enercities game in the multi-touch table (7 sessions), and in the Condition 2 two students and a teacher played the game (4 sessions).



Figure 9. The setup for the Mock-up 3 study in Portugal.

Before the experimental task itself, a previous phase was conducted in order to establish the game context for the teacher. In this phase the following was explained to the teacher:

- The game: Information regarding the game actions (e.g., rules, main goal) was provided to the teacher in order to get familiar with the game concept and tasks.
- The teacher role: It was explained that the teacher had the same goal objectives as the students. Nevertheless the teacher role would not be static. For that, according to students' performance, the teacher had a more guiding approach or could let them discover the game.
- Practical part: a game test was run with the teacher to ensure the set comprehension and some training.

A game test was also played with one group of students so that calibration of the multi-touch table could be done and to ensure that the game would run.

⁵ More information about the game will be presented later on in this deliverable, as well as in the Deliverable 6.1.

The experimental task procedure was conducted using the two study conditions:

- Condition 1:
 - The teacher was instructed to play the mayor role and the two other roles (environmentalist and economist) were divided among the students;
 - According to the assigned roles, the teacher and the students were positioned around the multi-touch table in pre-designated areas;
 - Instructions were given by running a brief test game (see **Appendix 2**);
 - Subjects played Enercities for 20 minutes;
 - After playing Enercities, the teacher answered individually to a brief questionnaire related to the previous game. This questionnaire was answered for each of the four group cases;
 - A set of questions was asked to students in a semi-formal individual interview. These questions had an open format and were related to the Enercities game, to the group with whom they had played, and some thoughts they may have regarding robots. Also, some basic demographic information was gathered.
- Condition 2:
 - The roles in the game were divided arbitrarily among the students;
 - According to the assigned roles the students were positioned around the multi-touch table in pre-designated areas;
 - Instructions were given by running a brief test game (see **Appendix 2**);
 - Subjects played Enercities for 20 minutes;
 - A set of questions was asked to students in a semi-formal individual interview. These questions had an open format and were related to the Enercities game, to the group with whom they had played, and some thoughts they may have regarding robots. Also, some basic demographic information was gathered.

Material

The following material was used in the study: A Multi-touch table; 3 video cameras capturing each participant; three tripods; three microphones for each subject; a multi track audio recorder (Zoom H6); a mini-Jack to mini-Jack audio cable (at least 3 meters); two triple socket; and three SD card.

All the data was video and audio recorded: Three video cameras were used to capture each participant, and three lavalier microphones were used for each participant allowing hands-free movements along the task.

Initial findings

Although we have not analysed the results yet or compared the two conditions, the first impression from the data obtained suggests that the collaborative learning setting is very rich and has indeed the right ingredients for the exploration of the second topic selected (sustainable development).

5. Scenario Design

Given the studies carried out with teachers and learners, we needed to agree on the two scenarios, taking also into account the technical constraints and limitations. So, in general we investigated the tutor's embodiment, technical considerations and limitations, and multi-touch tables in a learning context. These topics are introduced below.

5.1. Tutor Embodiment

It has been shown previously that interacting with both 2D and 3D virtual tutors can have some positive learning effects on students, most particularly in terms of students' overall presence, involvement and control, naturalism of the experience, and resolution (McQuiggan & Lester, 2007). Most significant research in artificial tutors has been performed by using virtual agents that interact with learners via a computer screen (D'Mello, et al., 2007). However, several studies suggest that people's perception of robots is qualitatively different from their perception of virtual agents due to robots' physical embodiment. Experiments comparing robots with their virtual representations have shown that the robotic embodiment was preferred by users in terms of social presence (Kidd, 2003), enjoyment (Pereira, et al., 2008) and performance (Bartneck, 2002).

So far, few studies have investigated the use of robotic tutors when compared to their virtual counterpart. This opens up opportunities for novel contributions in the field of artificial tutors. Recent research on socially intelligent robots shows that robots are increasingly being studied as partners that collaborate and do things with people (Breazeal, 2009). This has made the use of robotic platforms as tools for experimental learning more approachable (Leite, et al., 2012) and a few examples where robots are used in learning scenarios can already be found. Some examples explore what features are the most important for robots to affect students' learning and behaviour (Okita, et al., 2009; Saerbeck, et al., 2010). Home robots, when compared to other types of instructional media were shown to be more effective in increasing students' learning concentration, learning interests and academic achievement (Ryu, et al., 2007). All of these works show the potential of robots as a new interactive technology for learning.

As described in D6.1, the architecture that we propose for our tutor allows our agent to be virtually or physically embodied. It is intended according to the EMOTE objectives to test different embodiments and use our agent in different devices, such as cellphones and tablets. However, given the scarcity of studies on robotic empathic tutors and some of its promising results, we are currently focusing our user-centered design studies on robotic embodiments for our tutor. Designing the tutor for different embodiments or devices will be reported on in D2.2.

5.2. Technical considerations

The vision of the EMOTE project consists of a learning activity where one or more students are working together at a multi-touch table with a robot tutor. The interaction of the students with the multi-touch table was widely discussed among EMOTE partners taking into account the state of art on the subject and the objectives of the project. It was set that the process of

interaction between a student and the multi-touch table system involves the consideration of technical requirements as the use of the touch-screen interface as a vehicle of communication between the student and the system. As most of the children are used to interact with characters through touch-screen interfaces, this type of interaction with the system is a reliable one (Higgins, Mercier, Burd, & Joyce-Gibbons, 2012). Students' expectations about the capabilities of the system, and the system's understanding of students (e.g., behaviour) along the game are also related to this type of technical requirement.

Technical requirements

It was decided that students only interact with the system through a carefully designed touch-screen interface (e.g., selection of a location or a multiple choice answer). The alternative to this was to also use a speech recognition system. However, building an end-to-end speech system with speech recognition and speech output would require two additional components for each of the three languages of the participant countries (English, Swedish, Portuguese) namely Automatic Speech Recognition (ASR) and Spoken Language Understanding (SLU). ASR transcribes the words that the user says and the SLU component determines the appropriate meaning of the user's entire utterance (Belpaeme, et al., 2012). Although ASR for English is a relatively mature field there are still few studies on the accuracy of such systems for children's speech. It has been shown that children tend to have higher variability of linguistic tokens due to the growth of their vocal tracts (Lee, et al., 1999), which result in more speech recognition errors (Wilpon, & Jacobsen, 1996; Nicol, et al., 2002). Also, ASR systems for Portuguese and Swedish are not widely available and ASR tuned for children in these languages is definitely beyond the state of the art. In addition to this, creating three such end-to-end systems is beyond the scope of the project and would detract resources from the real focus, which is empathic tutoring.

One possibility is to have speaker dependent speech recognition whereby the student is asked to read a list of words to train the system to that individual's voice. This has still been shown to have a relatively high error rate (75% compared to 98% for adults (males), (Nicol, et al., 2002) and there would be concerns that the students would get tired and bored even before the experiment started. Even if this was an option, this tool is only available for English⁶ and would require the development of SLU components for each language.

By using a well-designed, robust touch screen interface instead of speech recognition, the likelihood of errors that could have a detrimental effect on the student experience and skew the results, is reduced. For example, in a the situation where the student asks for help by simply saying "help" but this where this is misrecognised as "hello", the system will not respond to the student's request for help, missing an opportunity for tutor intervention which may be deemed educationally unsound. It may also increase the frustration for the student and undermine their confidence in the tutor. However, due to this limitation several issues in the design of the learning platform have to be overcome:

⁶ With the exception of this Swedish voice search app from Nuance (which may not be available for development purposes) <https://itunes.apple.com/se/app/dragon-dictation/id341446764?mt=>

Setting students' expectations about the capabilities of the system:

The interaction will have to be carefully designed so that the student does not become frustrated with the inability of the system to understand verbal responses to questions, as with a robot in the shape of a human they may expect it to be able to respond to speech. However, we as most children are used to interacting with characters through a touch screen due to the widespread use of tablet devices at home and school. So, we believe that this will not constitute a major issue along the interaction. Studies point that the touch-screen type of interaction in children enables them to control and interact with the information on a screen, being better able to engage in this type of learning environment, especially in a collaborative learning set (Higgins, Mercier, Burd, & Joyce-Gibbons, 2012).

Understanding the students' behaviour, difficulties, and thought processes:

Also this will constrain how a student is able to explain their thought process or answers. Again the system will have to be carefully designed so that it can ensure the accurate detection of the area in which the student is having difficulties with (D'Mello, & Graesser, 2012). It will also need to be ensured that the student cannot deceive the system somehow and make it appear that they understand the skill when they are just guessing.

Finally, this system should be very robust, since students will be taking time to interact with it during school time. The system will need to work when there is no internet connection available. In some schools this may not be guaranteed.

5.3. Multi-touch tables in learning

A traditional table, by itself, is an object that allows a social interaction, sharing of ideas and communication between people (Morris, et al., 2006). In an educational context, having students working in groups at a table improves collaboration and allows an exchange of knowledge. According to Rochelle's theory of convergent conceptual change (Roschelle, 1992), when two learners work together with a reflective tool, they tend to converge on an understanding that is better than either could achieve independently (Roschelle, 1992). Specifically, using multi-touch tables in a pedagogical scenario, such as a classroom or as a support to students' study, will possibly enhance interest in learning. The flexibility and ease of use of multi-touch devices make them an interesting complement to other pedagogical tools.

Within the use of this system in a pedagogical context, aspects such as interaction, level of knowledge and collaboration emerge. This way, an important issue is to compare students working together on a normal table with paper with devices like a multi-touch table (Higgins, et al., 2012). In this case, the flexibility of multi-touch tables brings more benefits for the final goal of learning. These benefits are related to how the multi-touch characteristics allow for an organization and sharing of objects on the table. Not being able to grab objects but being able to zoom them instead, leads students to share objects with each other and think aloud, creating more interaction and exchange of ideas between participants. Collaboration is again a highlight, because students tend to interact more with each other, as their attention is more

focused on the common goal. The multi-touch table allows for more engagement of the group with the tasks.

There is also the case when one student knows more information on the subject than the other, so the more skilled one will help the less skilled. This matter is important when elaborating pedagogical scenarios with multi-touch tables. Some studies have focused on the multi-touch table design to improve collaborative activities as the horizontal surfaces offer significant advantages for interaction and collaboration. However, the pedagogical software and the collaborative-oriented tasks used have a higher impact on the overall collaboration, than the multi-touch device itself. The software can also help to reduce the problem of students that do not participate as much as others (Higgins, et al., 2011).

A common finding from the aforementioned literature suggests that multi-touch tables allow for better organization of ideas in terms of group and individual tasks. Collaboration is strong, because there is more interaction and communication and less individual focused tasks. The objects on the table are spread according to individual and group needs: individual objects are closer to the participant and the rest is set in the middle of the table (Antle, et al., 2011). Although the technology is still expensive for real-world applications, the development of pedagogical scenarios using multi-touch tables is growing due to the engagement students demonstrate, which improves their learning, and provides them a new educational experience (Higgins, S. E., Mercier, E., Burd, E., & Hatch, A., 2011). Due to the aforementioned information, a multi-touch table device will be used in EMOTE as a showcase system to develop the scenarios.

6. Learning Scenarios in EMOTE

Based on the studies described above two learning scenarios in EMOTE were determined. The **Map Reading Scenario** was chosen as the **individual scenario** in which adaptive support to an individual student is given by the robotic tutor. The **Sustainable Development Scenario** was chosen as the **collaborative scenario** because here the robotic tutor would be able to support complex reasoning and reflection within a group. The description of these two scenarios is described below.

6.1. Scenario 1

As mentioned before, scenario 1 focuses on local map reading as an individual activity. The scenario is easily adaptable to local maps and allows for adaptation of difficulty levels, as will be described below and an almost final version of Scenario 1 was developed. The scenario involves local map reading skills based around the back-story of a person/object that has to be found on a map. Steps:

The student has to find several informants on the map for which the robotic tutor gives directions in terms of map reading competencies (e.g., go south 200 meters). Difficulty levels can be varied by a) giving more complex directions, b) using more difficult versions of map reading skills (e.g., using South-South-West instead of just South or requiring to calculate), or c) using more difficult concepts (e.g., altitude instead of compass directions). For each informant that is found, the student receives a clue (or several clues) about the hiding place of the person/object. The clues are also defined in terms of map reading competencies, e.g. the person/object is hiding in a woody area. The same way of adapting difficulty levels as for the first step can be used in the clues.

After finding all informants, and thereby receiving all clues, the student has to point out the place of the person/object from a set of possible locations. Only one location fulfils all constraints provided by the clues, all other locations are incorrect in at least one of the constraints, thereby making it possible to detect flaws in the student's thinking. This phase requires the student to combine clues, which is inherently a more difficult task. Using more or fewer possible locations is a way to adapt the difficulty level of this task. A fictitious example of the scenario is presented in **Figure 10**, involving a thief and three informants, where the first informant is giving two clues.

6.2. Scenario 2

The second collaborative scenario is based on Enercities, an online game that teaches sustainable development through discovery learning (Knol, & De Vries, 2011). While playing Enercities, students can learn concepts such as pollution, energy shortages or renewable energy. Project Enercities was co-funded by the European Commission programme Intelligent Energy Europe. This project reports that it made students aware of energy expenditure. Schools across Europe have already used this game in their curriculum and this game was therefore chosen as the base of Scenario 2 (Knol, & De Vries, 2011).



Figure 10. Example of Scenario 1.

The original online single player game was adapted to a multiplayer version where participants, including the Nao robot as one, interact by using a multi-touch table. The idea of transforming it into a multiplayer version (3 players) was to stimulate collaborative learning but also to test the technology developed in EMOTE in a scenario where the empathic agent acts more as a peer rather than a traditional tutor with higher social distance. As reported before, this was suggested in the teacher interviews. When teachers were asked about the role that a robotic tutor should have in a learning scenario, most teachers conceived them as peers that can guide and motivate students. They highlighted that such a relationship can promote student's independent learning.

This new version of Enercities is turn-based and designed to be playable by three players: two human players and an artificial intelligent agent (see **Figure 11**). All players must build or improve structures in order to advance to the next level while maximizing a global score. The game is over when the players run out of non-renewable resources or when they complete the final level of the game. Players' final score is the sum of three individual scores: the environment, the economy and the wellbeing. At the beginning of the game each player chooses a role and each role is related to these scores. As such, each player can be the environmentalist, the economist or the mayor. They all have the same resources to spend: non-renewable resources (oil), energy and money. Oil never increases (yet, its decrease can be slowed down), money can be earned by building or improving certain structures, and energy can be generated through power plant structures or structure upgrades.

In each turn, the possible moves are:

- Building a structure: Every player can build housing or power plant structures. Only the environmentalist can build parks (which increases the environment score); only the economist can build industries and commerce structures (which increases the economy score, as well as the money); at last, only the mayor can build service structures (which increases the wellbeing score). As the game advances, more structures are available to be built. Building structures can decrease any of the resources available, as well as improve or decrease the individual scores.
- Upgrading a structure: Each type of structure has a set of upgrades that can be implemented in order to save resources or increase certain scores. These upgrades can simultaneously consume resources. Each role can upgrade the same kind of structures they can build. Each player can make at most three upgrades per turn.
- Implementing a policy: There is a special kind of structure that is already built by the beginning of the game: the City Hall. This structure allows the players to apply certain improvements to other buildings. It also increases the money value every turn.
- Skipping: A player can press the “Skip” button if they don’t want any of the actions above.

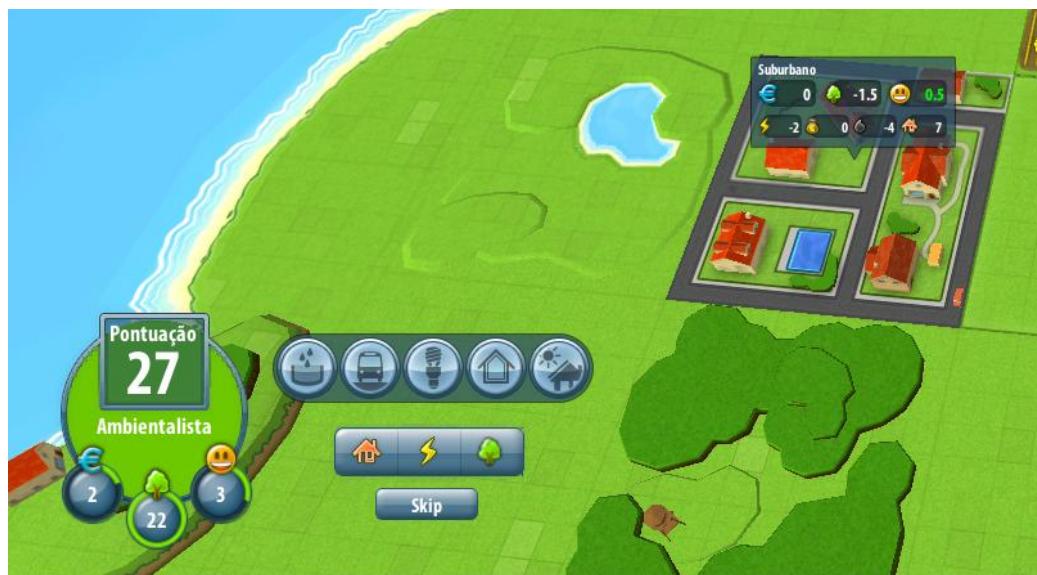


Figure 11. Example of Enercities game.

The game advances with population increase. Building houses can increase the population. These structures spend money, oil and energy and decrease the environment score. The score variation caused by a structure depends on where that structure is built (in terms of surrounding structures or proximity to certain elements, such as the river). When the game is over and at the end of each level, a new menu featuring the team global score, as well as the individual ones, is shown. This menu was created to promote discussion between the participants. By consulting this menu participants can reflect upon the influence of their actions both on their individual score and overall score of the game. It is expected, that they

conclude that it is beneficial to achieve balance between people's happiness, environment and profit.

The main goal of the empathic robotic tutor in this scenario will be to teach the other two students how to play the game, to stimulate energy consumption awareness, and to try to help or comfort users that are displaying negative affective behaviours. However, in order to be perceived as a peer, it tries to act as any other player trying to play the optimal move according to his role. The tutor will warn users about, for instance, energy or money necessities. Two extra user-centered design studies will be performed in order to inspire the robot's social and tutoring behaviour. In both of these studies the robot will be replaced with another human participant. In one study we are going to replace the robot with a student and in another with a geography professor. Both of these studies will be reported in D2.2.

7. Conclusions and Future Work

The main goal of this deliverable is to describe the design of learner-tutor interaction and learning scenarios and establish an overview of the pedagogical strategies designed to respond to learners' needs. To meet these goals, various pre-tests (mock-ups and WoZ studies) were conducted and feedback was used to alter the activities' design. In order to do that, different activities were held and related considerations were taken into account.

To set the context, the showcase of geography topics for the scenarios was established. Also, a review on the geography syllabuses was done assessing common curriculum among participating countries. Then, user-centered design activities were designed with teachers and students to gather information for the development of the scenarios as well to understand educational key-topics (e.g., levels of difficulty). Technical requirements for the development of the interaction with the system were discussed. This way, technical constraints related to system considerations were pointed out and adapted to the EMOTE Project purposes.

Several user-centered design activities to design preliminary versions of the scenario. To refine these scenarios we performed some further user-centered design activities based on the initial designs. This way, Scenario 1 was set in an individual format approaching map-reading activities and Scenario 2 resulted in an adaptation of Enercities to a multi-player collaborative game. These two scenarios comprise pedagogical strategies identified by teachers related to the covered curriculum and were conceived to respond to learner's needs.

For future work, annotations regarding video and audio records from the mock-ups will be performed according to the requirements gathered in D5.1.

Further, the adaptation of the learning scenarios to various embodiments is still being explored. Findings haven't yet indicated anything that outlines the role of a tutor in different embodiments. Due to that, the investigation about possible educational benefits in this type of user experience need to be addressed and are currently the objective of our future work.

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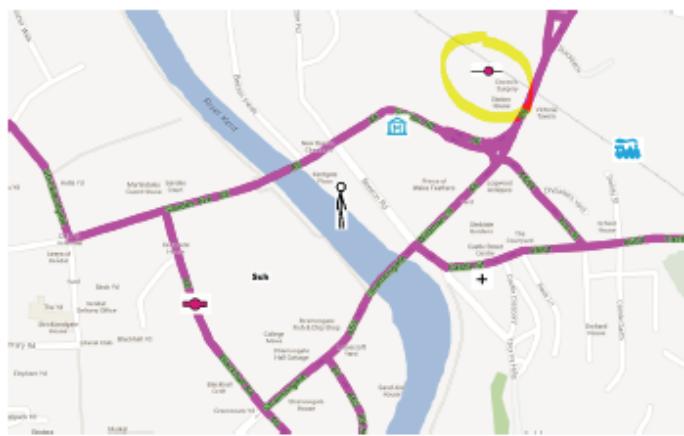
9. Appendix

9.1. Appendix 1 WoZ Instructions

Treasure Hunt in Kendal: Key

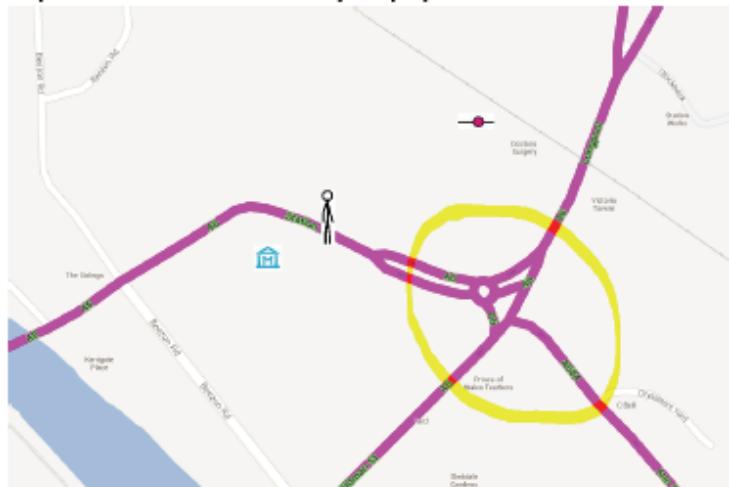
Step1: A valuable, magical recipe for Kendal Mint Cake has gone missing. Only these clues remain to say where it was hidden. Your task is to find it.

Step2: The suspect has just got off the train. Spot the Kendal train station. Drop a pin at the station.



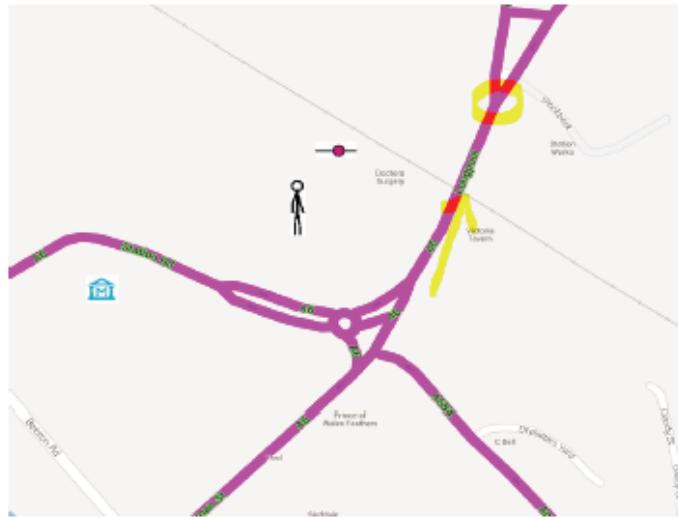
Train station is marked with a yellow circle above. The task is for learners to identify it using the OS symbol for train stations. Learners can mistake the preserved railway symbol on the right for the train station. They will have to create a way point near the station.

Step 3: There is a roundabout nearby. Drop a pin there.



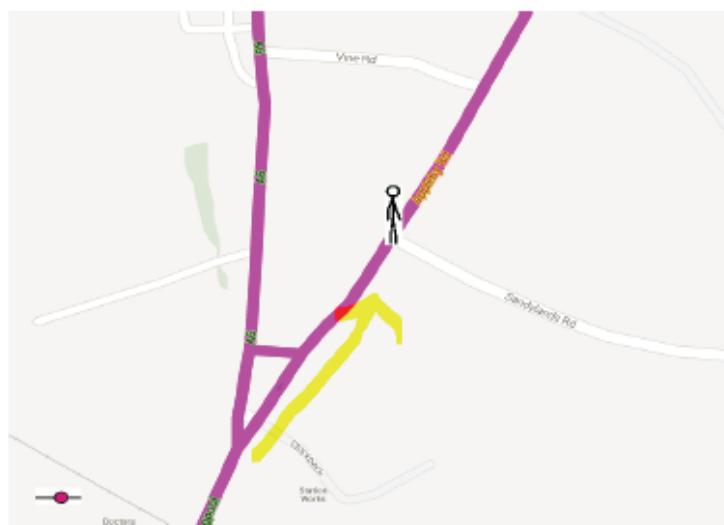
The roundabout near the station is marked in the yellow circle above. Learners can't see it unless they zoom in.

Step 4: There is a road that goes north east from the roundabout. What's the name of the road?



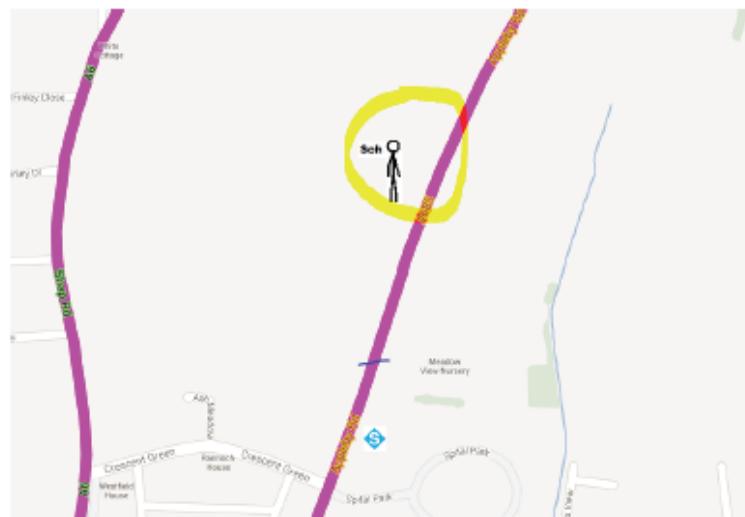
Direction and junction marked in Yellow. Name of the road going North East is **Longpool road**.
Learners can get confused with other roads if they don't know which way North-East is.

Step 5: Walk up until the road splits. I wonder which way he went? Okay, lets take the one that goes North East.



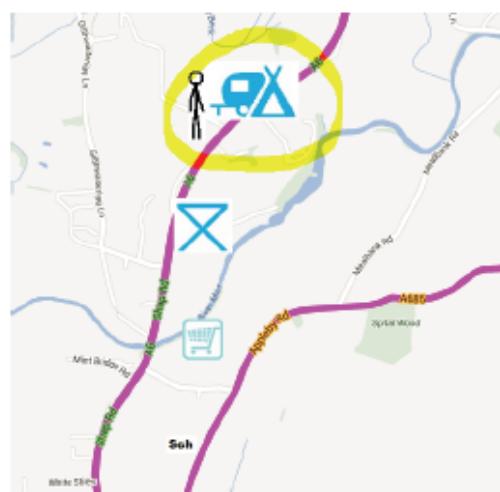
Road that goes North-East from the junction is **Appleby road**. The other road is going North.

Step 6: This is taking way too long. We need better transport. Lets go and find your bike that you left at school. You should see the school on the side of the road. Drop a pin at the school



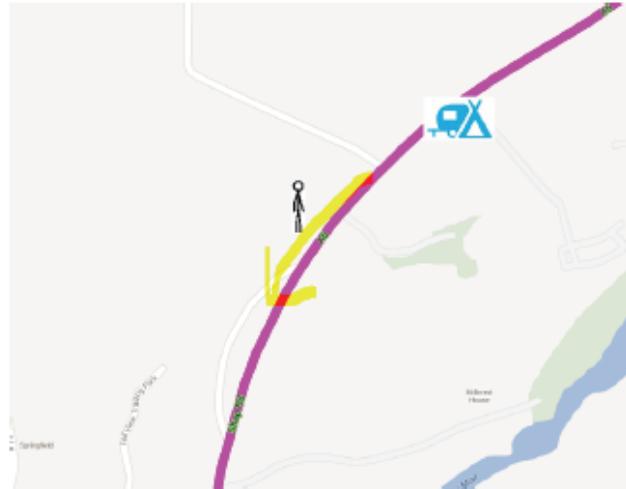
Learner has to identify a school along Appleby road using its OS symbol. There is a distractor on the right side of the road (a blue diamond with an "S" in it).

Step 7: Right so now we're on your bike. Good job you are wearing a helmet! So the suspect likes camping. Lets go north until you find a caravan site. Drop a pin at the site so we can keep track of where we've been.



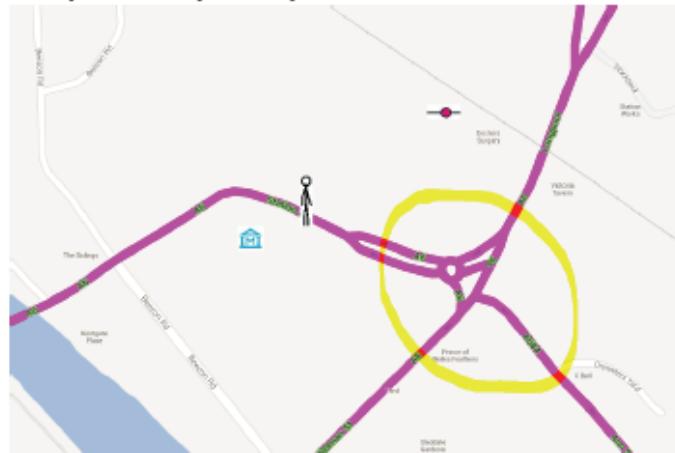
Learner has to identify a caravan site using its OS symbol. There are other distractors up north of the school (a supermarket and a picnic site).

Step 8: Oh dear. We couldn't find him there either. I hope he hasn't gotten back on the train. Lets take the Shap road and go back to the train station. Which direction would you take?

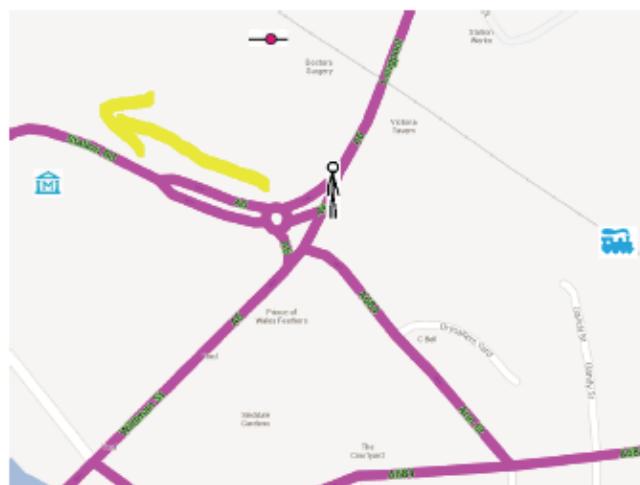


Learner has to identify which direction to take if he were to walk to the train station. In this case, its South West.

Step 9: Take the Shap road in the south west direction and reach the train station, if you haven't already done so. Drop another pin at the roundabout.

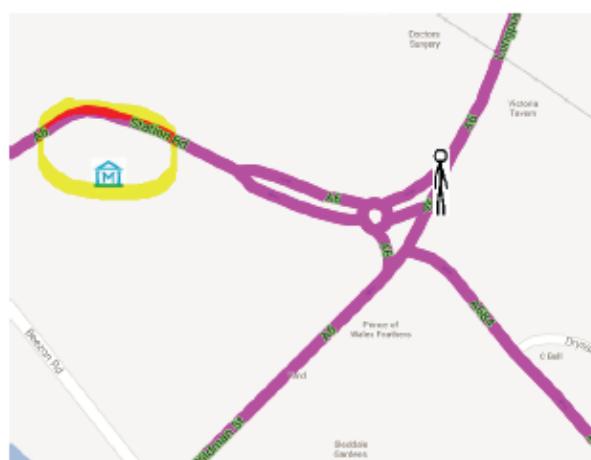


Step 10: Well there haven't been any trains leave here for hours so he must still be in the town. Take the road that goes north west. The name of the road should tell us where we've been. What's the road called?



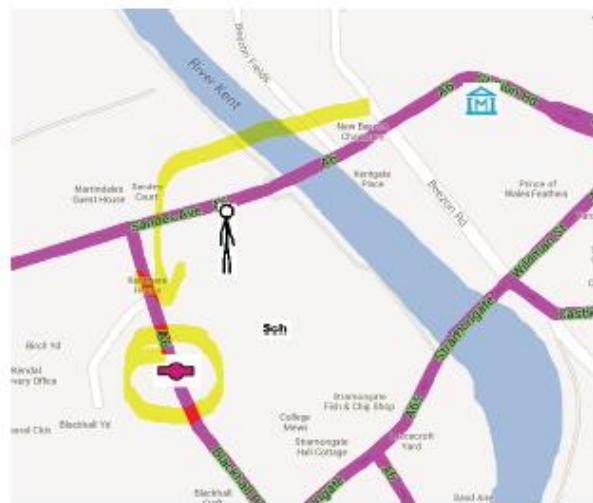
Learner has to identify the road that goes North-West. And name it. Station Road

Step 11: The suspect likes old things. Alongside the road, you see a building. Look at the symbol. What is it?



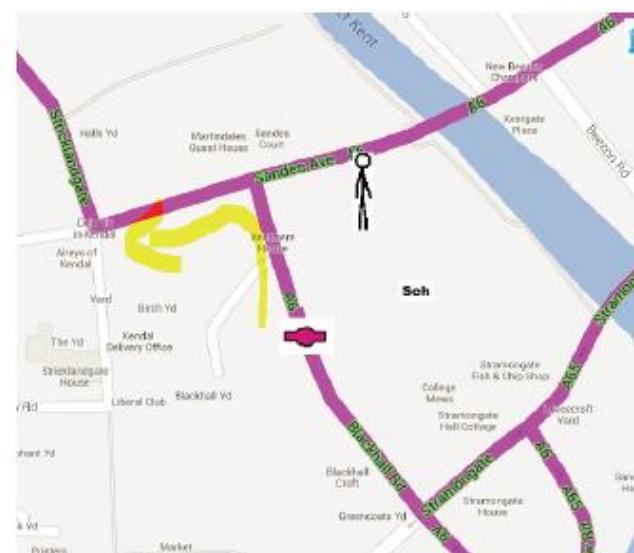
Learner has to identify what this OS symbol means? A Museum.

Step 12: Oh bother. He wasn't in the museum either. Ride along the road. Cross the river. Take the first left. What does the symbol on the road say?



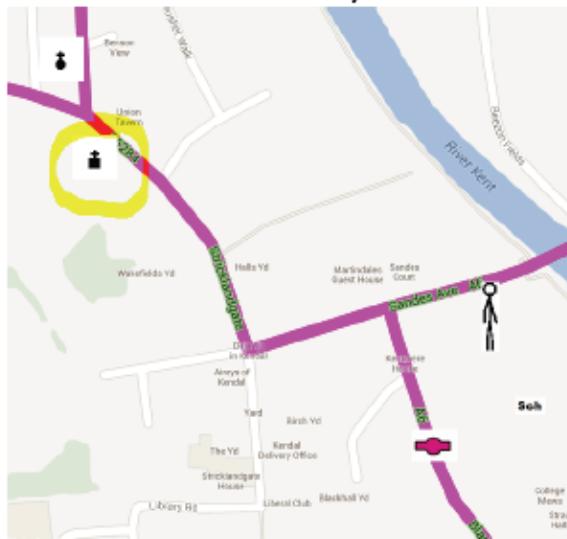
Learner has to identify that the OS symbol they see is a Bus Station.

Step 13: Nope he's not at the bus station either. Ho Hum. Lets go back up the road to Sandes Avenue. Go West South West.



Learner has to identify which way is West South West.

Step 14: Turn right at the end of the road. Ride up the road. There are two churches there. Maybe he's gone up a tower to get a good view of the town to figure out where to hide the recipe. Name the church with a tower. Click on the symbol to know its name.



Learner should be able to differentiate between two church symbols. Church with tower is St Thomas Church marked in yellow.

Step 15: Excellent. You did it. You found the lost recipe. The castle chef had stolen it to make mint cakes for a special dinner at the castle. But you found him before he could get to the castle.

9.2. Appendix 2 Mock-up study 3 tutorial

For all participants the brief test game was based in the following tutorial:

The main goal of the game is to develop a sustainable virtual city.



The game is played with three players: Mayor, Economist and Environmentalist, and each of them have different roles.

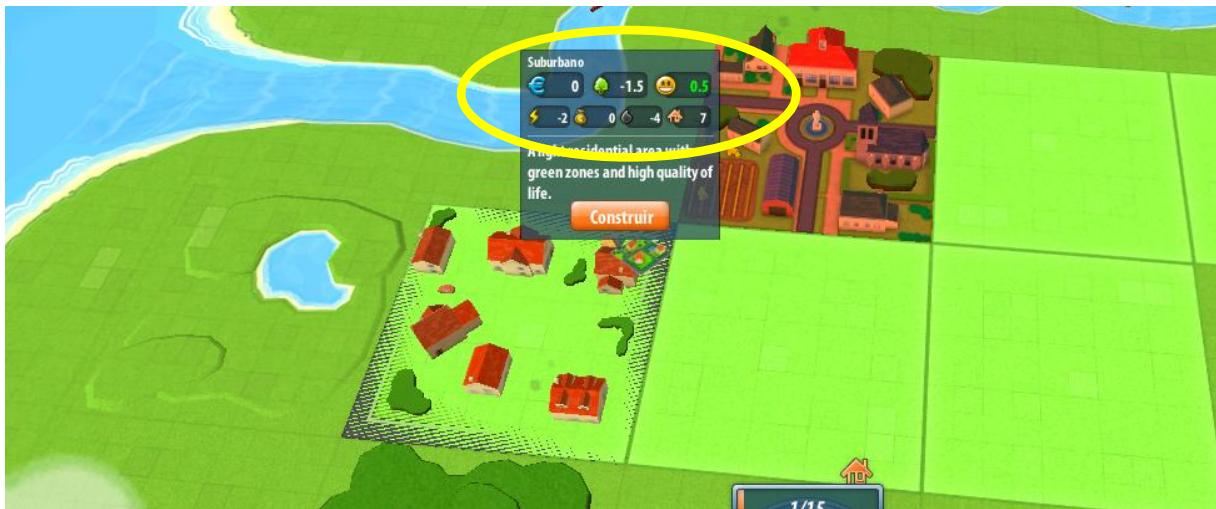
There are 4 types of possible plays and each player plays at a time:

- **Constructions:**

It is possible to choose one type of construction of three available options – *pointing to the red ellipse* – (according to the player’s role the constructions options may change, as you will see during the game).



There are some consequences inherent to each construction. As you can see here (*pointing to the yellow ellipse*) choosing this building there is no impact on the economy, yet the impact on the environment is negative... However these values may change depending on the place you will build it:



If you place this building here, the well being of your citizens is higher.

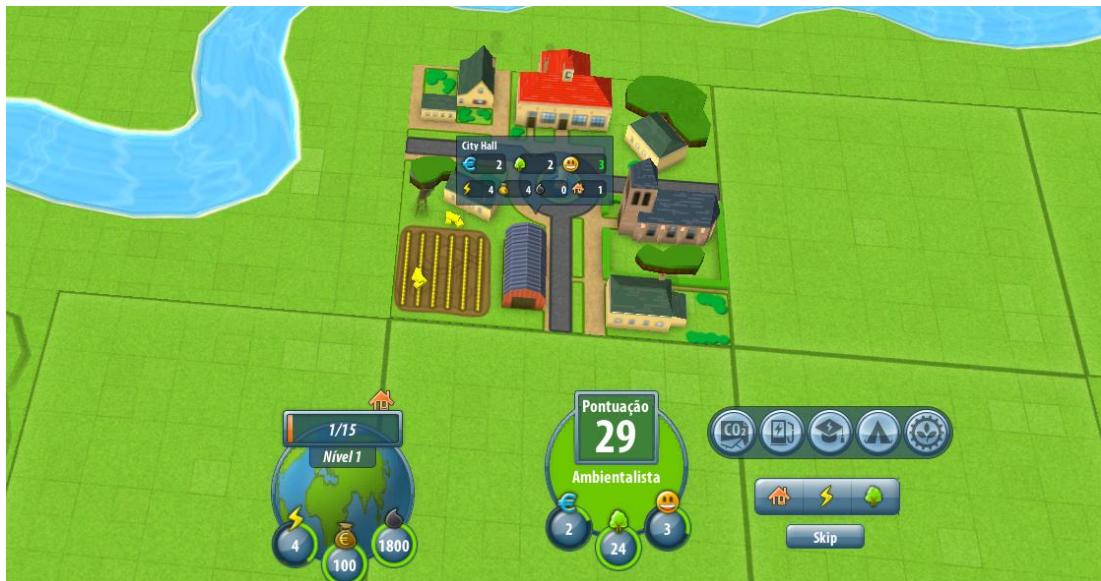
- **Updating previous constructions:**

By pressing the previous construction you want to improve, you will see all the update options available for the desired building (*pointing to the ellipse*). You can do three updates and they can be done on different buildings.



- **Political System:**

By pressing the City Hall you will see the available decisions you can implement in your city. You can choose only one option at a time.



- **Skip your turn:**

In case you do not want play any of the previous options you can skip your turn by pressing the skip button.



All the decisions you will make are depending on the energy resources, economical resources and natural resources available.



Some important considerations:

- When natural resources are extinct it means the game is over.
- The progress bar shows the number of citizens in your city. After you reach the desired number of citizens you will move to the next level.
- The game scores are divided in two types:
 - Group score: The group score represent the state of the game according to the team decisions.
 - Individual score: The individual score is showed by icons (*pointing to the three icons*). These scores are placed next to each player.



After each round of play the scores will be updated. This way, and taking all the game issues into account, the final goal is building a sustainable city.

9.3. Appendix 3 Mock-up study 1 Instructions UK

Note to Teacher:

The amount of independent work children are able to manage will depend on their familiarity and experience of using maps in general.

The step by step tasks are not meant to be read alone by children but as a guide for you the teacher to demonstrate or direct individuals as appropriate.

The contexts for the learning include both ‘physical’ and ‘human’ geography, and will explore different scales of mapping.

Activity

Pupils use given clues to follow direction on a map, they will follow a route. The pupil will then be asked to place the building in one of the locations.

Introduction

Trails are fun for children and help them to read and use maps with greater confidence. We provide maps at a range of scales and the large scale maps are very detailed. This helps pupils to get better at recognising map features as they learn how to take virtual ‘walks’ through the landscape. What is most important is that they recognise that these coordinates give detailed information about where something is. They can learn to use maps in an unpressured and fun way. This activity can be done in class but it links very well with fieldwork in the locality where pupils can research and plan their own trail and this makes an ideal follow up activity.

Main Activity

There is a trail mission.

Read the clues and follow the trail on the map.

Finally using the skill you have learned you will choose the location to place the wind farm.

Tasks

Read your trail mission and find the start location.

Read the next clues carefully and find your trail on the map.

When you have found the end of the trail, show on the map where you think you should place the new building and note the Grid Reference.

Your teacher will know if you are successful or not.

Trail clues: Wind farm trail

QT-1 is a Robot that will be joining the class soon. We are going to follow the trail so that we can learn the skills to choose the location to build a new wind farm to power QT-1. Can you follow the trail and build the wind farm?

Clues

Some examples:

The start of the trail is at Haybridge High School can you find this on the 1:2500 scale map?

Can you follow the Brake Lane East until you reach a crossroads?

What are the names of the roads at the crossroads?

Which Building is at the North East corner of the crossroads?

Can you see the Playing Field on the map? Which direction is this from the Church?

Which direction is the school from the Playing Field?

How many meters is it between the Schools Sports Hall and the Church?

How many meters is it between the Church and the centre of the Playing Field?

How many meters is it between the Playing Field and the School?

Can you find the School on the 1:10000 scale map?

What do you think the blue symbol of the of a man is for? You can look at the OS Explorer Map Key to find out.

How many Public Houses are there on the map?

How far is the Stourbridge Golf Club from the School? Hint the Golf club is North of the School.

Can you see a forest with only Coniferous Trees?

Can you see a forest with only Non-Coniferous Trees?

Can you see a forest with a mixture of Coniferous and Non-Coniferous Trees?

Can you see road less than 4m Wide?

Can you see a secondary road?

9.4. Appendix 4 Mock-up study 1 Instructions Sweden

Note to Teacher:

The amount of independent work children are able to manage will depend on their familiarity and experience of using maps in general.

The step by step tasks are not meant to be read alone by children but as a guide for you the teacher to demonstrate or direct individuals as appropriate. .

Activity

Pupils use given clues to follow direction on maps in search of a missing moose.

Tasks

There is a trail mission.

Read the clues and follow the trail on the map.

Think carefully about which way North, South, East or West is on the map!

Locating the missing moose

You are at your school at Ebba Lieberathsgatan 19, Gothenburg. You find out that a moose from Slottskogen has run away, and they need your help to return it to Slottskogen. The moose seems to be located East of the school. Can you find it? I will give you hints along the way, and ask you for some information on your current locations.

Clues

1. The start of the trail is at your school at Ebba Lieberathsgatan 19, Gothenburg. Ebbe Lieberathsgatan is a street running parallel to Mölndalsvägen to the West.

2. Can you find the street?

3. Now that you are at the school, I will guide you on the right path. First, head North-Northwest along Ebba Lieberathsgatan until you reach the end of the road.

4. Turn North-Northeast and follow this road across the river. Can you spot the tram stop on your left right before you cross the river?

What is it called? (ANSWER: Göteborg Elisedal)

5. Keep following this road Northeast until you cross the highway.

Can you point to the highway?

6. When the road splits, choose the road going Southeast.

7. Let me know when you cross the national highways 40 and 27, please.
8. Ok, now that you are there. Keep following this road. After 650 meters you need to turn left on a small road.
9. What is it called? (ANSWER: Gundla Mosse).
10. That means you are close to the moose. I need you to follow the road to the end, and describe your surroundings.

What do you see? (ANSWER: Forest/lakes)

11. Now, I have heard that the moose is standing in the center of a hill Northeast of your current location, and West of Stora Delsjön. Go there and I will let you know if you are in the right location.

*Upon arrival, student gains **moose card**.*

12. Ok, stay put now! I am sending a chopper your way, so that you can escort the moose back to Slottskogen.

*Place **helicopter card** on location*

13. Read the Pilot's quote on the card: "I have strapped the moose to the bottom of the helicopter, but since I am not from around here I don't know where Slottskogen is. You will need to give me directions before takeoff. I need to know the compass point, the distance, and the coordinates. Let me know when you are ready!"

9.5. Appendix 5 Mock-up study 2 Instructions

Activity

The student first have to find three informants by following different kinds of directions. For each informant that is found the student receives a clue that will lead to finding the thief.

Tasks

First you have to explain the goals of the activity: to find a thief that is hiding somewhere (see text).

Thereafter you explain that there are three informants that need to be found and that have information about the location of the thief. You will provide the student with instructions to find the three informants. Italic texts are information for you and are not supposed to be read to the students.

Tools and supplies

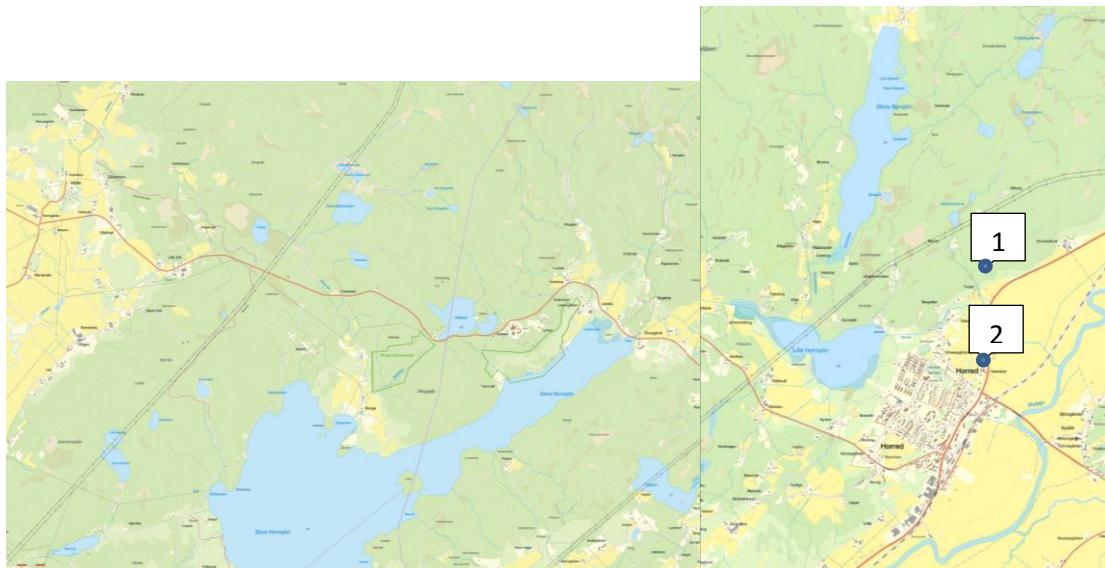
Map; Compass; ruler; rope (to measure distances on curved roads); playing piece; clues cards; overlay with possible hiding places

Route following

A thief has stolen a masterpiece from the Gothenburg museum and is said to be hiding somewhere in the neighborhood of your school. There are three informants that you need to find in order to receive information about where he is hiding. I will help you find the informants. Place the piece that you have here on the location that I indicate.

1. The first informant is hurt by the thief and needs to be rescued by helicopter.
 - a. Fly around 3000 meters to the east until you reach the power lines. Place your piece here if you know where that is. ***The correct place is point 1 on the map.***
Continue when the student has placed the piece at the correct position, do give help when necessary but without changing the assignment. So, you are allowed to explain the use if a compass in order to know what is 3000 meter, but you should not point at the right place or explain it in another way. You can praise the student for finding the correct place in any way you likel.
 - b. Now, fly south over the lake for about 800 meters. He should be lying here in a marsh area. Place your piece there if you know where that is. ***The correct place is point 2.***
 - c. The informant gives you the first clue. (***Here you can change the feedback as you think is best***) He gives you the first clue. (***Give clue 1, purple***).
2. Let's get back to the school and find the next informant.
 - a. First, go to the big road close to your school. Place your piece there. (***Point 3***)
 - b. Now, follow this road to the left until you reach another small road that goes almost straight north. Place your piece at the junction (***Point 4***)
 - c. From here, follow this road for about 800 meters. He should be here. Place your piece where you think he is. (***Point 5***)

- d. The informant gives you the second clue. (***Give second clue, white***)
3. So, now let's go back to school and find the third informant. This is a hard one!
- a. First, go to the big road close to the school again. (***Point 6***)
 - b. Take this road in a WNW direction. After 0,2 kilometers there should be a small road to the NE. Place your piece there. (***Point 7***)
 - c. Take this road until you get to the first crossing, place your piece here. (***Point 8***)
 - d. Take the road to the NNW and follow it for 1 kilometer. Place your piece there. He is standing here at the side of the road. (***Point 9***)
 - e. The informant gives you the third clue. (***Give the third clue, yellow***)



Clues

1. Now you have found all clues. Can you combine them to find the thief? I will show you some possible hiding places on the map. ***Place the overlay on the map, placing the football field on the overlay on the football field on the map.***
2. Only one place is correct. Can you tell me which number that is? Bara ett av dem är rätt. ***On the map below you will see circles that can aid to find the right place. Those circles are not placed on the map and are only there for your convenience. Point 5 is correct.***
3. ***You are allowed to help the student by explaining how one measures distance, used the compass or can know that something is an area with wood. You should reveal the correct place in another way.***
4. ***If the student really wants to quit can you can reveal the correct point and explain why.***

