SCeTGo: Inquiry with Augmented Reality miniatures

Summary:

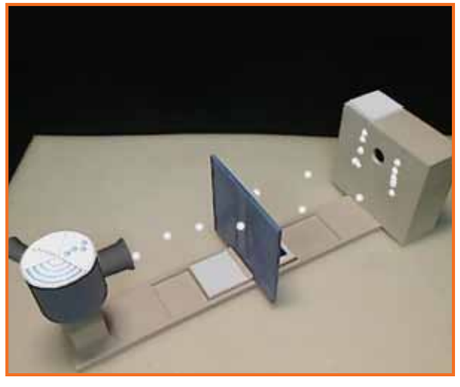
Science Center to Go (SCeTGo) bridges formal and informal learning through the use of inquiry-based teaching in the classroom. It uses a mobile science exhibition where miniature models are enhanced with Augmented Reality and invisible phenomena are made visible. It allows user-centered hands-on experimentation where the aim is to increase students' understanding of the physics content, bring understanding of the scientific processes, and foster general interest in science.
SCeTGo could be also used in teacher training. Hereby SCeTGo is used within a workshop on inquiry-based teaching given to pre-service experimental science teachers or to in-service teachers with the use of Science Center To Go suitcase.

Aims:

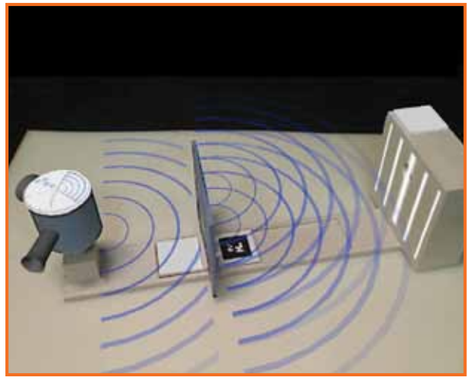
- To train pre-service teachers from the Master's degree on secondary school science teaching about innovative educational approaches based on IBSE and Augmented Reality.
- To train in-service natural science teachers about innovative educational approaches based on IBSE and Augmented Reality.

Main activities:

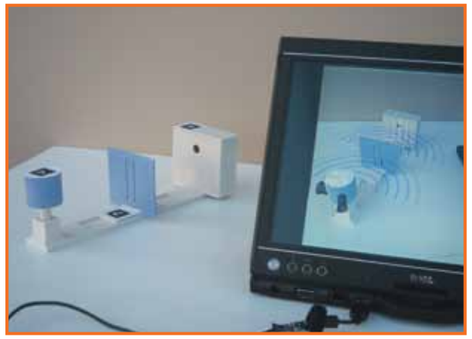
- Introduction to Inquiry-Based Science Education (IBSE) as pedagogical methodology and presentation of Augmented Reality (AR) with the Science Center to Go (SCeTGo) miniatures as a way to teach certain Physics phenomena.
- Some of the participants make demonstrations of each miniature exhibit contained in the SCeTGo suitcase.
- A hands-on session within which the participants experiment with the miniatures.
- Participants are presented a possible inquiry-based lesson plan with SCeTGo suitcase and discuss its strengths and weaknesses compared with a standard approach to teaching the same content.
- Participants are required to create their own lesson plan.
- The session finishes with a discussion about IBSE opportunities and limitations in school practice.



Double slits in large particle mode



Double slits in wave mode



Narrative:

The proposed workshop on inquiry-based learning might be given to pre-service experimental science teachers or to in-service teachers. For the workshop and the hands-on activities the Science Center To Go (SCeTGo) suitcase is used, which contains different miniatures to realise five experiments:

1. Mini Wing model, demonstrating Bernoulli principle;
2. Mini Fire Truck model, demonstrating the Doppler effect;
3. Double Cone miniature model, demonstrating forces, such as gravity;
4. Mini Fridge and Heater model, demonstrating the temperature-molecule movement and the Boltzmann constant;
5. Double-slit model, demonstrating Young experiment on basic quantum physics.

The miniatures are used by the participants to experiment with the listed invisible phenomena which are added as a digital layer on top of the real image. A laptop and a webcam are used, which included in the suitcase. SCeTGo suitcase and miniatures can be used for studying physics in various educational levels, aiming at secondary school, although hereby it is presented as a tool to demonstrate IBSE and innovative ICT usage to pre- in-service teachers.
The event includes a number of sessions, such as presentation, hands-on and reflection. The participantsthemselvesuseinquiryforlearningabout:

- a series of topics in physics, i.e. those listed above, which are related to the curriculum in many European countries;
- IBSE as pedagogical approach, its advantages and challenges to apply in real teaching settings;
- theSCeTGo miniatures and its Augmented Reality as an innovative ICT tool to teach physics in secondary school level.

The event can start with an introduction to Inquiry-Based Science Education (IBSE) and Augmented Reality (AR). Then, the participants could make demonstrations of each miniature exhibit contained in the SCeTGo suitcase. Afterwards, all participants can experiment with the miniatures within a hands-on session. Participants work in groups, cooperate to make hypothesis and design the experiments, collect evidence, etc. At the end of the session they can discuss about the opportunities and limitations of IBSE, SCeTGo approach, miniatures and AR in school practice.
Participants are also given an example of IBSE-based lesson plan for upper-secondary education on which they have to reflect and debate. Later on they should create their own inquiry-based lesson plan.
A discussion between the participants, either involving the whole class or in groups depending of the number of participants, is highly recommended.

SCeTGo: Inquiry with Augmented Reality miniatures

PATHWAY

As previously described, UB best practice suggestion is a learner-centered seminar/ workshop to pre-service teachers that introduces inquiry-based methodology, using advanced ICT technology (i.e. Augmented Reality) through a series of activities - presentations, a demonstration, a hands-on session and a reflection session. The approach covers:

- Competencies related to subject matter/ content knowledge, e.g. knowledge on particle duality in quantum physics related to SCeTGo double slit experiment. In the training students are provided materials (i.e. example lesson plan), which also incorporates content related to the subject. Also, during the hands-on approach, pre-service teachers are able to study the phenomena themselves through experimenting with the miniature, thus gaining even deeper understanding of the matter.
- Competencies related to the nature of science (NOS) including inquiry knowledge and skills - through the hands-on approach pre-service teachers experience first-hand concepts such as posing scientific questions, elaborating a hypothesis, looking for evidences, making experiments, providing explanations, etc. and how they can link them to the classroom activities. Furthermore, through the reflection/discussion session students were stimulated to further reflect on issues, such as the nature of scientific inquiry and its application in today's education.
- Competencies related to self-reflection and metacognition – the reflection session at the end of the seminar has the objective to stimulate students to reflect on and discuss about the challenges and limitations of the approach, its applicability in the classroom, to make comparison with other teaching approaches, etc.
- Competencies in using laboratories, experiments, inquiry, projects, etc. – The related equipment (laptop, webcam, miniatures and the software) were demonstrated to the students and then they tested it. They have been given trips on how to resolve problems with the SCeTGo package, such as lack of contrast in the image, staying in the visible area, etc.
- Competencies in the use of ICTs - The chosen activity uses an advanced ICT technology (i.e. AR: Augmented Reality) through a standard ICT equipment (i.e. laptop and web camera). The presentation and demonstration of the AR at the beginning of the training session, together with the hands-on activity increase pre-service teachers' ICT competences in general. Future teachers are shown and are stimulated to discuss on the use ICT to enrich the lessons and relation between advanced ICT, such as AR to the interest of students.
- Competencies in the knowledge, planning and use of curricular materials - The phenomena involved in the proposed IBSE training are all related to the curricula and the exemplar lesson plan clearly states the link. Teachers should be able to customize the suggested materials to their needs.
- Competencies in Pedagogical Content Knowledge concerning Information and Communication Technologies with Technological Pedagogical Content Knowledge – participating pre-service teachers are given a presentation about Augmented Reality and its applications and possibilities, with special focus on its affordances.

Methods of learning/training :
Combination of transmitting knowledge (i.e. presentations about IBSE and AR and a demonstration of one of the experiments), active user-centered activities (i.e. hands-on sessions in which participants experimented with the miniatures; creation of lesson plans), and reflection session.

End user: In service and/or teachers-to-be of secondary school for science subjects (e.g. biology, physics, chemistry, etc.)

Involved actors: Natural sciences school teachers

Location:

- Within a Master degree program with pre-service experimental sciences teachers
- In a Continuous Professional Development program for in-service physics teachers;
- In summer/winter schools
- As and interactive seminars within conferences related to science education and/or pedagogy.
- As an interactive workshop in science museum with visiting science teachers

Languages available: English for most of the supportive tools, such as manuals and possible scenarios. Some materials, such as example lesson plan, assessment tools, etc. are available in Spanish and Catalan. The software itself is language independent, i.e. there is the visual part, graphical elements as arrows, graphs, angles and mathematical formulas.

Where to find the application:
N/A (SCeTGo is an ongoing EU project. Currently, the SCeTGo suitcase with miniatures, computer and AR software are demonstration material privately owned by the consortium. Further information will be available at the end of the project by 01/01/2012)

Evaluation parameters:
SCeTGo suitcase has been used in a series of interactive hands-on seminars at University of Barcelona (UB) with pre-service teachers in the Master degree on secondary school science teaching. UB research team used two assessment tools, both containing a set of questions to check the level of understanding of the students over one of the miniatures, namely the double slit experiment. The assessment demonstrated that the students' understanding on the selected phenomena has increased after the hands-on seminars with SCeTGo suitcase (evaluation reports of project SCeTGo are available).

Duration: One time workshop of approximately 3 hours, although it could be extended.

Optimum number of participants:
How many teachers can participate in the training at a time?
The workshop could be made either to small number of participants 5-10 people or to a larger group 15-20 participants. In case of many participants, they would be split in groups for the hands-on session and might rotate with the use of the miniatures. One group is not expected to exceed 5-6 people, thus the activity will be appropriate for less than 30 participants.

Additional information or resources:

- Science Center To Go project web site: www.sctg.eu
- video demonstrating the SCeTGo suitcase in use: www.youtube.com/watch?v=E0boVa5zbfo&feature=youtu.be
- SCeTGo teacher manual, currently available in English (printed and digital) and in Spanish, Catalan

Teachers' Competencies

1	subject matter/content knowledge	x
2	nature of science	x
3	Multidisciplinary	
4	knowledge of contemporary science	
5	variety of (especially student-centred) instructional strategies	
6	lifelong learning	
7	self-reflection	x
8	teaching/ learning processes within the domain	
9	using laboratories, experiments, projects	x
10	common sense knowledge and learning difficulties	
11	use of ICTs	x
12	knowledge, planning and use of curricular materials	x
13	Information and Communication Technologies with Technological Pedagogical Content Knowledge	x

Mapping best practices with main principles

PATHWAY

1. Building interest in natural science phenomena and explanations:

Building interest in natural science phenomena and explanations: SCeTGo miniatures are developed together with a set of comprehensive Inquiry-based pedagogical scenarios (at least one scenario per miniature). The IBSE phase "provoke curiosity" is incorporated in all SCeTGo scenarios, providing ideas and materials, such as videos, images, etc. that easily can be used by teachers to provoke students curiosity. The SCeTGo approach is to use Augmented Reality on top of five miniature exhibitions. The exhibitions have been carefully selected to trigger students' curiosity. For example, in the mini double cone experiment, the students would be amazed to see that the cone will go uphill, instead of, as they would have expected, downhill. The software itself further provokes students' curiosity by visualising the invisible phenomena, such as the forces that apply on a wing. The combination of miniatures and the software with the Augmented Reality facilitate the students to ask questions, like "what will happen if…". The representation of the invisible attracts and engages the students.

2. Building up informed citizens: Students understanding the nature of Science & Science in society:

The proposed approach covers a set of phenomena that largely differ one from the other, i.e. from the double cone uphill runner from the 17th century that is at first perceived as magic, through the Doppler effect observable in everyday life, and to the double slit experiment that is the basic of modern quantum physics. Some of the example scenarios provide also historical background and show to the students the relevance of science to their life. In this way, the approach is equally inclusive towards students that may later become scientistsand to those who may not do so. With the use of SCeTGo the teacher can stimulate students' observation, reasoning, and interest in science in general.

3. Develop multiple goals:

- **understanding big ideas in science including ideas of science, and ideas about science**
- **scientific capabilities concerned with gathering and using evidence**
- **scientific attitudes**

As stated in point 2, SCeTGo miniatures and scenarios provide basis for reflection and discussion about specific scientific phenomena, some classical and other (as the double-slit) modern ones. Also, they provide evidence about the relevance of the included phenomena and of science in general to our everyday life.

4. Understanding students' concepts and learning style about of science phenomena:

At least some of the SCeTGo scenarios include suggestions/tools for assessing students understanding and give a list of common students misconceptions which can be taken into account.

5. Relevance of the content to daily life of students:

As already described (see point 2), some of the miniatures represent phenomena that are easily observable in everyday life (e.g. Doppler effect). Furthermore, the related scenarios give detailed suggestions of how to further link them with well known examples of their appearances.

6. Understanding science as a process not as stable facts. Using up to date information of science and education:

Also, underlying that science could be seen as a process not as stable facts could be done within single SCeTGo scenarios, for example, in the double-slit experiment.

7. Activities for gaining knowledge, not for entertainment, nor for simple imitating of results:

The SCeTGo scenarios contain the full set of IBSE activities. Also, there are developed tools for assessing the pedagogical gain/learning outcomes and catch misconceptions. Some of the scenarios have been validated and have shown (through the use of pre- and post-tests) that there is real knowledge acquisition. The restofthescenariosarecurrentlybeingvalidated.

8. Doing science: experimenting, analyzing, interpreting, redefining explanations:

SCeTGo miniatures and scenarios are designed with the central goal to support experimentation. Active experimentation with the miniatures is performed by the students who should be stimulated to observe the changes of parameters that are represented by the augmentation. The tool does not provide facilitation for data collection in the form of pre-defined forms or organisation of the data pool. Nevertheless, it supports the investigation by focusing students' attention on those variables that influence on the phenomena. Also, each scenario contains the full set of IBSE activities, including phases such as define hypothesis, plan and conduct investigation, gather evidence, explain, consider alternative explanations, etc. The scenarios contain instructions that could be used in a guided inquiry.

9. Assessment: formative ~ of students' learning and the summative ~ of their progress:

Some of the SCeTGo scenarios provide ready to use and validates assessment tools. For the rest, such tools are under development.