



**MATERIALS
SCIENCE**



SCIENCE AND SOCIETY



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Materials Science

University-school partnerships for the design and implementation of research-based ICT-enhanced modules on Material Properties.

Specific Support Actions

FP6: Science and Society: Science and Education

Materials Science Project

Publishable Final Activity Report

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University of Cyprus, Learning in Science Group.

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Section I: Project Execution

1. Introduction

Materials Science (MS) is a European Union 6th Framework Programme, funded under the “Science and Society” area. The focus of the project was the development of innovative teaching materials that adhere to contemporary theories and approaches and give emphasis on bridging research findings and practice. Specifically, the teaching materials emphasize the advantages of research based design, iterative refinement and participative design. The design of the teaching materials followed the principles of inquiry based science, active student engagement and collaborative learning. All the developed module titles were under the broad area of Materials Science, an interdisciplinary subject that offers the advantage of relating science concepts with technological products, helping students develop a personal interest and appreciation for the role of science in society.

During the project each of the teaching materials developed was implemented, evaluated and redesigned at least twice in the local educational system and then it was transferred into another country where it was adapted, implemented and evaluated once more. The iterative refinement process generated many insights regarding the design of teaching materials and the learning process which are accumulated in a forthcoming publication. Through the transfer of the innovative teaching materials to other EU countries, the intention was to shed light to the complicated issue of knowledge transfer. The complications that arose from the transfer process as well as the methodology followed by each of the exchange pairs along with their perspectives are presented in depth in one of the main deliverables of the project.

2. Project Partners

University of Cyprus - UCy

The University of Cyprus was established in 1989. The Department of Educational Sciences is a large department with 25 members of the faculty, and 35 associate or assistant personnel. The Learning in Science Group at the University of Cyprus conducts a co-ordinated program of research, curriculum development and instruction and is directed by Pr. Costas. P. Constantinou (Project Co-ordinator). The Group have had a longstanding involvement in research projects funded at European and local level with an established expertise in University-school-educational authority partnerships. The key people involved in the MS project apart from Pr. Constantinou are: Dr. Theodora Kyratsi, Dr. Nikos Papadouris and Phd Candidate Marios Papaevripidou.

University "Federico II" of Napoli - UoN

The “Federico II” University of Naples was established in 1226 and is one of the oldest State Universities in Italy. The Department of Physical Sciences is one of the bigger departments, including more than 200 personnel members. Collaboration with well acknowledged international institutions are very common and established for many years. The key people involved in the project are: Pr. Elena Sassi, Pr. Gabriella Monroy and Pr. Italo Testa.

Aristotle University of Thessaloniki - AUTH

Aristotle's University of Thessaloniki was established in 1929. It includes 45 Departments. The Science Education department has a long and outstanding research record in investigating students' understanding of scientific concepts and phenomena, modeling their conceptual evolution, etc. The key people involved in the project are Pr. Dimitris Psillos, Pr. Euripides Hatzikraniotis and Dr. Maria Kallery.

University of Helsinki -UH

The University of Helsinki has the widest range of disciplines in Finland and it was established in 1640. The number of faculties is eleven. The Department of Applied Sciences of Education is one of the five Departments of the Faculty of Behavioural Sciences and it is one of the largest departments of the University of Helsinki. In addition, the Department has thirteen research centres, which are organised according to the different themes. Key people involved in the project are: Pr. Jari Lavonen, Pr. emeritus Veijo Meisalo and Dr. Kalle Juuti.

University Autònoma de Barcelona - UAB

The Centre d'Estudi i Recerca per a l'Educació Científica i Matemàtica (CRECIM) is an interdepartmental research centre of the Universitat Autònoma de Barcelona. It was created by a national consolidated research group (Computing Technology and Educational Research, TIRE), joining efforts of researchers from different disciplines on the same institution. It is an entity very sensible to scientific and mathematic literacy, and in particular places very high emphasis in the teaching and the diffusion of science. The director of CRECIM, Pr. Roser Pinto, is also the director of a Thematic Network of Research Centres and institutions in the region of Catalonia, the Xarxa per la Recerca en l'Educació Matemàtica i Científica (REMIC). Other people involved are: Dr. Digna Couso and Phd Candidate Maria Isabel Hernandez.

University of Western Macedonia - UWM

The University of Western Macedonia was established in 1989 as branch of the Aristotle University of Thessaloniki. Now it is an independent University with five Departments (Primary Education, Early Childhood Education, Balkan Studies, Engineering of Energy sources, Engineering of Information and Telecommunications). The School of Education (Primary and Early Childhood) includes 33 staff members and 30 associate or assistant personnel. The Group of Science Education at the University of Western Macedonia has the following research interests: design, implementation and evaluation of teaching – learning sequences. The key people involved are: Pr. Petros Kariotoglou and Dr. A. Spyrtou.

External Experts

Three external experts participated in the project and their contribution was vital to the successful conclusion of the project. The external experts are presented in the list below.

- Niedderer Hans – Malardalen University, Sweden

Hans Niedderer is Professor emeritus of Physics Education at the University of Bremen, Germany, and guest professor at Mälardalens University. His main interests are in research about learning physics, teaching and learning quantum physics at high school, and the role of student ownership of learning for motivation of students. His main areas of research are:

- Learning processes in physics (electric circuits, quantum atomic physics, geometrical optics, sustainable energy, chemical thermodynamics), learning effects, cognitive layers, cognitive development
- Curriculum development and evaluation in quantum atomic physics
- Labwork in physics education
- Ownership, motivation, holistic learning in mini-projects

- Pr. Meheut Martine - Paris Diderot University, France

Martine Meheut is Science Education Professor at Creteil Teacher Training Institute, in Paris Diderot University. From 1990 she has been teaching science education, coaching students for research projects and coaching PhD students. Her main domain of interest is teaching and learning transformations and structure of matter. In this domain she has developed two lines of research, ‘common sense’ conceptions studies, starting from analysis of learning difficulties and, strongly linked with this first line, designing and validating teaching-learning sequences in a constructivist paradigm. Since 1998, she has developed new research lines, these include amongst others:

- Evaluation of first year university physics courses
- Teaching thermodynamics at University level
- Teaching Chemistry in secondary schools

- Vicentini Matilde – University of Rome, Italy

Matilde Vicentini started her research doing experimental work on diffusion in liquid metals. The research continued in the field of superfluid helium and on the phenomenological analysis of experimental data in the critical region of fluids and magnets in the light of the scaling hypothesis. She then shifted to educational research with a starting interest in primary school curriculum in an interdisciplinary framework. She did research on the alternative conceptions of students and teachers. As a full professor at the University of Messina first and then at Roma La Sapienza she focused the problems of University teaching and on Physics teachers education with a specific interest on Thermodynamics and on epistemological issues. She retired in 2004 but continues to collaborate in teachers training courses.

3. Project Objectives

The **main objective** of the project was to develop a mechanism for focusing the combined collaborative efforts of experienced science education researchers and science teachers in using established principles and knowledge in order to solve teaching-learning problems in specific domains of science (using Materials Science as an example). Also, the international expert panel group that was set up during the first year of the project had been loaded with the responsibility to identify critical attributes that distinguish successful teaching efforts and to employ these in the design and development of the innovative research-based modules, in a way that these can be implemented independently of the systemic, cultural, organizational and language barriers that generally impede transfer of educational programs from one educational setting to another.

The **specific objectives** of the project were the following:

- To create a European network of national partnerships between University researchers and school teachers focused on promoting inquiry based teaching and learning in Introductory Materials Science
- To develop a series of ICT-enhanced teaching modules covering the needs of 10-17 year old students in inquiry based learning and teaching
- To develop a handbook of guidelines for the design of research-based modules for teaching and learning in science, addressing issues of process and quality in an iterative cycle of design, development and validation of teaching-learning materials.
- To facilitate the exchange of good practice through the development and implementation of Recommendations that address the issue of transfer of inquiry oriented science teaching and learning programs from one educational setting to another.
- To undertake a series of peer review study visits with the overall purpose to better understand the learning process as well as to identify approaches to overcome the instructional problems and the learning difficulties that commonly occur in science and technology education, and elicit information for the improvement of the Guidelines and the formulation of Recommendations for transfer.

The main goals of the project were:

- To contribute towards improving the existing evidence for the quality of learning that emerges out of inquiry-based teaching practice.
- To illustrate with examples of specific educational programs how it is possible to bridge the gap between science education research and science teaching practices.
- To contribute towards transforming schools into organizations that have the capacity to improve their practice based on the collection and analysis of evidence on student learning.
- To contribute towards closing the gap that commonly exists between elementary and secondary education in relation to both science teaching policy and teaching approaches.

4. Rationale and State of the art

4.1 The argument in favour of designing for science teaching and learning

The Materials Science project began as an answer to the increasing “innovative” activities promoting the somehow naive view that **science is fun**. These projects invested on the perception that school science is boring and the remedy is the development of fun, exciting and intriguing science activities. Such initiatives tend to present a very distorted view of science that may temporarily make some children enthusiastic. However, it soon drives those same children to disappointment and desperation at the very first instance that they discover that science also requires persistence and perseverance; science is not just fun and it certainly is not always fun. In contrast, the Materials Science project focused on generating meaning as a more effective way of communicating science. Materials Science view is that *science is exciting because it is meaningful and not that science is meaningful because it is exciting*.

Therefore, it departs from the premise that initiatives that inspire children to do science and thereby gain positive experiences out of personal engagement with science have more potential to win children into science learning and science related careers.

Despite longstanding efforts, teaching methods remain very resistant to change and innovation in science curricula has been quite slow in many countries. In many educational systems teachers rely on blueprints in order to carry out their planning and subsequent teaching. In some systems, traditional science textbooks take on the role of such blueprints. In other situations, laboratory manuals and practical exercises (sometimes in the form of instructional recipes to be followed), guide laboratory work in science. For teachers such materials offer support structures that aid and guide their teaching as well as the evaluation of the learning outcomes. For educational systems these same materials ensure some degree of uniformity and adherence to teaching and learning standards. In many educational systems, such blueprints for teaching act more as a barrier than a facilitator to good quality by promoting memorization instead of the development of critical thinking. Moreover, in most cases, established findings in science education are ignored during the development of these materials. As a result, science in school still remains distant from issues of contemporary interest, from social expectations, including the needs of industry and other employers, and from the way science is done, in authentic contexts, as a process of inquiry aimed at the development of problem solving and predictive capabilities. Arguably, reversing this situation poses a significant challenge for science education which requires concerted efforts targeted at the development of teaching innovations and also at the enhancement of the available knowledge basis underlying the process of curriculum development. The project has sought to contribute towards addressing this challenge through implementing the process of designing and refining ICT-enhanced teaching innovations. The project went even further to transfer the developed materials to different educational settings in another country in order to study the transfer process. The modules were transferred between the three exchange pairs and were implemented in the new educational context after being subjected to adaptations as required. This transfer process was closely monitored so as to identify and document various aspects including the key steps

involved in the adaptation of the modules and the main issues that tended to either facilitate or impede the transfer. Throughout the project we have reflected on, and monitored, the processes of developing and refining the modules in order to create a Handbook with guidelines on how to do this and also how to transfer examples of successful teaching practice from one educational setting to another.

The curriculum development process that was implemented in the project was specifically designed so as to adhere to certain principles and satisfy specific constraints, which were deemed likely to facilitate the attainment of the projects' objectives. The most important of these principles and specifications are presented below.

Constraint 1: Design of modules for topics falling in the wider area of Materials Science

Each module has focused on a certain topic drawn from the wider domain of Materials Science, which is currently lacking in educational innovations. The interdisciplinary subject of Materials Science offers possibilities for exploring the potential of combining scientific investigation with technological design activities and thus promoting the relationship between science and technology, helping students to develop epistemological awareness. Furthermore, the promotion of the bidirectional relationship between science and technology illustrates the relevance of science learning in addressing social problems and responding to human needs.

Constraint 2: Design of modules that promotes science as a process of inquiry

The modules specifically rely on activity sequences that seek to promote science as a process of inquiry. That is, through the activity sequence students engage with meaningful questions and are guided so as to collect and process appropriate data and formulate conceptual models with predictive capability.

Constraint 3: Employ ICT tools (to serve roles they are appropriate for)

In designing each module the partners were encouraged to assume the various ICT tools that are currently available and incorporate them, as needed, (or develop their own) so as to facilitate the attainment of the targeted learning objectives. However, special care was taken to avoid undue use of such tools and safeguard their productive incorporation that is consistent with the learning objectives.

Principle 1: Need for establishing participative curriculum design processes

One of the most important principles is that curriculum development should be viewed as a joined task that could be productively undertaken by synergies combining multiple expertises. Throughout Europe there exist many isolated cases of successful practice in science and technology education, sometimes with impressive results. In some cases, these examples are the result of efforts of individual teachers who are highly dedicated and have managed to develop expertise that flourishes in individual classrooms. More commonly however, success comes as a result of close **partnerships** between (a) people at University who have taken it upon themselves to dwell scientifically into student learning and to respond to a sense of responsibility to the community and the educational system, (b) teachers who have welcomed outsiders in their classroom as an

opportunity to complement their expertise and engage in a process of collecting evidence of student learning as a means to improving their practice, and (c) science education policy makers who have tolerated and sometimes encouraged such partnerships of complementary expertise, of bridging research and practice because they have identified them as a means to bring about a long lasting improvement in the quality of science teaching and learning as well as a process of promoting science for all. The project seized this opportunity by building a network of partnerships at national level as a mechanism for spreading such initiatives. Specifically, each partner organized a Local Working Group (LWG), consisting of experienced science researchers and science teachers who worked together to develop the module on the topic they had selected.

Principle 2: Need to view the development of teaching modules as an iterative, research-based process

The development of teaching and learning materials should be best conceived as an iterative process involving cycles of development, implementation, evaluation and refinement. It is only through the execution of such (usually several) cycles that curriculum materials might gradually converge to a form that can be reliably used to address the targeted learning objectives. In order to conform to this principle the modules that were developed by each LWG were subjected to iterative refinement through their implementation in classroom environments. The data that emerged during the implementation, as a means to assess the effectiveness of the modules, were then used to guide its refinement so as to better meet the objectives it had been designed for.

4.2 The importance of research-based teaching and learning modules

As mentioned previously the modules have been designed and developed following the research-based approach. **Research-based modules** have many advantages, they are compilations of teaching and learning activities that (a) begin from where the students are, taking into consideration established knowledge about student ideas and alternative conceptual frameworks; (b) are intellectually challenging while at the same time they are sequenced to facilitate the construction of meaning by helping students to sustain active engagement and to overcome conceptual, reasoning and epistemological barriers which have also been established through research; (c) are designed to elicit the activation of reasoning patterns, argumentation strategies and commonly shared, collaboratively developed understandings that emerge through extended processing of theory and evidence in a mutually interacting manner; (d) have been documented through iterative processes of implementation, evaluation, refinement to work effectively in real classrooms in order to promote science learning for all students.

Such teaching and learning modules have the additional advantage that because they rely on established principles of teaching and learning they can be more easily transferable across diverse educational settings. Transferring exemplary practices from one national educational system to another is difficult because of cultural, linguistic, organizational and systemic differences between any two countries. Furthermore, transferring lessons learned and taking a reform-based initiative to scale is difficult even within the same educational system.

The most commonly cited reasons for these difficulties include differing teacher backgrounds and motivation, inability to provide adequate support for sustaining or replicating an innovative effort when the designers of the innovation or the researchers are no longer present, strong inhomogeneities in the characteristics of the student population, local school cultures, explicit and implicit leadership, differing educational priorities, coordination of resources, and local knowledge-sharing and knowledge-building mechanisms. In short, the human, social, and physical capital ingrained in any educational system, often operate as barriers to any effort to transfer educational expertise from elsewhere.

Two of the main outputs of the project are the Guidelines for developing research-based modules and the recommendations for transferring successful teaching practice to new educational settings in another country. Both documents have been developed by identifying and reporting the essence and the generic principles, of curriculum development and the transfer process, thus making them reusable. These documents could be of use to the wider community and more specifically could help in overcoming the barriers described earlier and provide guidance on transferring expertise. An ambition of the project is that the main outcomes and especially these documents will inform science education policy. In relation to the transfer recommendations the added value is twofold:

- They emerged through the participative process that involved the designers of the original educational module, the professionals who implemented it successfully and the professionals who adapted it in order to implement it in their country as a way of solving existing educational problems or simply improving science teaching and learning.
- The process was scaffolded, first the critical attributes for transfer were identified with the aim to be able to decontextualize from specific contextual constraints of the original educational system. The next step was the recontextualization of the key ideas in the new system, making sure to adjust to the distinctiveness of the new system without compromising the elements that established it as a success in the first place.

4.3 Contribution to policy development

The Materials Science project seeks to inform science education policy making in three respects:

- a. the project's results highlighted the issues and associated barriers in relation to University – school partnerships especially with a view to using curriculum development as a medium for impacting on classroom teaching practice for secondary science.
- b. peer group study visit reports highlighted the issues and identified the existing barriers that impeded the exchange of successful teaching practice in secondary science.
- c. the Curriculum Development Guidelines and the Handbook of Transfer Recommendations highlighted the critical issues related to principles of curriculum design and how these can be implemented across diverse educational settings

The project also provided useful insights on the importance of science education research in informing policy development. In particular, the methodical examination of issues related to curriculum design, implementation and evaluation led to generic principles that could be adhered to, independently of context.

5. Methodology

The methodology used in the MS project was mainly based on the Management Structure of the project and especially the Expert Panel and Local Working Groups (LWGs). The Expert Panel (EP) consisted of at least one experienced researcher from its institution and the three external experts. The Expert Panel had the responsibility of over viewing the key activities of the project. Peer Review Study Visits held a pivotal role in the completion of the project. They served as a monitoring mechanism to safeguard that the Curriculum Development Guidelines, developed by the Expert panel, were employed as a guiding framework in the design and development of the modules. Specifically the study visits were intended to facilitate the collection of information regarding the implementation process followed by each LWG with emphasis on the teaching/learning strategies that had been employed in each module and their appropriateness for the corresponding learning objectives. The Study visits served two main functions. Firstly, the Host LWG received feedback on the design and implementation of the module while, at the same time, the visiting experts gathered data for improving the Curriculum Development Guidelines. The involvement of 5 different countries in the project enabled the collection of data from diverse educational settings.

The project entailed two cycles of peer review study visits. During the first cycle, which took place in the second year, a group consisting of at least one member of the Expert Panel observed the implementation process of the initial version of the module in a local student environment. The second cycle of study visits took place during the third year. This time the visiting experts observed the implementation of the adapted (transferred) module. The purpose was to collect information regarding the process followed by the recipient LWG in adapting and implementing the module. The compilation of the reports that emerged from both the first and the second round of study visits were used to improve the Curriculum Development Guidelines, the Teaching/Learning Sequences (TLS) and the Transfer Recommendations.

6. Work Performed and Major Achievements

The main achievements of the project are summarised below.

- Guidelines for the design, development, implementation and evaluation of teaching modules for science learning

The final version of the Guidelines is the product of the combined efforts of all the partners, from UCy that created the initial draft and all the partners that provided feedback and comments, to the iterative process itself. The final additions to the guidelines were drawn from the iterative process to increase their adaptivity to diverse educational settings.

The guidelines were developed to work as a framework for the design and development of innovative science TLS and not as a blueprint that will work miracles in the field of curriculum design. The guidelines present a collection of important information based on years of scientific research on the field of educational sciences. The guidelines emphasise on research-based design and the iterative process, as well as the participative design of curriculums comprised teachers, policy makers and of course science education researchers. Moreover, emphasis is placed on science as an inquiry process offering students the advantage to perform their own investigations building in depth conceptual understanding, scientific and reasoning skills and thus, cultivating positive attitudes towards science. Finally, it encompasses pedagogical approaches and teaching strategies.

➤ Final version of the ICT-enhanced, research-based inquiry modules

The titles of the six modules and the designer groups are shown below:

- Materials Around us – UH
- Material's density in floating/sinking phenomena - UWM
- Acoustic properties of materials - UAB
- Optical properties of materials - UoN
- Thermal Conductivity applications of materials - AUTH
- Electromagnetic properties of Materials - UCy

One of the main outputs of the project are the six TLS that were designed by the partners. In the first year of the project, each partner selected the members of their LWG. All the LWG comprised experienced science education researchers and science teachers in an attempt to bridge the gap between research and practice. By the end of the first year, each LWG had prepared a draft version of their module. All the modules employed the inquiry learning approach and their design was based on the Curriculum Development Guidelines. Each of the groups at the end of the first year delivered a teaching material based on inquiry and enhanced with the use of ICT tools. During the second year, these modules were implemented locally and they were refined after evaluation based on student assessment, feedback received from the external experts after the study visit, comments from the teachers that performed the implementation, etc. During the final year of the project, the module created by one country was transferred to another. The exchange pairs, which were determined in the first year, were UCy-UAB, UoN-AUTH, UWM-UH. The modules were adapted to meet the needs of the new educational settings and they were revised again after their implementation in a real classroom. The final four versions of each module are: the designed module in English and native language of the LWG that undertook the initial design and the adapted (transferred) module in English and native language of the LWG that undertook its adaptation.

➤ Final version of the assessment tasks for measuring student performance and effectiveness of the curriculum

Each module is accompanied by a series of tasks intended to assess students' understanding of the corresponding core concepts. The initial version of the assessment tasks for each of the modules was developed in the beginning of the second year. The

assessment tools have a threefold purpose; first, to monitor students' performance and to determine the extent to which the learning objectives had been attained; second, to use students' learning gains (or lack thereof) as a measure of the effectiveness of the TLS and finally, to identify parts of the activity sequence that were not effective and, hence, guide the refinement process. After each implementation the appropriateness of the assessment tasks was reconsidered and this often led to revisions to increase their capability to measure what they had been designed for. The final versions of the assessment tasks include four versions for each module (i.e., tasks for the original version of the module in English and the native language of the LWG that undertook its initial development; tasks for the adapted version of the module in English and the native language of the LWG that undertook its adaptation).

➤ Motivation tools for monitoring student engagement with science learning

Self-Determination theory by Deci and Ryan was identified as the most appropriate for the classroom activities employed in the modules. During the second year the instruments were formulated by HU partner to facilitate the collection of data from students during the implementation of each of the modules. The tools include two likert-scale questionnaires and an interview protocol. The first questionnaire is entitled "Academic Motivation for Learning Science" and the results were used to cluster students in three main categories, those intrinsically motivated, extrinsically motivated and amotivated. The second questionnaire is entitled "Evaluation of Science Inquiry Activities" and it targets at identifying motivating features of science inquiry activities. The questions are intended to draw out the perceptions of the participating students in relation to the following five categories: activities that support a) their feeling of competency, b) social relatedness c) interest in terms of value, usefulness d) interest in terms of enjoyment and e) autonomy (choice). The final tool is the semi-structured Interview Protocol. A sample of students is selected for interviews on the basis of their responses to the first questionnaire so as to get additional insights on which activities students' with different motivational behaviour identified as interesting and why. During the third year of the project, UCy and UAB partners introduced an additional research question to the motivation study. The aim was to study the variation of students' interest for different types of science inquiry activities. As a result, the "Evaluation" questionnaire was shortened since addressing this new research question posited its administration quite a few times throughout the implementation of the modules. The partners have agreed to extend the dissemination plan beyond the dissemination activities agreed in the project's contract to include a journal publication presenting the results of the motivation study.

➤ Recommendations for achieving transfer of successful teaching practice from one educational system to another

The information collected from the reports of the second cycle of peer review study visits, describing the adaptation process (e.g. key concepts and teaching approaches that remained unchanged, type of modifications that were undertaken along with the underlying rationale) were used to develop and refine the recommendations. The report presents the main steps of the transfer process and then focuses on elaborating on each of the transfer cases of the project. Finally, the recommendations are organized around three questions, a) what is transferable and what factors determine this b) which

mechanisms are considered as crucial for the quality and extend of transfer, and c) what factors contributed, acted as facilitators, in succeeding a better transfer.

➤ Development of a Handbook for Developing Teaching Modules in Science and Technology Education

The handbook focuses on the development of teaching/learning materials based on the principles of research-based design, participative design and iterative refinement following cycles of design and development, implementation, evaluation and redesign. The handbook includes theoretical chapters introducing these innovative approaches for curriculum development and then the actual development process is presented in individual Case Studies for each of the six modules. The handbook will be published as a book in the following months. A contract has already been signed with Springer Publishing.

➤ Materials Science Website

One of the key dissemination tools of the Materials Science project is its Website. The initial design of the website which took place in the first months of the project was replaced by a more functional and efficient design that makes the navigation of the visitors easier. The website provides open access to the project's results and different user groups have the opportunity to download any of the information provided in the website by following a simple procedure. The website, also, includes sections with restricted access, accessible only by members of the consortium. The website is accessible from the link below:

<http://lsg.ucy.ac.cy/materialsscience/>

Section II: Dissemination and use

Introduction

A project's success and sustainability is directly linked to the dissemination activities that have been decided. The dissemination activities have to raise awareness and publicity of the project's methodology and outcomes. This report highlights all the dissemination activities that were undertaken during the lifespan of the Materials Science project and future dissemination activities planned by the consortium.

The dissemination report comprises three sections, which are:

1. **Exploitable results and its use:** under this section are included all the project's outcomes that are characterised as "knowledge having a potential for industrial or commercial application, for creating or marketing a product or creating or providing a service". In our case, exploitable results are considered the outcomes that have the potential to be of use to interested groups by exploiting the derived knowledge. The overview table is followed by a short description for each exploitable result.
2. **Dissemination of knowledge:** this section presents all the dissemination activities that were undertaken by the consortium in the full duration of the project. The activities are organised in an overview table in a descending chronological order. A subsection has been allocated to present planned activities. The consortium is clear about representing the project in major forthcoming conferences and other events. Furthermore, peer-reviewed publications have been decided for significant outcomes of the project.
3. **Publishable results:** this section presents the publishable exploitable results, each one accompanied by a publishable summary.

1. Exploitable knowledge and its use

Materials Science is a Specific Support Action project and as anticipated did not generate any commercially exploited technical knowledge. However, many of the deliverables of the project are of great importance to interested groups, for example science teachers, science education researchers and education policy makers. The Overview Table below lists the exploitable results of the project and underneath the table there is a short description of each one, explaining, also, the potential of these deliverables as supportive tools to interested groups.

Exploitable Knowledge	Sector(s) of application	Patents or other Intellectual Protection Rights (IPR)	Owner & Other partner(s) involved
Curriculum Development Guidelines	Education Policy & Practice, Teachers, etc.	---	C.P. Constantinou & EP
Teaching/Learning Modules	Primary and Secondary Education	Creative Commons: Attribution Non-commercial Share Alike License	Authors of each TLS
Transfer Recommendations	Education policy & Practice, Teachers, etc.	---	C.P. Constantinou & EP
Case Studies Book	Scientific community, Education Policy & Practice	---	All authors

Table 1: Overview table of exploitable results

- Guidelines for the design, development, implementation and evaluation of teaching modules for science learning (Curriculum Development Guidelines)

The guidelines were created in an attempt to support the effort to change science teaching/learning methods in schools by developing innovative curriculums based on established research findings in the field of science education. Even though, there have been many attempts to change science teaching methods and hence students' attitudes towards science, the reality is that students' wishing to continue their studies in science is decreasing. This trend is attributed to the gap between school science and how science is done in authentic contexts. The Curriculum Development Guidelines present the most significant theories and strategies in science education according to the views of the experienced science education researchers that comprised the Expert Panel of the project. The intention is the guidelines to be used as a framework by anybody interested in the development of teaching/learning materials, from teachers to policy makers.

- ICT-enhanced, research-based inquiry modules (Teaching/Learning Modules)

The six modules developed by the partners are the main product of the project. The modules' development is based on two relatively new design approaches, research based design and participative design. Research based modules have a clear advantage by investigating, students' beliefs and misconceptions and using teaching and learning strategies that research has shown to help students overcome entrenched false beliefs coming from prior knowledge. Moreover, the activities follow students existing knowledge keeping them engaged and at the same time offering support and facilitating deep conceptual understanding by being well sequenced. Additionally, the activities go through an iterative process of design and development, implementation, evaluation and

refinement. The iteration in real classrooms increases the effectiveness of the modules by bridging theory with practice. This union is also exploited in the modules by employing the participative design; the initial design is the result of a close collaboration between experienced, researchers and science teachers.

The topic of Materials Science was selected due to the emerging technological trends and the lack of innovative curriculums in this field. The design of the ICT enhanced modules is based on inquiry activities; students design and carry out investigations in order to produce meaningful answers (evidence based explanations). Science teaching through inquiry supplies students with knowledge and skills that are essential for living and working in the “information society”. Summarising, all the modules have a common base, they are innovative teaching and learning materials aiming at improving the quality of science teaching and learning in schools, by cultivating appreciation for the nature of science and scientific reasoning and by promoting science teaching and learning approaches that follow closely the way science is done in authentic contexts.

The teaching/learning modules are copyright protected. The modules are covered by the Creative Commons Attribution Non-commercial Share Alike License. This license lets others remix, tweak, and build upon the protected work non-commercially, as long as they credit the authors and the project and license their new creations under the identical terms.

- Recommendations for achieving transfer of successful teaching practice from one educational system to another (Transfer Recommendations)

Throughout Europe there are many isolated examples of successful teaching practice, sometimes with impressive results. However, attempts to transfer exceptional teaching examples, even to other school communities in the same educational system, begin with high expectations and most of the times finish in disappointment. Knowledge transfer has been vastly researched in business, technology and medicinal contexts over the last two decades. In education though, knowledge transfer is a subject that has not received the proper attention. Knowledge transfer is a complicated topic in any context but in education is a subject that is often avoided due to the multiple factors that impede such an endeavour; these include all the human, social, and physical capital ingrained in any educational system.

The recommendations report presents a framework for replicating teaching innovations away from the place they originated from. Immediately after this, the focus is on each of the three transfer cases. For each exchange pair there is a table reporting on the adaptation, implementation and evaluation of the modules with additional insights on factors and actions that facilitated the transfer process. Throughout the report emphasis is given on the people network that had to be created between the two countries (partners) to succeed a better transfer. The recommendations are organized around three questions, a) what is transferable and what factors determine this b) which mechanisms are considered as crucial for the quality and extend of transfer, and c) what factors contributed, acted as facilitators, in the transfer process.

- Development of a Handbook for Developing Teaching Modules in Science and Technology Education (Case Studies Book)

The handbook focuses on the development of teaching/learning materials based on the principles of research-based design, participative design and iterative refinement. Design based research as a methodological framework that has the potential to contribute substantially in reforming science teaching and learning. Participative design as a mechanism for harnessing complementary expertise, bringing theory and practice. And iterative refinement as a way to develop effective teaching materials tested in real classrooms to promote science learning for all students. The remaining chapters reflect on the development of each of the six modules in individual Case Studies. The handbook will be published as a book in the following months. A contract has already been signed with Springer Publishing.

2. Dissemination of knowledge

Throughout the duration of the project all the partners have made a substantial contribution towards the dissemination of the methodology and outcomes of the project. All the partners participated in the GIREP 2008, ESERA 2009 and the Panhellenic Science Education Conferences with a Symposium of individual paper presentations and interactive poster presentations. Additionally, the partners individually participated in international and national conferences with paper presentations, key note presentations, etc. Moreover, papers were published in scientific peer-reviewed journals, edited books and conference proceedings. On October 13th, 2010, UCy represented the Materials Science Project in the S-TEAM meeting that took place in Glasgow, Scotland. The conference hosted various Science and Society projects and we had the chance to present the project's results and also to participate in reflection sessions for future directions of Science Education projects. Furthermore, the Materials Science project website is listed in the SCIENTIX website since October 2010.

Finally, on November 6, 2010, UCy organised a closing conference to inform the research community and the educational authorities of the project's outcomes. The participation exceeded our expectations with approximately 120 attendees. On November 30th, 2010, another conference was organised by UWM partner for the dissemination of the project's results with high participation from the local educational authorities, educational community, academic representatives and Education post-graduate students.

2.1 Completed Dissemination Activities

The dissemination activities listed in the overview table below include all the activities carried out in the full duration of the project. Furthermore, underneath the table there is a list presenting all the papers published in the duration of the project in scientific journals, edited books and conference proceedings.

Overview Table

Planned/ actual Dates	Type	Type of audience	Countries addressed	Size of audience	Partner responsible /involved
Under review	Article in <i>Science & Education</i> (Journal)	Research Community	International		UCy
In press, 2010	Article in Physics Education (Institute of Physics)	Research Community	International		AUTH
2010	Materials Science Closing Conference	Research Community and Teachers	National	120	UCy
2010	Materials Science Conference	Research Community and Teachers	National	150	UWM
2010	Article in Conference Proceedings of <i>GIREP 2008</i>	Research Community	International		AUB
2010	Article in Conference Proceedings of <i>GIREP 2008</i>	Research Community	International		UWM
2010	Article in Conference Proceedings of <i>GIREP 2008</i>	Research Community	International		AUTH
2010	Article in Conference Proceedings of <i>GIREP 2008</i>	Research Community	International		UoN
2010	Article in <i>International Journal of Science Education</i> Vol. 32, No. 2, 15 January 2010, pp. 143–172	Research Community	International		UCy
2010	Article in <i>Multiple Literacy and Science Education</i> . Hershey: IGI Global, pp. 225 – 239	Research Community	International		UH

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2009	Article in <i>Alambique. Didáctica de las Ciencias Experimentales</i> (Journal)	Research Community	International		AUB
2009	Article in Proceedings of the <i>International Conference on Science Education in Europe</i> .	Research Community	International		UH
2009	Article in <i>Physics Education</i> (Institute of Physics)	Research Community	International		UoN
2009	Two articles in <i>Proceedings of the Annual Symposium of the Finnish Mathematics & Science Education Research Association 2008</i>	Research Community	National		UH
2009	Article in <i>Proceedings of the Annual Symposium of the Finnish Mathematics & Science Education Research Association 2007</i>	Research Community	National		UH
2009	Paper presentation in ESERA 2009 Conference	Research Community	International	1000	All
2009	Paper presentation in ESERA 2009 Conference	Research Community	International	1000	UH
2009	Presentation in ESERA 2009 Conference	Research Community	International	1000	UCy
2009	Paper presentation in ESERA 2009 Conference	Research Community	International	1000	UWM
2009	Interactive Poster Presentation in ESERA 2009 Conference	Research Community	International	1000	Ucy
2009	Interactive Poster Presentation in ESERA 2009 Conference	Research Community	International	1000	UoN
2009	Interactive Poster Presentation in ESERA 2009 Conference	Research Community	International	1000	AUTH
2009	Interactive Poster Presentation in ESERA 2009 Conference	Research Community	International	1000	UH
2009	Interactive Poster Presentation in ESERA 2009 Conference	Research Community	International	1000	UAB
2009	Interactive Poster Presentation in ESERA 2009 Conference	Research Community	International	1000	UWM

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2009	Oral presentation at NARST 2009	Research Community	International	1000	UAB
2009	Key Note Presentation at the International Conference on Science Education in Europe	Research Community	International		UH
2009	Key Note Presentation at "Women and Science" and BEYOND, Prague	Research Community	International		UH
2009	Oral presentation at Congreso Internacional sobre Investigación en Didáctica de las Ciencias 2009	Research Community	International		UAB
2009	Paper Presentations at 7TH General Conference of the Balkan Physical Union	Research Community	Balkan		AUTH
2009	Presentation at Joint Research Training: Berlin Summer School	Phd Students	Europe		
2009	Poster Presentation at Joint Researcher Training: Rovaniemi Winter School	Phd Students	Europe		UH
2009	Symposium at 6th Panhellenic Conference on Science Education	Research Community and Teachers	Greece	500	UCy, UWM, AUTH
2009	Key Note Presentation at 6th Panhellenic Conference on Science Education	Research Community and Teachers	Greece	500	UCy
2009	Paper Presentations at 6th Panhellenic Conference on Science Education	Research Community and Teachers	Greece	500	UCy
2009	Interactive Poster Presentation at 6th Panhellenic Conference on Science Education	Research Community and Teachers	Greece	500	UCy
2009	Interactive Poster Presentation at 6th Panhellenic Conference on Science Education	Research Community and Teachers	Greece	500	UoN, UCy
2009	Interactive Poster Presentation at 6th Panhellenic Conference on Science Education	Research Community and Teachers	Greece	500	AUTH
2009	Interactive Poster Presentation at 6th Panhellenic Conference on Science Education	Research Community and Teachers	Greece	500	UH, UCy

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2009	Interactive Poster Presentation at 6th Panhellenic Conference on Science Education	Research Community and Teachers	Greece	500	UAB, UCy
2009	Interactive Poster Presentations at 6th Panhellenic Conference on Science Education	Research Community and Teachers	Greece	500	UWM
2009	Key Note Presentation at Annual congress of the Italian National Society of Physics	Research Community and Teachers	Greece		UoN
2009	Paper Presentation at 1st Panhellenic Conference on Cognitive Science	Research Community and Teachers	Greece		UWM
2009	Presentations at the Annual Symposium of the Finnish Mathematics and Science Education Research Association	Research Community and Teachers	Greece		UH
2009	Seminar	Teachers	Finland	120	UH
2009	Science Fest	Teachers and students	Finland	1000	UH
2009	In-service training for teachers	Teachers	Finland	15	UH
2009	Presentation at University	In-service teachers	Naples, Italy	100	UoN
2009	Seminar within the Continuous Professional Development Science Education programme	Secondary school teachers	Catalonia, Spain		UAB
2009	Article in the local newspaper "Elefthero Vima tis Florinas"	General Public	Florina, Greece		UWN
2008	Presentations at the Annual Symposium of the Finnish Mathematics and Science Education Research Association	Research Community and Teachers	Greece		UH
2008	Article in <i>Themes in Science and Technology Education</i> 1(1), 7-36	Research Community	International		UH

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2008	Article in <i>Journal of Baltic Science Education</i> 7(2) 86-103	Research Community	International		UH
2008	Article in <i>Journal of Baltic Science Education</i> 7(2) 188-199	Research Community	International		UH
2008	Symposium at GIREP 2008 “Physics Curriculum Design, Development and Validation”	Research Community	International	500	All
2008	Interactive Poster Presentation at GIREP 2008 “Physics Curriculum Design, Development and Validation”	Research Community	International	500	UCy
2008	Interactive Poster Presentation at GIREP 2008 “Physics Curriculum Design, Development and Validation”	Research Community	International	500	UoN
2008	Interactive Poster Presentation at GIREP 2008 “Physics Curriculum Design, Development and Validation”	Research Community	International	500	AUTH
2008	Interactive Poster Presentation at GIREP 2008 “Physics Curriculum Design, Development and Validation”	Research Community	International	500	UH
2008	Interactive Poster Presentation at GIREP 2008 “Physics Curriculum Design, Development and Validation”	Research Community	International	500	UAB
2008	Interactive Poster Presentation at GIREP 2008 “Physics Curriculum Design, Development and Validation”	Research Community	International	500	UWM
2008	Plenary presentation at Nordic-Baltic Seminar on Science Education	Research Community	International	50	UH
2008	Small Group Presentation at Nordic-Baltic Seminar on Science Education	Research Community	International	50	UH
2008	Paper Presentation at The Ninth International Partnership Conference	Research Community	International		UH
2008	Paper Presentation at ESERA Summer School 2008	Phd Students	International		UWM
2008	Flyer distributed in Conferences during 2008 and 2009	Research Community	International	1000	UCy

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2008	Special TV-Series for Teacher/Student Use	General Public	Finland		UH
2008	Website of the project CRECIM	Researchers and Teachers	Catalonia, Spain		UAB
2008	Seminar	University Students	Sweden	200	EP
2008	Presentation – Science Camp for High School Students, Closing Ceremony	Students, Parents, Teachers	Cyprus	150	UCy
2008	Presentation - Inaugural Ceremony for the Laniteion Science Museum	Students, Parents, Teachers	Cyprus		UCy
2007	Announcement to Conference Participants at ESERA 2007	Research Community	International	1000	All
2007	Oral Presentation GIREP – EPEC	Research Community	International		UoN
2007	Presentation at the Annual Symposium of the Finnish Mathematics and Science Education Research Association	Research Community and Teachers	National		UH

Table 2: Overview table of completed dissemination activities

Publications

Papers in Journals

Hadjilouca, R., Constantinou, C.P., Papadouris N. (Under Review), Epistemological considerations about interconnections between science and technology: the rationale of a teaching innovation, *Science & Education*

Hatzikraniotis, E., Kallery, M., Molohidis, A., Psillos, D. (In press) Students' design of experiments: an inquiry module on the conduction of heat, *Physics Education* (Institute of Physics)

Constantinou, C.P., Hadjilouca, R., Papadouris N. (2010), Students' Epistemological awareness concerning the distinction between Science and Technology, *International Journal of Science Education* Vol. 32, No. 2, 15 January 2010, pp. 143–172

Lombardi, S., Monroy, G., Testa, I., Sassi, E. (2009), Measuring variable refractive indices using digital photos, *Physics Education* (Institute of Physics), January 2010, 45(1) 83-92

Couso, D., Hernández, M.I., Pintó, R. (2009), La propiedades acústicas de los materiales: Una propuesta didáctica de modelización e indagación sobre Ciencia de Materiales, *Alambique, Didáctica de las Ciencias Experimentales*

Lavonen, J., Byman, R., Uitto, A., Juuti, K., Meisalo, V. (2008), Students' Interest and Experiences in Physics and Chemistry related Themes: Reflections based on a ROSE-survey in Finland, *Themes in Science and Technology Education* 1(1) 7-36

Lavonen, J., Gedrovics, J., Byman, R., Meisalo, V., Juuti, K., Uitto, A. (2008), Students' motivational orientations and career choice in science and technology: A survey in Finland and Latvia, *Journal of Baltic Science Education* 7(2) 86-103

Laherto, A., (2008), The need, challenges and central contents for informal nanoscience and -technology education in Finland, *Journal of Baltic Science Education* 7(2) 188-199

Papers in Edited Books

Constantinou, C.P., Papaevripidou, M., Lividjis, M., Scholinaki, A., Hadjilouca, R. (2010) Teaching & Learning about Electromagnetism in High School: Addressing issues of Relevance & Epistemic practice, In C.P. Constantinou & N. Papadouris (Eds.) *Physics Curriculum Design, Development and Validation, GIREP 2008 Conference Proceedings*, pp. 296-310.

Lombardi, S., Monroy, G., Sassi, E., Testa, I. (2010) Design and Development of a module about Optical Properties of Materials, In C.P. Constantinou & N. Papadouris (Eds.) *Physics Curriculum Design, Development and Validation, GIREP 2008 Conference Proceedings*, pp. 332-350.

Pintó, R., Couso, D., Hernández M.I. (2010), Modelling and Inquiring Sound Attenuation: Design-based research about an ICT enhanced unit on Materials Science, In C.P. Constantinou & N. Papadouris (Eds.) Physics Curriculum Design, Development and Validation, GIREP 2008 Conference Proceedings, pp. 351-371.

Psillos, D., Hatzikraniotis, E., Molohidis, A., Kallery, M., Petridou, E. (2010) An innovative inquiry-oriented module on Thermal conductivity: Design, Development and Application, In C.P. Constantinou & N. Papadouris (Eds.) Physics Curriculum Design, Development and Validation, GIREP 2008 Conference Proceedings, pp. 372-390.

Spyrtou, A., Zoupidis, A., Kariotoglou, P. (2010) The design and development of an ICT-enhanced module concerning density as a property of materials applied in floating/sinking phenomena, In C.P. Constantinou & N. Papadouris (Eds.) Physics Curriculum Design, Development and Validation, GIREP 2008 Conference Proceedings, pp. 391-407.

Lanoven, J., Laherto, A., Loukomies, A., Juuti, K., Kim, M., Lampiselka, J., Meisalo, V. (2010), Enhancing scientific literacy through the industry site visit, Multiple Literacy and Science Education. Hershey: IGI Global, pp. 225 – 239

Papers in Conference Proceedings

Petridou, E., Hatzikraniotis, E., Molohides, A., Psillos, D. (2010) Aspects of microscopic models in the teaching of physics: The case of polarization and thermal conductivity, 7th General Conference of the Balkan Physical Union, AIP Conference Proceedings, Volume 1203, pp. 1409-1413

Molohides, A., Hatzikraniotis, E., Kallery, M., Psillos, D. A European project on Material Science: The case of thermal conductivity teaching-learning sequence, 7th General Conference of the Balkan Physical Union, AIP Conference Proceedings, Volume 1203, pp. 1388-1393

Hernández, M.I., and Pintó, R., Desarrollo iterativo de una secuencia de enseñanza y aprendizaje sobre propiedades acústicas de los materiales, Congreso Internacional sobre Investigación en Didáctica de las Ciencias 2009 “Enseñanza de las Ciencias en un mundo en transformación”, 7 – 10 September 2009, Barcelona, Spain

Zoupidis, A., Pnevmatikos, D., Spyrtou, A., Kariotoglou, P. (2009) The gradual approach of the nature and role of models as means to enhance 5th grade students' epistemological awareness, ESERA 2009 Contemporary Science Education research: Learning and Assessment, pp. 415-424

Constantinou C.P., Kariotoglou P., Psillos D., Tselfes V. (2009) The importance of authenticity, articipatory processes and reflective research in use of research findings for designing educational innovations: the example of project Materials Science, Proceedings of the 6th Panhellenic Conference on Science Education and ICT in Education (2009), The multiple approaches of teaching and learning science, pp. 122-126

Scholinaki, A., Livitzis, A., Papadouris, N., Constantinou, C.P. (2009) Participative Design and Research Validation of Curriculum materials: an example on the Electromagnetic Properties of Materials, Proceedings of the 6th Panhellenic Conference on Science Education and ICT in Education (2009), The multiple approaches of teaching and learning science, pp. 827-836

Livitzis, M., Loizidou, E., Scholinaki, A., Constantinou, C.P. (2009) Possible Transfer of educational innovations from one educational setting to another: an attempt to adapt and implement in Cyprus a module on Acoustics that was designed and developed in Catalonia, Proceedings of the 6th Panhellenic Conference on Science Education and ICT in Education (2009), The multiple approaches of teaching and learning science, pp. 504-512

Pintó, R., Couso, D., and Hernández, M.I (2009) Design-based research on Materials Science: Modelling and inquiring sound attenuation, NARST Annual International Conference, Grand Challenges and Great Opportunities in Science Education, 17-21 April 2009, Garden Grove, California, US

Lavonen, J. (2009) Students' interest and motivation in science learning: Reflections based on two European projects, Proceedings of the International Conference on Science Education in Europe, 5-7 January 2009, Taipei, Taiwan

Janson, J., Lavonen, J., Loukomies, A. & Juuti, K., Materiaalit ympärillämme – opintojaksoi ja opettajien käyttökokemuksia, Proceedings of the Annual Symposium of the Finnish Mathematics & Science Education Research Association 2008

Juuti, K. & Lavonen, J., Design-Based research ainedidaktisen tutkimuksen metodologisena lähestymistapana. Proceedings of the Annual Symposium of the Finnish Mathematics & Science Education Research Association 2007

2.2 Future Dissemination Activities

In the duration of the project, all the partners participated in dissemination activities presenting the methodology and the outcomes of the project. The consortium will continue to participate in International and National scientific and teacher enhancement conferences as well as various meetings of teacher associations that take place at a national level. Also, the project outcomes will continue to be disseminated through the various teacher preparation and postgraduate programmes that different members of the consortium are engaged in.

Furthermore, in addition to the publication commitments that are included in the contract, we also intend to publish the following:

- A Handbook for Developing Teaching Modules in Science and Technology Education (Case Studies Book).
As mentioned in the previous section, a contract has been signed with Springer. Dimitris Psillos and Petros Kariotoglou serve as editors and have undertaken the responsibility to monitor the process of the development and review of the case studies and the theoretical chapters. A draft version of the Case Studies Book was submitted with the final report as Deliverable 7.1.
- A paper on students' interest in science learning which will be submitted for publication in a scientific journal.
Draft versions of the paper have been already submitted and presented in conferences. The authorship of this article will be with the Finnish group.
- A special issue in a science education journal dealing with the issue of integration of laboratory work and model-based activities for the purpose of facilitating inquiry-oriented teaching and learning in Materials Science.
An extended summary of each of the individual papers for the special issue has been submitted to the project co-ordinator. At this stage the extended summaries have been reviewed and the next step is the submission of the full articles.

3. Publishable results

The publishable exploitable results of the project are the Teaching/Learning modules and the Handbook for developing Teaching Modules in Science and Technology Education. This section includes a summary for each of the modules and the proposal submitted for review in Springer publications for the Handbook (Case Study Book).

3.1 Teaching/Learning Modules

The teaching/Learning modules have been made publicly available under the Creative Commons - Attribution Non-commercial Share Alike License. The modules are available for download from the project's website accessible from the link below:

<http://lsg.ucy.ac.cy/MaterialsScience/>

Electromagnetic Properties of Materials – University of Cyprus

This module focuses on the magnetic properties of materials and electromagnetism and it encompasses two distinct, albeit interrelated, components. The first seeks to gradually help students develop core ideas of magnetism and electromagnetism and formulate conceptual models that allow analyzing relevant phenomena. The second engages students in the design of a magnetically levitated train. Students are expected to address this task by transferring concepts and ideas elaborated in the first part of the module. Throughout the module, an attempt is made to engage students in explicit epistemological discourse on a range of issues including the role of human invention in science and the distinction and interrelation between science and technology.

Materials around us – University of Helsinki

The module introduces students to properties and origins of materials around us, in an attempt to offer an overview of careers and occupations in materials science related businesses and industries, and to increase students' interest to study science. The rationale is that scientific innovations with direct applications on our everyday life can arouse interest in science studies if integrated in school science curricula.

Materials' density in floating/sinking phenomena – University of Western Macedonia

The module studies density as a property of materials in floating and sinking phenomena. It employs a combination of different teaching/learning strategies with real experiments and simulations intended to help students to develop conceptual understanding of the factors affecting floating/sinking and to be able to interpret and predict these types of phenomena in various mediums. The focus is on the density of a wide range of materials, from everyday to hi-tech materials. In addition the module incorporates the scenario of salvaging the cruise-ship "Sea Diamond" in an attempt to bridge science with technology and engage students in a real life application.

Optical properties of materials – University “Federico II” of Napoli

The module “optical properties of materials” handles the key concepts of refractive index and transparency, cladding and light attenuation and specific characteristics of optical fibers. Through a series of inquiry-based activities, the concepts are investigated and modeled making use of the materials’ properties. The main aim is to motivate students towards scientific studies through an attention on a “techno-object” which has multiple applications on our every day life. The context of the module is the application of optical fibers in telecommunications.

Acoustic Properties of materials – Autonomous University of Barcelona

The focus of the module “Acoustic Properties of Materials” is on analyzing the relationship between acoustic properties of some materials and their fundamental structure in order to account for their acoustic behaviour, specifically their sound attenuation properties. The module introduces the concepts of sound absorption and sound reflection. At the beginning of the module a scenario is presented to the students with the intention to engage them in a personally meaningful investigation. The scenario involves soundproofing a disco.

Thermal Conductivity applications of materials – Aristotle University of Thessaloniki

The module aims at facilitating students to construct a deeper understanding of thermal conductivity. Students study thermal conductivity in a range of conductive and non conductive materials from different perspectives. Students start from the specific cases of metals and ceramics and in later chapters discuss the broad categories of conductors and insulators. The sequence is scaffolded with students starting by carrying out experimental investigations and steadily moving to design their own investigations. Furthermore, microscopic models are provided and students use them to describe and interpret conduction. Students conceptual understanding is tested using the scenario of the “energy saving house”, where they have to provide suggestions for preventing heat loss.

3.2 Handbook for Developing Teaching Modules in Science and Technology Education

One of the main products of the project was the Handbook for developing teaching modules in Science and Technology Education. The consortium succeeded to sign a contract with Springer for the publication of a book based on the draft version of the handbook included in the final report of the project. A short description of the book is given below.

The handbook focuses on the development of teaching/learning materials based on the principles of research-based design, participative design and iterative refinement. Recent policy efforts in the European Union have emphasized the need to increase students' interest in science, enhance their understanding of scientific inquiry and stimulate their appreciation of the relevance of science in society and the connections between science and technology (Gago et al. 2005). Design based research in science education is a methodological framework with the potential to contribute substantially to each of these goals, through promoting innovations both in terms of the new strategies and processes that will be necessary, but also in terms of the new tools that will be needed to support new forms of teaching and learning.

In this framework, we have explored participative aspects of educational design with a view to creating a mechanism for harnessing diverse expertise in the development and iterative refinement of research-based modules as tools for promoting better quality teaching and learning in science and technology. Specifically, six Working Groups were established, which included science education researchers, content experts and experienced teachers, with the remit to design, develop and implement an innovative module about some aspect of the Properties of Materials. The members of the group brought together diverse expertise about the corresponding topic in Materials Science, the local educational context, the curriculum values and priorities, and about educational design and research as a mechanism for infusing and validating the development of educational tools. The focus of the book will be to reflect on the work of these six Working Groups crystallizing the main ideas that guided these efforts but also reporting on the various forms of evidence used to monitor the process of iterative refinement of teaching modules in Materials Science.

Thus, the book will include a series of theoretical papers highlighting specific aspects of research-based design and participative design, as well as a set of Case Studies on the development and iterative evolution of six modules about innovative approaches to introducing various aspects of Materials Science in school. The Case Studies in the book will elaborate on the importance of iteration, mapping and supporting the modifications and types of changes (frame for reporting modifications, some documentation of specific elements as well as changes, beyond existing generalities, looking at certain commonalities and rich variations between the different studies).

The titles of the theoretical and Case Study chapters are given below:

PART I: THEORETICAL ASPECTS

- 1. An overview of theoretical frameworks and empirical studies regarding the development and iterative refinement of Teaching Learning Sequences**
- 2. Materials Science: Current developments and Educational perspectives**
- 3. Design-based research – understanding teachers as a starting point in designing**
- 4. The design and development of research-based teaching-learning sequences about Materials Science to integrate Science and Technology education in school practice**
- 5. Participatory approaches on curriculum design: a promising paradigm for science education reform and research**

PART II CASE STUDIES

- 6. The process of iterative development of a teaching/learning sequence on Acoustic Properties of Materials**
- 7. An inquiry based Teaching Learning Sequence for introducing density as materials' property, in floating / sinking phenomena: the process of the sequence refinement**
- 8. Engaging students in active learning on properties of materials around us: A design based research approach for developing learning activities**
- 9. The iterative design of a research-based teaching learning sequence on Optical Properties of Materials aimed at effectively integrating Science and Technology education**
- 10. Development and iterative evolution of a research-based Teaching Learning Sequence on Thermal Conductivity of Materials**
- 11. Design, Development and Iterative Refinement of a Module on the Electromagnetic Properties of Materials**