TEACHERS' COMPUTER SUPPORTED CONSTRUCTIONS WITHIN A EUROPEAN VIRTUAL COMMUNITY COLLABORATIVE SPACE FOR SCIENCES EDUCATION
An Experience Achieved in a Multinational European Project

Maria Kordaki
Department of Computer Engineering and Informatics, Patras University, 26500, Rion Patras, Greece

Mihai Bizoi, Gabriel Gorghiu
Automatic Control, Informatics and Electrical Engineering Department,Valahia University, 130082, Targoviste, Romania

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Abstract: This paper presents some essential considerations referred to the constructions performed by European teachers in terms of virtual experiments and lesson plans within the framework of a *Virtual community collaborative Space for Sciences education*. This framework was set up in the context of the Socrates Comenius 2.1 European project: "*VccSSe - Virtual Community Collaborating Space for Science Education*". In this project, teachers from five European countries (Romania, Poland, Finland, Spain and Greece) participated in blended learning courses aiming their training for the use of Information and Communication Technologies in real teaching and learning practices. Within this framework, on-line training materials and virtual experiments were created and developed. After the end of the designed courses, teachers were asked to form their own virtual experiments and lesson plans and then to implement their products in the classrooms. The analysis of the data shows that teachers who participated in the *VccSSe* Project encouraged by the aforementioned blended course, expressed a favourable feedback related to the implementation of their own virtual experiments in the teaching activities.

1 INTRODUCTION

Appropriately designed educational software can catalytically affect the changes in the whole learning context in terms of learning content, learning activities and the roles of both teachers and learners (Solloway, 1993; Noss and Hoyles, 1992; Jonassen, Carr & Yueh, 1998). In particular, computers provide wide opportunities for the construction of various, different, linked and dynamic representation systems such as: texts, images, equations, variables, tables, graphs, animations, simulations of a variety of situations, programming languages and computational objects (Kaput, 1994). The use of Multiple Representation Systems (MRS) is acknowledged as crucial in encouraging the expression of learners' different kind of knowledge regarding the subject to be learned (Dyfour-Janvier, Bednarz & Belanger, 1987; Janvier, 1987). In addition, multiple and linked RS provide learners with opportunities to study how variation in one system can affect the other. In this way, each learner can make connections between different aspects of a learning concept and develop broad views about it (Lesh, Mehr & Post, 1987; Janvier, 1987).

Appropriately designed computer learning environments can also provide various tools (embodying diverse learning concepts) which could be used alone and in combination for the construction of multiple solution strategies to the tasks at hand (Kordaki and Balomenou, 2006). For the construction of such multiple solution strategies different learning concepts could be integrated. In addition, appropriately designed computer learning environments can provide opportunities for the learners to actively construct their knowledge as well as to develop their problem solving skills (Dubinsky and Tall, 1991; Jonassen, Carr & Yueh,

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1998). In addition, richly endowed computer environments can embody powerful scientific ideas which students can explore and reflect on as well as conceptualize, and construct for themselves, scientific concepts that has already been formulated by others.

Most importantly, in the context of Information and Communication Technologies (ICT), modern social and constructivist perspectives of teaching and learning can be realized (Papert, 1980; Balacheff and Kaput, 1996; Noss and Hoyles, 1996; Jonassen, Carr & Yueh, 1998). From these perspectives, the need for training primary and secondary level education teachers in the use of ICT in education is of vital importance not only for their integration into the modern social and educational context created, but also for the integration of ICT into education (European Commission, 1997). The necessity of training teachers in ICT concerns the acquisition of basic technical and pedagogical skills related to the use of ICT so that they will be capable of integrating it into the teaching and learning of the subject-matter they teach (Davis and Tearle, 1998).

Blended learning is an approach suitable for teacher training as it aligns learning undertaken in face-to-face sessions with learning opportunities created online (Littlejohn & Pegler, 2006). The aim of blended learning is basically to join the best points of classroom or face-to-face learning with the best points of online learning as well as to compensate the pitfalls and weakenesses of the one type of learning with the benefits of the other type and vice versa. On the one hand the opportunities presented by online learning in terms of flexible opportunities to learn anytime and anywhere as well as to communicate and collaborate virtually throughout the world (Harasim, Hiltz, Teles & Turoff, 1995; Pallof & Pratt, 2004; Roberts, 2005; Van Eijl & Pilot, 2003) are essential for teacher training because teachers are adults with many constrains in terms of time and space. On the other hand, several constraints of online collaboration such as: not appropriate perceptions about e-learning, negative attitudes, luck of on-line collaborative skills, not appropriate knowledge about the basic technological skills needed for participation in online learning and a sense of difference between online learning and reality (Nel & Wilkinson 2006) can be eliminated through face to face sessions.

Based on the above, a blended teacher training framework was formed in the context of a European project: "VccSSe - Virtual Community Collaborating Space for Science Education", (project number no. 128989-CP-1-2006-RO-COMENIUS-C21). This 3 years project, started in October 2006 and carried out by 9 partner institutions from 5 different European countries (Romania, Poland, Spain, Finland and Greece) has as main purpose to adapt, develop, test, implement and disseminate training modules, teaching methodologies and pedagogical strategies based on the use of ICT in terms of virtual instruments and tools in teaching and learning of positive Sciences : Mathematics, Physics, Chemistry. To this end, one of the main targets of this project was to encourage teachers to develop their own Learning Objects (LO) consisting of specific constructions based on the use of appropriate educational software - henceforth called "Virtual Experiments" (VEs) - and appropriate lesson plans, and then implement these LO in their classrooms. Those learning objects are uploaded in a virtual space frame named "Products Matrix", which is included in the VccSSe web-site, being accessible via Internet, using the following link: http://www.vccsse.ssai.valahia.ro/main/matrix.

In the following section of this paper the previously mentioned framework for teacher training is analytically described. Then, a presentation of the "Products Matrix" including the teachers' learning objects is demonstrated. Finally, a series of results are discussed and conclusions are drawn.

2 TEACHER TRAINING IN THE CONTEXT OF VCCSSE

The project team have implemented an e-learning platform (Moodle) to support the course activities and developed the e-Space, a repository of virtual instruments to be used as examples in the frame of the course. The course "Virtual Instrumentation in Science Education" introduces the specific virtual instruments concepts, pedagogical methods and also particular and didactical elements for some very used educational platforms: Cabri Geometry, LabVIEW, Crocodile Clips and GeoGebra.

Teachers were supported to create their own learning objects in diverse ways such as providing training materials and realizing specific meetings and various types of communications. In fact, the teacher training process, in the context of the VccSSe project, can be described in terms of: (a) aims of the blended teacher training course; (b) training materials used; (c) training procedure followed; (d) educational software used.

2.1 Aims of the Blended Teacher Training Course

The blended teacher training course within the context of VccSSe was designed with the aim to contribute to the acquisition of the following competences by the teachers:
(a) Familiarization with the use of specific educational software (Cabri Geometry Plus, LabVIEW, Crocodile Clips and GeoGebra - the last one, in the second training phase of the project), in the teaching and learning of positive Sciences. (b) Acquisition of educational design abilities in terms of design of both interactive constructions using the mentioned educational software and appropriate lesson plans referred to the implementation of the constructions in teaching and learning in real classrooms. (c) Construction of at least one learning object by each teacher participated in the VccSSe project. (d) Familiarization with the use of Moodle platform.

2.2 Training Materials

One of the most important outcomes of the project was to create and develop specific training materials to provide teachers with basics about the use of ICT in education using virtual instruments and tools. These training materials were dedicated to in-service teachers from all educational levels in the partners' countries.

The training materials consisted of: (i) Seminars: In particular 3 seminars were prepared to present the specific virtual instrumentation concepts; (ii) Labs: Specifically, 3 labs were designed in order to familiarize the teachers with the educational software particularity and basic steps for VIs creation; (iii) Familiarization materials - in pedagogical and technical terms - with the previously mentioned Educational software selected for use. The aim of these materials was to familiarize teachers with the main pedagogical dimensions of the software as well the basic technical skills needed for using this software effectively; (iv) ready made specific VEs which are dedicated to be used as examples to illustrate the potential pedagogical features of the aforementioned pieces of software. In fact, a number of 55 ready made VEs were presented by the partnership, those ones being accessible at the following link: http://www.vccsse.ssai.valahia.ro/main/e-space; (v) lesson-plan templates to assist teachers to organize their teaching intervention using the appropriate VEs.

Assessment tools were also constructed for the evaluation of these training materials by the participants in the blended courses performed in each partners' country. All the presented training materials produced for teacher training and the assessment tools were initially designed in English (http://www.vccsse.ssai.valahia.ro/main/outcomes) and then, these were translated in all partners' national languages: Romanian, Spanish, Polish, Finnish and Greek. It was considered that all the training materials described above will constituted a solid basis for the teachers to acquire the knowledge needed for the creation of their own VEs.

2.3 The Training Procedure

The duration of the training sessions covered an amount of approximately 42 hours, including the evaluation through the projects' web-page. It is worth noting that, the face-to-face teaching sessions provided teachers with opportunities to clarify some complicated issues related to the construction of VEs using the selected educational software, to exchange ideas about didactical issues using ICT, to be motivated to construct their own VEs and implement them in their classrooms, and most importantly to overcome their fears and doubts about the introduction of an innovation in real educational practices. In fact, these face-to-face sections became very serious to the teachers' progress in creating and implementing virtual experiments in their classrooms. Various type of communications also helped teachers to make progress in their work such as telephone calls to their tutors, e-mails to their tutors and their colleagues as well as asynchronous communications via forum and synchronous communications via chat. Some teachers also motivated to construct their own VEs by their intention to try new ideas in their classrooms as well as to improve their knowledge and be well situated in the 21th century. After they have finished the training course, teachers have implemented the new learned methodologies in the classroom and this activity involving children was evaluated.

The course was implemented in two editions and started at different moments, depending on each partner. This offered the opportunity to improve some elements of the course, based on the partial evaluation made at the end of the first edition.

2.4 Educational Software Used

2.4.1 Cabri Geometry II and Geogebra

Dynamic Geometry Systems, and specifically the well known educational software Cabri Geometry II (Laborde, 1990), and Geogebra (http://www.geogebra.org/) offer a context where constructivist mathematical learning settings can be supported. In fact, the aforementioned software is highly capable of facilitating the design of learning activities that encourage learners to take an investigative and exploratory perspective, to express their knowledge and make self-corrections, as well as formulate and verify conjectures (Straesser, 2001; Kordaki & Balomenou, 2006). In addition, authentic, meaningful, real-life learning activities can be integrated within the context of this software. In particular, Cabri and Geogebra provide students with potential opportunities in terms of: (a) A rich set of tools to perform diverse geometrical constructions according to various concepts in Euclidean Geometry; (b) Tools to construct a variety of representations, both numerical and visual, such as geometrical figures, tables, equations, graphs and calculations. These representations are of different cognitive transparency; consequently, students can select the most appropriate to express their knowledge; (c) Linking representations, by exploiting the interconnection of the different representation modes provided; (d) Dynamic, direct manipulation of geometrical constructions, by using the “drag mode” operation, enhancing their knowledge about the issue at hand by dynamically exploring the invariance of their constructions; (e) The possibility of collecting large amounts of numerical data. These data can be used by the students to form and verify conjectures regarding the geometrical concepts in focus; (f) Interactivity and multiple types of feedback providing learners with opportunities to form and verify conjectures as well to be self-corrected; (g) Presenting information to the students in various forms; (h) Capturing the history of student actions to provide teachers and researchers with a valuable amount of data for further studies; (i) Extension. Certain operations could be added as buttons on the interface of the said software following the formation of specific macros.

2.4.2 LabVIEW

LabView (http://www.ni.com/**labview**/) is an intuitive graphical programming language with built-in functionality for simulation, data acquisition, instrument control, measurement analysis, and data presentation. This software is suitable for creating a wide range of applications in different areas of industries but also in education for Science subjects teaching. The graphical nature of LabVIEW allows users to focus on the theory being taught and not on the tool manipulation and on the programming nuances. The time to develop complex applications is shorter than using a general programming language. Due to the fact that LabVIEW is specifically designed for engineers and scientists, and it is used in a wide range of areas, the students’ transition from school to industry is smoother (Suduc, et al., 2009).

2.4.3 Crocodile Clips

The Crocodile Clips (http://www.crocodile-clips.com/) simulation packages are developed specifically for education and allow students and teachers to recreate experiments, model mathematical theories or simulate real life quickly and easy. Crocodile simulators let students experiment in a safe, accurate environment, and come with a wealth of ready-made simulations and models. Crocodile Clips includes four packages: Crocodile Physics, Crocodile Chemistry, Crocodile ICT and Crocodile Mathematics. In the frame of the VccSSe project, the first two packages were selected.

The main Crocodile Clips advantages are related to the user-friendly interface and curricula focus features for the primary and secondary school. In order to easily learn how to use these tools, the Crocodile Clips developers provide many useful free training videos (Suduc et al., 2009).

3 RESULTS

A number of 363 in-service teachers involved in lower and upper level of secondary education as well as in primary education were trained through the previously mentioned blended learning approach about how to create, use and implement ICT based lessons in their real teaching practices. These in-service teachers - functioned on their background and goals - were required to choose one of the software environments for understanding its main functions and creating at least one LO (that has to include also at least one VE for students with a significant level of interaction, for specific Sciences disciplines: Mathematics, Physics, Chemistry). Their lesson plans - designed under the previously mentioned specific Template – proposed explanations on the concepts to be learned. In the following section, the components of the "Products matrix" including those teachers' LOs, is presented. This presentation reveals with the following essential parts: (a) structure; (b) number of VE's; (c) partner institutions involved; (d) searching; and (e) tools included.

Table 1: First layer of the Product's matrix.

VccSSe Institutions	1st Edition Products	2nd Edition Products
Valahia University of Targoviste	13	11
Teacher Training and Educational Innovation Centre Valladolid II	5	14
Teachers Training Centre of Gijon	17	54
Teachers Training Centre of Zaragoza 1	9	6
Warsaw University of Technology	9	4
Regional In-service Teacher Training Centre "Wom" in Bielsko-Biala	3	20
University of Joensuu	-	13
Babes-Bolyai University Cluj Napoca	19	2
University of Patras	11	8

(a) *Structure*. The general structure of the Product's matrix for all the partner institutions has a three layer-structure. The first layer (see Table 1) of the aforementioned structure is organized in a Table demonstrating all partner institutions (see column 1) and the number of VEs constructed by the teachers in the 1st and 2nd edition of the course (2nd and 3rd columns correspondingly) by each institution. For example, in the 2nd row one can see that teachers participated in the courses organized by Valahia University of Targoviste produced 13 VEs during the 1st edition of the course and 11 VEs during its 2nd edition. The second layer (see Table 2) of the structure of the Product's matrix is dedicated for each partner institution and has the structure demonstrated by the 1st row of Table 2. To clarify this structure, a specific example (see Table 3) of the part of Product's matrix dedicated for the 1st Edition of the course realized by the University of Patras is demonstrated in Table 2.

To clarify the content of this Table, let's present the content of its 1st row: Here one can see that, a VE and the appropriate Lesson Plan was constructed (see 7th column) to teach about 'perpendicular line in the mid of a segment' (see 1st column) that is dedicated for 'Lower Secondary school" (see 2nd column), especially for the learning of Geometry (see 3rd column). The name of the creator of this VE and Lesson Plan is "Evagelos Stamos" (see 4th column) in the school of "Kato Achaia" (see 5th column), while the keywords describing the basic concepts are "perpendicular line and the mid of a segment" (see 6th column).

(b) *Number of VEs included* - First Edition: 86 VEs were produced in total. Second Edition: 132 VEs were produced in total. Data indicating relevant number of products for each discipline/per partner institution and in total is presented in Table 3. Here, it is worth noting that, teachers designed a variety of types of VEs supporting various learning activities. For example, mathematics teachers designed VEs supporting the following types of learning activities: (i) Forming/verifying conjectures by focusing on the alteration of an interactive geometrical construction using the drag-mode operation; (ii) Forming/verifying conjectures by focusing on the numerical data automatically collected during the alteration of a geometrical construction using the drag-mode operation; (iii) Verifying a formula by focusing on the numerical data automatically collected during the alteration of a geometrical construction using the drag-mode operation; (iv) Multiple Representation-based activities; (v) Constructions simulating real-life problems; (vi) Black-box activities; (vii) A scenario-based approach emphasizing the formation of networks of learning concepts; (viii) Multiple-solution activities.

(c) *Partner institutions involved*. All partner institutions were involved and specifically, the number of VEs per institution is demonstrated in Figure 1.

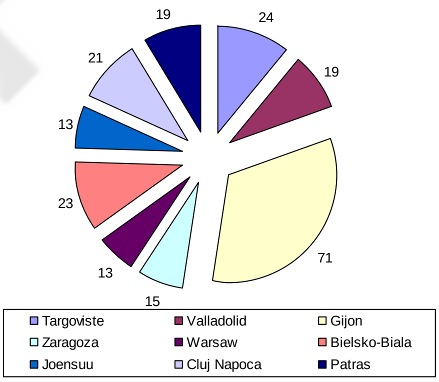

Figure 1: Number of VEs per institution.

(d) *Searching*. One can search the content of Product's matrix by realizing step by step the following procedure: (1) Entering the main page of VccSSe at http://www.vccsse.ssai.valahia.ro; (2) Clicking on the link labelled as: "Product's matrix". In this way the visitor is automatically trans-located to the 1st layer of the structure of the Product's matrix that is allocated in the URL: http://www.vccsse.ssai.valahia.ro/main/matrix

Table 2: An example of the second layer of the Product's matrix (the first three lines).

No	Lesson Name	Level	Area /	Teacher	School	Keywords	Final Products
1	Perpendicular Line	Lower	Maths	Evagelos	Kato Achaias	Perpendicular line,	Perpendicular_MId
2	Secants of a Circle	Upper	Maths	Dimitris	1st Lykeum of	Circle, Secant, Upper	Secants of a circle
3	The Theorem of	Upper	Maths	Dionisia	Private	Circle, Secant's	The theorem of

Table 3: Relevant number of products for each discipline and institution.

VccSSe Institutions	Math	Physics	Chemistry	Technology	Total
Valahia University of Targoviste	16	4	4	0	24
Teacher Training and Educational Innovation Centre Valladolid II	0	6	10	3	19
Teachers Training Centre of Gijon	37	33	0	1	71
Teachers Training Centre of Zaragoza 1	0	15	0	0	15
Warsaw University of Technology	2	8	0	3	13
Regional In-service Teacher Training Centre "Wom" in Bielsko-Biala	21	1	0	1	23
University of Joensuu	10	3	0	0	13
Babes-Bolyai University Cluj Napoca	8	11	2	0	21
University of Patras	19	0	0	0	19
Total Number of Products for Each Discipline	113	81	16	8	218

Here the visitor can explore the matrix demonstrated in Table 1. The numbers included in the 2nd and 3rd columns of this Table are dynamic that links allowing the visitor to access the 2nd layer of the structure of the Product's matrix. (3) Clicking on the numbers included in the 2nd and 3rd columns of the Table 1 (Product's Matrix). For example, by clicking on the number 11 which is included in the cell that is allocated in the crossing point of (row: University of Patras and column: 1st Edition) the visitor can automatically trans-located to the URL: http://www.vccsse.ssai.valahia.ro/main/matrix?org=9&edition=1. In this place one could acquire an image of the products performed by the teachers involved in the 1st Edition of the course realized by the University of Patras (see Table 3). The content of the 7th column of this Table is dynamic and automatically allocate the visitor to the specific VEs and Lesson Plans constructed by each teacher. (4) Clicking on the name of each specific VE included in the 7th column of the Table illustrated in the 2nd layer of the structure of the Product's matrix, the visitor can access the 3rd layer of the structure of this matrix where specific VEs and their correspondent lesson plans are allocated.

(e) *Tools included*. The tools included in the Products Matrix are: (i) the "Products Matrix Updater - First Edition" (PMU-1st) and (ii) the Products Matrix Updater - Second Edition (PMU-2nd). These tools are identical, except the fact that each one serves as a tool to update the 1st and 2nd Editions of the course correspondingly. Both tools are located in the 1st layer of the structure of the Products Matrix. By clicking on the 'Products Matrix Updater- First Edition' link, the system automatically transfer the user in the following location: http://www.vccsse.ssai.valahia.ro/main/matrix-up Here, the system asks the user for username and password to trans-locate him/her to update the second layer of the Products Matrix dedicated to a specific partner institution. Accesses to this layer have only the local coordinators. For instance, considering Patras' University, after entering the appropriate username and password, the system transfer the user in the following page: http://www.vccsse.ssai.valahia.ro/main/matrix-up

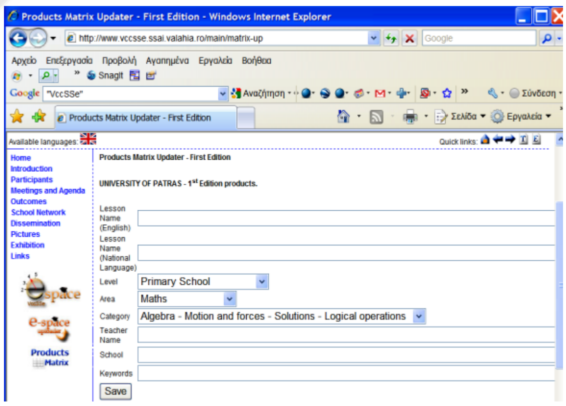

Figure 2: The form dedicated to the adaptation of the Products Matrix with information regarding teacher VEs and Lesson Plans.

In the fields of the form illustrated in Figure 2 the appropriate information regarding each teacher VEs could be recorded. After saving this information, the user is provided with the opportunity to upload the correspondent files namely; the specific VI and Lesson Plan constructed by the teacher.

4 DISCUSSION

In this section the "Products matrix" is discussed in terms of appropriateness of its essential parts referred to in the previous section, namely: (a) appropriateness of the structure, (b) relevant number of products for each discipline, (c) relevant number of products for each partner, (d) usability of the searching engine, (e) usability of the up-loader.

(a) Appropriateness of the structure. The structure of Products Matrix is appropriate to save and provide access to the VEs and Lesson Plans constructed by the teachers. It is also simple, and easy to use. Visitors can search the teachers' products in each country and Edition of the course.

(b) Relevant number of products for each discipline. More than half of teachers' VEs and Lesson Plans related to the learning of Maths (113 VEs and Lesson Plans; 52%). A considerable number of teachers' VEs and Lesson Plans related to the learning of Physics (81 VEs and Lesson Plans; 37%) while some of teachers' VEs and Lesson Plans related to the learning of Chemistry (16 VEs and Lesson Plans; 7%). Finally, few teachers' VEs and Lesson Plans related to the learning of Technology (8 VEs and Lesson Plans; 4%).

(c) Relevant number of products for each partner. A considerable number of products were constructed by all institutions (218 VEs and Lesson Plans) as well as by each partner institution; Maximum: 71 VEs and Lesson Plans (33%) and Minimum: 13 VEs and Lesson Plans (6%).

(d) Usability of the searching engine. It is very convenient; just three clicks to visit a specific teacher construct (a VE or a Lesson Plan).

(e) Usability of the up-loader. This tool is very convenient; just six clicks to upload a VE and a Lesson Plan constructed by a teacher followed by a description in terms of: teacher name, school name, lesson name, education level, key-words and discipline.

5 CONCLUSIONS

This paper presented the diversity of LOs in terms of VEs and lesson plans designed by the European teachers who participated in a Virtual Community Collaborative Space for Science Education (VccSSe). At first glance, the results emerging from this study show that teachers designed a variety of types of LOs supporting diverse type of learning activities but most importantly, these teachers used these LOs in their actual classroom practices. By performing such learning activities, students had the chance to experiment, express their individual knowledge, make interconnections with various concepts, develop multiple perspectives regarding the learning concepts in focus and also be motivated to be actively involved in their learning process.

On the whole, the results of this study suggest that teachers are able to design pedagogically sound learning activities using ICT and also use these activities in their teaching practices. More effort is needed to ensure support in such communities for teacher professional development and lifelong learning as well as for the use of ICT in everyday classroom practices. To this end, the integration of ICT in the typical school curricula, the provision of appropriate technical infrastructure in schools, and the training of teachers through formal procedures will constitute a solid background for the introduction and exploitation of the benefits of ICT-based teaching and learning in the every day classroom of 21 century.

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