Implementation of an In-service Course on Integration of ICT into Inquiry Based Science Education: A Case Study in Slovakia

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Abstract

In the framework of the ESTABLISH project, a variety of support materials for teacher learning about the application of technological tools in inquiry-based science lessons were developed. These materials are organized in a Moodle platform and meant for the blended approach, enabling effective courses with limited life sessions and in different educational contexts. Besides case studies with pre-service teachers in the Netherlands, these materials were used in Slovakia for in-service training in the context of an accredited course at PavolJozefŠafárik University in Košice. In this course the ICT tools for data logging, video measurement, and modeling, integrated in the Coach learning environment were introduced. Before the course, many teachers did not have any experience with the Coach tools, the modeling tool, in particular, while others were just moderately or slightly familiar. The teachers' theoretical knowledge about the intentions of inquiry-based teaching was good, but they still had problems in developing and carrying out an inquiry-based lesson plan in the classroom.

In the case study on the implementation of the course, a variety of research methods (i.e. observation, questionnaires, and documents) were designed and used to collect data on the teachers' learning process and outcomes. The positive course results proved the successful application of the blended set-up in which traditional workshop sessions were extended appropriately with the home assignments and the final assignment with presentation of teachers' lesson plans, which supposedly incorporated what they learnt in the life sessions. The teachers became aware of educational benefits of the ICT tools and were motivated to apply the ICT activities in the classroom. Their familiarity and confidence with the ICT tools increased remarkably. The main goal was attained as 37 teachers (out of 39) could develop their own Coach activities and design their inquiry-based lesson plans enhanced by the ICT tools. The main obstacle during the course implementation was that the teachers had little experience with the ICT tools. As a result, the teacher trainer had to explain concepts and manipulations in detail but always under the time constraint. On the other hand, the teachers complained of too much new information to follow and remember, about the modeling tool, in particular. Consequently, some advanced skills were not achieved as expected. In this case, the online platform for the distance learning mode where teachers could access support materials and receive timely feedback became very helpful. The crucial issue was how to keep teachers on task and continue when facing technological problems.

Keywords

In-service teacher education, ESTABLISH, IBSE, ICT, Coach, datalogging, videomeasurement, modeling

1.1 The ICT element of the ESTABLISH teacher-education programs

The Rocard report (2007) indicates the European Community's desire to change science education in direction of inquiry-based methods. Today several large EC-funded projects involving many countries are addressing this challenge. The main focus lies on preparing and supporting teachers by providing them with innovative curriculum materials and teacher training activities (Ellermeijer, 2013). In the framework of the ESTABLISH project (http://www.establish-fp7.eu/), the teacher education programs were built around teaching and learning units that consist of a common core supported by additional materials and resources to address aspects of implementation of Inquiry Based Science Education (IBSE) within real classrooms. The core is then supported by a number of other elements that can be implemented as required to suit local teachers, environment, curriculum etc. (Kedzierska et al., 2013).

For a long time we have known that ICT might stimulate and enable science education in a direction that brings students in a similar position as researchers in science. However, many teachers still have not been able to use the ICT tools in the classroom due to lack of training. Therefore, one of the supporting elements, called "ICT in IBSE teacher-training course", focused on the development of teacher confidence and competence in the effective use of ICT in IBSE. Among ICT applications, the following ICT tools are considered crucial in order to enhance science education in general and inquiry in particular:

- Data logging tool enables to gather and record real-time data by sensors.
- Video measurement tool enables to collect position and time data from a video of a moving object.
- Modeling tool provides teachers and students with a powerful set of possibilities to create and analyze models of science systems. It should be differentiated from animation or simulation.
• Data processing and analysis tool helps to analyze or process the data, which is collected by data logging, video measurement, or modeling.

These four ICT tools are integrated in the Coach learning environment (http://cma-science.nl/) that was used as the main learning platform of this ICT-in-IBSE teacher-training course. Considering this fact, we will refer to the activities developed in the Coach environment as Coach activities. When talking about ICT tools, we will mean these specific four tools. More details about these ICT tools of the Coach system can be found in Heck et al. (2009).

Within the ICT-in-IBSE teacher-training course, a variety of support materials have been developed and organized in the Moodle environment (http://ibse.establish-fp7.eu/) to support blended set-ups (incl. life meetings and home assignments) in different educational contexts. The Moodle environment is now open for every teacher and teacher trainer to utilize. The Coach activities are for teachers to learn how to use a particular tool, divided into three categories:

• Coach basic activities are ready-to-use activities, which introduce simple manipulations and elementary concepts related to a certain tool. Practicing these basic activities does not require any previous experience with the Coach platform.

• Coach tutorial activities help to improve skills corresponding to a certain tool through step-by-step written instructions or video tutorials.

• Coach subject activities are ready-to-use activities focused on a particular topic or concept (e.g. damped oscillation), which serve as a source of ideas or as a resource for further development.

The ICT slides, background articles, and ESTABLISH units are for teachers to become aware of educational benefits and possible applications of ICT tools in science education as well as to learn how to integrate these tools into a particular inquiry-based lesson.

The ICT-in-IBSE teacher-training course has been adapted and implemented in two countries. Besides tryouts with pre-service teachers in the Netherlands (Tran et al., 2014), the materials and the blended approach were already applied in Slovakia, but for an in-service course. This paper will present the adaptation of the course in the Slovak educational environment as well as the assessment on its implementation through the case study in 2013.

1.2 Adaptation of the ICT-in-IBSE course into the Slovak context and research questions

In Slovakia, there is a systematic approach to continuous education of in-service teachers. There are a number of accredited teacher-training courses offered by universities or educational institutions for teachers to enroll. After successful completion of the course teachers get credits for their professional development. Gaining a certain number of credits results in promotion in the teacher’s career, so teachers are quite motivated to educate themselves. In addition, Slovak science teachers are also assisted to apply for their own projects (prepared by the school itself), aimed at innovation of science teaching. These projects can also involve participation in the teacher-training courses (e.g. ICT-in-IBSE course or IBSE course). Since these courses are not free of charge, teachers need to plan some money in order to participate in such courses. Together with purchasing ICT hardware and software, teachers might also need to develop related lesson materials on the basis of IBSE, enhanced with ICT. Our case study took place in the context of an accredited course, named "Active learning in computer-based science laboratory" at Pavol Jozef Šafárik University in Košice for 39 in-service physics, chemistry and biology teachers from lower and upper secondary schools. The course aimed for teachers' knowledge and skills to use the Coach tools and creating students' learning activities which are enhanced by these Coach tools within the IBSE framework.

The participating teachers' experience varied between 1 and 32 years of teaching; the average was about 19 years. Before the course, there were a number of participants with no experience with a certain tool. 72%, 54%, and 41% of all participants were not at all familiar with modeling, video measurement, and data logging, respectively. Chemistry and biology teachers were not reasonably educated in this field. However, there were some physics teachers who had considerable experience with one or two particular tools. The teachers' theoretical knowledge about the intentions of IBSE and about the use of ICT for science education was good. However, many teachers lacked experience of integrating and implementing ICT in the classroom. This statement was even more true for those participating teachers who graduated a long time ago.

Utilizing the ESTABLISH support materials and applying the blended set-up, we developed a course scenario to support this heterogeneous group of Slovak teachers to get certain levels of competency with regard to integration of ICT into IBSE about which most of them did not have much practical knowledge beforehand. Through data collection from the implementation of the course, we investigated the answers to the following questions:

• To what extent was the course implemented as intended?
• To what extent did the course have effects on the teachers as expected?
• What were the problems that the teachers came across in learning how to use the ICT tools?

2. Methods

2.1 Teachers' learning scenario
The participating teachers were divided into two parallel groups in such a way that in each group, heterogeneity regarding the teachers' experience with ICT tools was minimized.  
- **Group 1**: 19 physics teachers who were moderately familiar with Coach data logging and video measurement, but just slightly familiar with the modeling tool beforehand,
- **Group 2**: 13 physics teachers, 3 biology teachers, and 4 chemistry teachers who had no or very little experience with all of these Coach tools.

There was remarkable difference between Group 1 and Group 2 regarding the experience with the Coach tools, but no difference in the average number of teaching years. The two groups followed the same scenario (Table 1) which was scheduled for 20 hours of 4 life sessions at the university and for 10 hours of home assignments plus a final assignment with presentation.

### Table 1. Teachers' learning scenario for the two parallel groups

<table>
<thead>
<tr>
<th>Sessions</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Main activities</th>
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</table>
| 1. Data logging (a day) | March 28 | April 2 | - Introductory presentation about data logging with Coach  
- Practicing basic and tutorial data-logging activities  
- Introductory presentation about data processing & analysis, and practicing data processing & analysis activities. |
| **Home assignment 1** | | | |
| 2. Video measurement (a half day) | April 15 | April 16 | - Introductory presentation about video measurement with Coach  
- Practicing basic, tutorial & subject video-measurement activities |
| **Home assignment 2** | | | |
| 3. Modeling (a half day) | April 30 | April 29 | - Introductory presentation about modeling with Coach  
- Practicing basic, tutorial & subject modeling activities |
| **Home assignment 3** | | | |
| 4. Implementation of ICT into teaching (a half day) | May 10 | May 9 | - Introductory presentation about the use of ICT in IBSE  
- Presenting and discussing sample activities in interactive demonstration, guided discovery, guided inquiry, bounded inquiry, and open inquiry  
- Discussion on implementation of ICT-IBSE activities in the class |
| **Final assignment with presentation** | | | |
The course ended with a final assignment with presentation (Figure 1c) in front of a three-member committee. To prepare for the assignment with presentation, the in-service teacher had to develop a lesson plan aimed at a certain level of IBSE following the structure used in ESTABLISH teaching and learning units involving activity title, learning aims, teaching materials, suggestions for use, possible questions. The essence of the teaching materials was a Coach activity that each teacher was expected to develop on her/his own, using data logging, video measurement, or modeling or their combination (with activity descriptions and student assignments). The outputs of each teacher (i.e. a COACH activity with exemplary results complemented with the inquiry-based ICT-integrated lesson plan) were collected before the assignment with presentation itself.

2.2 Assessment instruments

During the case study, we designed and used a variety of research methods to collect data on teachers' learning process and outcomes. The use of multiple methods enables us to validate data through triangulation (Denscombe, 2010). Findings from one method can be compared and contrasted with the outcomes from another. Following this approach, we designed and used the following assessment instruments:

- **Q1 - Pre-course questionnaire**: an online pre-course questionnaire collected information about the teachers' background related to the course contents. It was administered before the first session of the course.
- **Q2 - Post-course questionnaire**: an online post-course questionnaire administered a few days after the session 4. It obtained information about teachers' knowledge, experience, and attitude towards the course contents as well as about their evaluation of the course.
- **O1 - Observation of life sessions**: we observed the teachers' learning process to compare it to the intended program and to find out the teachers' learning problems.
- **D1 - Coach activities**: the teachers had to upload their own Coach activities to the Moodle platform involving home assignments and the final assignment with presentation. Through these Coach files, we examined the teachers' skills at manipulating the particular Coach tool.
- **D2 - Lesson plans**: Through lesson plans that the teachers submitted for the final assignment with presentation, we assessed their skills in designing an inquiry lesson with ICT integration.
- **D3 - Final assignment with presentation results**: judgments of the committee about the teachers' lesson plans with related Coach activities in the assignment with presentation provided us extra information on the teachers' learning outcomes.

(The labels about data sources such as Q2, O1, D3 etc. are referred from the following texts)

Data from various independent sources, i.e. questionnaires (Q1, Q2), observation (O1), documents (D1, D2, D3) was in line with each other. This allows us to formulate the following assessments about the implementation of the course.

3 Results

3.1 To what extent the course was implemented as intended

The course went smoothly as almost all contents intended for the life sessions were covered (O1), and the majority of the teachers managed to accomplish the home assignments and the final assignment with presentation. Many teachers appreciated the good organization of life sessions, followed by self-training on particular Coach tools by which they could work on their own time and pace with support materials on the online platform (Q2).

a) About teachers' learning in the life sessions

The beginning of the first three sessions was always optimistic, even for non-experienced teachers, as the teachers were interested in the introduction and demonstration of the Coach tools, and they embarked on Coach basic activities seriously and fluently. Next, the teacher trainer carried out the tutorial activities together with the teachers and illustrated the manipulations using an overhead projector, so everybody followed and checked what she/he had done (O1). The teachers were expected to go through all given Coach activities to be able to master advanced skills of manipulating a particular Coach tool at the end of each session. However, this expectation turned out to be over-optimistic. It took much time for the teacher trainer to present and demonstrate all concepts and possibilities associated with a particular Coach tool (O1). There were some teachers with very little experience with ICT tools, even missing basic computer skills. This made the hands-on process (following step-by-step instructions of the teacher trainer) slower than intended (O1). For instance, regarding Coach modeling, the teacher trainer had to explain the procedure in detail very slowly, i.e. what are a state variable, an auxiliary variable, an independent variable, and a constant; the flow, connection icons, and other settings.

Teachers complained of too much new information to follow and remember in a long meeting. Furthermore, it was hard for 19 or 20 teachers (in each group) to follow only one learning path at the same pace, including a lot of instruction about technical and conceptual details. In addition, some teachers argued that they needed extra time for learning to use a
particular tool to master such a level that they could apply the tool in the classroom (D3, O1). Therefore, teachers suggested less time for plenary introduction plus demonstration and desired more time to practice Coach activities with close supervision, especially the Coach subject activities (Figure 2). This suggestion is in line with a conclusion in Thurston et al., 1997, "Hands-on practice is more critical than theory and demonstration in a technology-based training course".

The ratings: “less”, “unchanged”, or “more” time for each activity correspond to the weights, -1, 0, or 1 (Q2)

Act 1: Plenary introduction and demonstration of the ICT tools
Act 2: Practicing simple activities in groups.
Act 3: Practicing tutorial activities following step-by-step instruction
Act 4: Practicing subject activities in groups.
Act 5: Plenary discussion on home assignments
Act 6: Plenary discussion on implementation of ICT in IBSE
Act 7: Discussing about inquiry activities enhanced by ICT tools aimed at different levels of inquiry

Figure 2. The teachers’ opinions about adjustment of time allocated for each activity in the course sessions

b) About the teachers’ learning at distance through assignments
The teachers’ self-reports (Q2) showed that they spent an average of 2.6, 3.5, and 3.6 (hours) for the three home assignments on creating new Coach data logging, video measurement, and modeling activities, respectively. 4.6 hours on average were needed for the final assignment with presentation. The common problem to almost all teachers was time constraint for home assignments because of daily demanding tasks in their own schools (Q2). A total of 14.3 hours spent for individual work (more than the intended 10 hours) proved that the teachers invested a lot of efforts on these learning activities outside the life sessions. In addition, 25 teachers (out of 39) already tried out the given Coach activities or their own ones with their students, although it was not compulsory. They implemented a few different try-outs with Coach video measurements or measuring with sensors which could be loaned from the course (but none of them tried out the Coach modeling). The teachers evaluated that timely help from the teacher trainer (3.8) was the most influential factor on teachers’ learning in distance (Q2), followed by the online platform (3.7), clear assignments including a strict deadline (3.7), and awareness of benefits of carrying out assignments (3.6) (5-point scale, 1 = not at all influential, 5 = extremely influential).

Teachers reported that the online platform provided an easy-access resource of support materials and enabled simple upload of home assignments. Support materials were very useful, especially the Coach activities at three levels (Q2) which were self-explanatory and convenient to use at home or at school. However, the maximum upload size to Moodle (8 MB) was small. This sometimes caused troubles as teachers tried to submit large files of Coach video measurement.

3.2 To what extent the course had effects on the teachers as expected

a) About the teachers’ learning to use Coach tools

Responses from pre- and post-course questionnaires (Q1, Q2) showed that the teachers’ familiarity with the Coach tools increased significantly, especially for the less-experienced group (group 2) (Figure 3). The teachers were much more confident in manipulating the particular Coach tools (Q1, Q2) (Table 2). After the course, the group-1 teachers were very familiar with data logging and video measurement. Starting as non-experienced Coach users, the group-2 teachers finished
the course at just a moderate level of familiarity of all the tools. Also with regard to particular manipulations with each Coach tool, teachers from the group 2 were less confident.

Learning Coach modeling was demanding and time-consuming to both groups as their familiarity and confidence with the modeling tool was remarkably lower than with other Coach tools. Some teachers seemed not to understand the principle of dynamical modeling even after the course. They sounded not confident at all to teach with modeling (D3). After the course, just a few teachers were confident to make a small change to a given model or develop a computational graphical model. This was in line with the teachers’ opinions about whether students can learn modeling in secondary schools. They assumed that students could use, explore, and make a small change to a given model with moderate help from the teacher, but to develop a new graphical model, students will need significant support (Q2).

Table 2. Confidence levels to manipulation skills of particular tools (5 point scale, 1 = not at all confident, 5 = extremely confident)

<table>
<thead>
<tr>
<th>Manipulation skills</th>
<th>Group 1</th>
<th>Group 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-course</td>
<td>Post-course</td>
</tr>
<tr>
<td><strong>Data logging</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Connecting sensors to an interface, connecting an interface to a computer</td>
<td>3.3</td>
<td>4.6</td>
</tr>
<tr>
<td>Setting particular sensor connection in the software</td>
<td>2.8</td>
<td>4.3</td>
</tr>
<tr>
<td>Setting time-based measurement</td>
<td>2.7</td>
<td>4.1</td>
</tr>
<tr>
<td>Setting event-based measurement</td>
<td>2.4</td>
<td>4.0</td>
</tr>
<tr>
<td>Setting a measurement based on a trigger event</td>
<td>2.3</td>
<td>3.8</td>
</tr>
<tr>
<td>Determining the calibration factors of a sensor</td>
<td>1.8</td>
<td>3.2</td>
</tr>
<tr>
<td><strong>Video measurement</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Making scale settings</td>
<td>2.0</td>
<td>4.4</td>
</tr>
<tr>
<td>Specifying features of the co-ordinate system</td>
<td>2.3</td>
<td>4.4</td>
</tr>
<tr>
<td>Setting time calibration for video</td>
<td>1.8</td>
<td>4.3</td>
</tr>
<tr>
<td>Performing perspective correction</td>
<td>1.3</td>
<td>3.6</td>
</tr>
<tr>
<td>Correcting video points by dragging wrong measured points to the correct position</td>
<td>1.5</td>
<td>3.6</td>
</tr>
<tr>
<td>Setting point tracking by which the measurement is performed automatically through the selected frames according to the given settings</td>
<td>1.8</td>
<td>3.9</td>
</tr>
<tr>
<td><strong>Modeling</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Using a given model to understand a phenomenon</td>
<td>2.1</td>
<td>4.2</td>
</tr>
<tr>
<td>Exploring to gain insight into a given model</td>
<td>1.8</td>
<td>3.9</td>
</tr>
<tr>
<td>Making a small change to a given model</td>
<td>1.6</td>
<td>3.6</td>
</tr>
<tr>
<td>Developing a computational graphical model</td>
<td>1.5</td>
<td>3.3</td>
</tr>
<tr>
<td>Developing a computational text model</td>
<td>1.5</td>
<td>2.4</td>
</tr>
</tbody>
</table>

During the course, the teachers could create their own Coach activities either connected to data logging, video measurement, or modeling. Levels of these activities varied from very simple to quite advanced (D1, D3). The majority of teachers applied basic ideas and skills, which can be found in exemplary Coach activities. For example,

- **Data logging**: change of temperature during heating, studying motion with a motion sensor;
- **Video measurement**: motion on an incline, free fall, oscillating motions;
- **Modeling**: model of uniform motions.

![Figure 4](image-url) A teacher's Coach video measurement activity on motion of the center of gravity of a hammer

However, there were outstanding outcomes. 4 teachers (all from the group 1) combined modeling with data logging or video measurement to stimulate nice investigations. For instance,
• A model of heating liquid with different electric appliance or a model of phase transition combined with real-time data from the temperature sensor
• A model and a video measurement of a projectile motion or of a braking car in relation to different surfaces

7 teachers showed advanced skills with particular Coach tools, e.g. video measurement on motion of the center of gravity of a hammer (Figure 4), model of motion in the presence of resistive forces. Some teachers just used basic skills but introduced nice ideas to apply the Coach tool, e.g. motion of diaphragm during breathing, comparison between a free fall and a horizontal projectile motion. It was not surprising that the group-1 teachers mastered more advanced skills with Coach than those from Group 2 (D1).

b) About the teachers' learning to apply the Coach tools
The in-service teachers were passionate and motivated to learn about the possibilities of the Coach tools (D3). The teachers' self-reports (Q2) presented their awareness and positive attitude of added values of the ICT tools to science teaching. For example:
• Application of the ICT tools might enhance students' motivation towards science, creative thinking, inquiry practice, and enable students to recognize misconceptions. Students will be more active and independent.
• The ICT tools facilitate simple sensor connection; fast, accurate measurement; immediate data presentation in graphs; and convenient, powerful data processing. It saves time for the students' interpretation of the data and meaning making.
• The ICT tools enable to investigate complex phenomena and present data immediately through interactive graphs.

37 in-service teachers (out of 39) could explain in the final assignment with presentation how they integrated their own Coach activities into the inquiry-based lesson plans. The committee judged that the in-service teachers achieved basic skills concerning the use of ICT in science teaching. The lesson plans were aligned only at the first three levels of inquiry: interactive demonstration, guided discovery, or guided inquiry (D3). Determining the appropriate topic and specific inquiry levels for the lesson was the common problem for the teachers. Teachers generally were not optimistic about the successful implementation of a higher level of inquiry activities (bounded and open) in the classroom. Even during the course (Session 4), participants themselves found it difficult to design an experiment and formulate a hypothesis related to a given/proposed problem (O1). They also shared their difficulties in carrying out an inquiry-based lesson, regardless whether they use ICT or not. Consequently, teachers themselves expressed their desire of devoting more time on discussion about inquiry activities enhanced by ICT tools aimed at different levels of inquiry (Figure 2).

Before the final assignment with presentation, 10 teachers already tried out their designed lesson-plans with students (D3) although it was not obligatory. Some teachers got extra motivations as their students were engaged in the ICT activities actively and effectively, beyond their expectations (O1). Those teachers experienced that more detailed instructions for students, smaller working groups, and simpler Coach activities would lead to more effective ICT-IBSE lessons (Q2). After the assignment with presentation, some teachers continued to implement their lesson plans in the classroom. It sounded quite optimistic as the communication between the course trainers and teachers was still alive even after the course (D3). However, the teachers were quite pessimistic because of the high number of students in the class and changes in the curricula (O1) which led to a limited number of lessons. They considered "Availability of appropriate computer hardware & software" and "Available teaching time" as the two most influential factors (Q1) of the integration of ICT into their teaching practice. They planned to invite colleagues in their own schools to share the experience and to promote the use of ICT. They were very eager to participate in another course for advanced Coach users and looked forward to tailor-made activities by the institute which are ready to use in the classroom (Q2).

3.3 Problems of the teachers in learning how to use the Coach tools
Some particular problems of the teachers' learning to use the Coach tools were observed during the life sessions (O1), examined through the teachers' own Coach activities (D2), or reported via the post-course questionnaire (Q2). Besides basic manipulations with which most of the teachers were familiar, several advanced skills shown in Table 2 (Q1, Q2) were hardly achieved, for example: determining the calibration factors of a sensor, setting a measurement based on a trigger event (data logging); performing perspective correction, correcting video points (video measurement); developing a computational text model (modeling).

The CoachLab II+ interface allows automatic sensor detection which is more convenient than older panels in some schools that require choosing the appropriate sensor (Q2). However, teachers still had to learn to deal with some problems:
• It was hard for many teachers to define triggering conditions. The measurement did not start because the triggering conditions were not satisfied.
• The force sensor did not show the proper values that the teachers expected. They had problems in changing the sensor calibration (set zero, set value) or choosing the right range.
• For measurements such as position of a falling object, frequency of sound, alternating current, some teachers could not define appropriate measuring time and frequency.
• In regard to data processing, at the beginning the teachers found difficult to define a new variable that is defined by measured variables and constants. The graph did not show a data curve because the teachers did not set appropriate
maximum and minimum values on the axes. Using and manipulating a function fit was problematic to the lower secondary school teachers.

The teachers practiced the given activities on video measurement without major problems, but it turned out to be difficult while they worked on their own activity.

- Problems with perspective correction: after the rectangle was set to the position of the rectangular object in the video, only the selected rectangle and its narrow surroundings were shown. Sometimes a part of motion could not be seen e.g. perspective correction in the video measurement activity of free fall. The teacher had to choose the rectangle which covers the whole track of motion.
- The teachers' video format was not compatible with Coach, or its size was too large. The teachers had to learn to resize their video and convert it to AVI or MPEG formats.
- The chemistry teachers found difficult to get an idea for video measurement for chemistry teaching.
- The teachers planned to use a video from the internet, but could not find real scale and frame rate of the video. The teachers had to learn how to find out this information for time and scale calibration.

Many teachers admitted that they would need more training to be able to create their own model. Problems were connected to developing a new model such as finding an appropriate phenomenon that could be modeled in Coach; defining state variables, flow variables, constants; connecting these variables; and setting a condition – if, then, else. One teacher had experience with Modellus modeling system, but it was not easy for him to work in a different environment.

4 Conclusion and discussion

4.1 Conclusion

The course was implemented quite successfully as the life sessions covered all the intended contents, and majority of the teachers put much effort into the fulfillment of the home assignments and the final assignment with presentation. Division of teachers into two-level groups proved to be appropriate. The main obstacle experienced during the course was that teachers had little experience with the Coach tools. As a result, the teacher trainer had to explain and instruct concepts and manipulations gradually in detail but always under the time constraint. On the other hand, the teachers complained of too much new information to follow and remember. Consequently, some advanced skills with the Coach tools were not achieved as expected.

The course was implemented quite effectively as almost all teachers gained basic knowledge and skills in using and applying the Coach tools in inquiry lessons. Highlights of the results were:

- The teachers became aware of possibilities and educational benefits of the introduced ICT tools. They were motivated to apply the Coach activities in the classroom.
- The teachers' familiarity, confidence, and skills with the Coach tools increased remarkably.
- 37 teachers (out of 39) could develop their own Coach activities and design their inquiry-based lesson plan enhanced by the introduced ICT tools.

The teachers were quite successful in learning Coach data logging and video measurement, but they still had many problems in learning the modeling tool. To master advanced skills, the teachers needed more time to practice Coach activities or develop their own Coach activities as well as to enrich their background with related knowledge (e.g. principle of dynamical modeling). It is challenging, but still possible as some teachers already achieved advanced skills with the particular Coach tool after the course completion.

The course was successful in applying the blended set-up in which the life sessions were extended appropriately with the home assignments and the final assignment with presentation about applying what they learnt in the life sessions to develop their own Coach activities and lesson plans. Literature on teacher professional development (PD) shows that in order to retain and apply new strategies, skills, and concepts, teachers must receive coaching while applying what they are learning (Guskey, 2000). A training course will only be effective when supplemented by expert or peer coaching and other school-based activities (Fullan, 2007). It is essential to create the proper conditions for teachers to prepare personally work plans and teaching materials for their students (Borghi et al., 2003). A crucial issue was how to keep the teachers on task while they worked in the distance learning mode. In this course, teachers were provided with an online platform where they could access support materials and receive timely feedback from the teacher trainer. The support materials, especially Coach activities at three levels, were very helpful for the teachers' self-study.

4.2 Discussion

The course aimed at the teachers' knowledge and skills in developing lesson plans enhanced by the Coach tools in accordance with the IBSE framework. Implementation of lesson plans in the classroom was not required although it could enable teachers to gain classroom experience with all aspects of integration of ICT into IBSE. Therefore, it is interesting and relevant to carry out a follow-up study of which the research question should be "To what extent can the teachers implement ICT-IBSE lesson plans in the classroom?" The online follow-up questionnaire may be administered to all teachers one or
two year after the course. We can also ask them to submit ICT-IBSE lesson plans and related Coach activities which they implemented in the classroom.

The course will be continuously offered to Slovak in-service teachers in the coming years. The new model enables to redistribute the course in order to spend more time and focus on problems that were identified in this case study. Some tentative changes for the next course are suggested as follows:

- More time and support for the teachers' learning of the modeling tool compared to the other Coach tools, instead of dividing time equally
- Less time for presentation and demonstration and more time for the teachers' practice of the Coach activities with supervision and for discussion in groups. This allows the teachers to work on their own learning path with suitable pace.
- Teachers are expected to master advanced skills with each Coach tool when fulfilling the related home assignment instead of at the end of each session. It requires the teacher to work harder in between the meetings with support materials which have been developed for the self-study tasks.
- More time on discussion about implementation of inquiry activities enhanced by ICT tools aimed at different levels of inquiry and principles of an ICT-IBSE lesson plan design.
- Teachers should be encouraged to try out classroom activities. It means they will go through a complete cycle of designing, executing, and evaluating an ICT-IBSE lesson instead of just designing the lesson plan.
- The course is extended to a longer time (40 hours instead of 30 hours), with 5 five-hour life sessions and 15 hours of distant learning instead of the model of 20 present/10 distant hours of learning.

Some difficulties in learning a particular Coach tool were encountered and presented in section 3.3. In the life sessions of the next course, we should emphasize on these issues to help the teachers.

It is possible to offer the ICT-in-IBSE course to ESTABLISH project partners or other interested institutions if their institutes have a basic set of the Coach apparatus and software. Translation of the support materials presented in the Moodle environment to more languages is feasible (e.g. Polish and Italian). The Czech partners could already use the Slovak Moodle course as it is now. The purpose of the blended training is to support more teachers for a longer time (not just in workshops). For a long term effect, it is crucial to keep in touch with the teachers and provide them with support, either within face-to-face meetings or through online help. It is necessary to think of critical tasks which suit the local context and come up with how to support further actions, at least from some of the teachers. Maybe that will stimulate others, too.

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