COMPUTER ASSISTED SCIENCE INQUIRY IN THE SCIENCE CLUB

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Abstract

This paper examines the innovative teaching approach of computer assisted inquiry in science subjects. This approach is justified through research to promote effectively knowledge, skills and attitudes in science as well as computer subjects. When teachers implement it though, challenges arise. Most of these challenges are generated by factors of the school context where teachers work. In this research the approach was implemented in the Science Club, in a primary school in Greece. In this club, attempts were made to reduce these factors. Through a qualitative research it was concluded that the club was indeed a fruitful context, but several challenges remained.

Introduction

This research focuses on computer assisted science teaching through inquiry. It aims to identify the possibility to implement it effectively, in a context designed appropriately. Inquiry includes processes, such as asking questions about natural phenomena and the natural world, interacting, investigating and giving answers (Crawford, 2007). According to the National Research Council (2000, p. xii), "Inquiry is in part a state of mind...Students need to learn the principles and concepts of science, acquire the reasoning and procedural skills of scientists, and understand the nature of science as a particular form of human endeavor."

There are many benefits in teaching science through computer assisted inquiry. Mainly, the profound understanding of science knowledge and work, as well as the familiarization with ICT in science processes (Osborne & Hennessy, 2003; Ødegaard, Haug, Mork, & Sørvik, 2014). However, its implementation is often hindered by the school's context (Twidle, Sorensen, Childs, Godwin, & Dussart, 2006; Kellow, 2006). This research implements this approach in the context of the science club, which is composed of pupils interested in science subjects. Thanks to the flexibility of this context it is possible to reduce the presence of hindering factors (Law No. 3966/2011).

The conclusion on whether implementation was effective or not requires thorough exploration of this approach along with the research context and process (Cohen, Manion, & Morrison, 2011).

Implementing Teaching through Computer Assisted Science inquiry

In order to examine the implementation of computer assisted science inquiry in class, it is necessary to investigate the main points of science inquiry, the potential of ICT, evaluation and challenges arising.

Scientific inquiry

Inquiry is significant in scientific work. Recent approaches to science teaching, involve participation in science inquiry tasks, which enhance science learning through the engagement in authentic scientific problems and everyday experience, negotiated through inquiry (Ødegaard et al., 2014). During the teaching of scientific inquiry, learners ask questions, give answers and benchmark them to those the scientific community accepts as correct. It also involves selecting the appropriate method to gather, analyze data, represent them and apply them to explain concepts or phenomena. This is done though continuous group work to explain, justify and review every action. This approach treats science as a process and not as a sum of concepts and phenomena to memorize (NRC, 2000; Crawford, 2007).

Eastwell (2009) has identified four different levels of scientific inquiry. These can assist teachers in selecting dimensions or parts of the inquiry that can be included in a teaching intervention. The first level is confirmation research. As can be understood by the name, this kind of research aims to guide learners to confirm a principle or a theory of science through tasks such as hands-on activities or experimentation. Within such inquiry, learners are provided with a question. They are expected to work with a specific method, which is thoroughly described to them, as it is known and decided well in advance. The results that learners are expected to come across are also known.

The second level is structured research. At that stage, the question is still given to learners. There is also a pre-decided process of tasks and methodology that they will follow. Results and the answer are also studied and known in advance. However, flexibility is provided. Learners can comment on methods presented and can choose others. Overall, they will use data as basis to explain a scientific phenomenon and construct knowledge (Eastwell, 2009; Přinosilová, Mechlová, & Kubicová, 2013).

The next level is known as guided research. Learners, who are working on a scientific inquiry at that level, are guided solely by the research question, which is provided to them by the teacher as in previous levels. There are no predetermined approaches to answer it. Learners have the flexibility to choose method and means. Moreover, the results are not predetermined. In other words, learners should be able to plan an investigation in order to discover new knowledge that will give the desired answer. The teacher does not pre-describe a particular path for learners to follow anymore.

The ultimate level of scientific inquiry is open research. At that stage, it is up to learners to state and specify research question, as well as the plan they will use to answer it. Teaching inquiry should ideally aim at reaching this level. This can be achieved gradually after passing the previous three. In other words, for learners to be able to ask science-oriented research questions, they should initially become familiar with applying methodologies to justify or draw conclusions as well as planning research methods. This way, learners can understand that inquiry is the essence of science.

Teaching inquiry across the four levels is not a linear process. Teachers should provide contexts for learners to work with different levels during the same period and not move statically from one level to another. This allows further on-going deepening with the individual elements of the inquiry (Eastwell, 2009; Přinosilová et al., 2013).

Computer Assisted Scientific Inquiry

Computers and generally information and communication technologies (ICT) have been invading education research and teaching practices over the last decades, bringing on opportunities for innovation in teaching. In science teaching, computers and ICT are supported by research to assist in tasks of data collection, as they offer a wide range of up-to-date resources. Moreover, digital-recording equipment and software can help in gathering, categorizing, analyzing any kind of data, findings and information. Additionally, presenting, disseminating and publishing tools can help in exchanging information, conclusions and ideas about findings and results. Aside from that, ICT can help science teaching with other measures such as virtual experiments and simulations, data logging kits and hardware, which also focus on gathering and managing various types of data (Osborne & Hennessy, 2003; Bingimlas, 2009).

ICT helps promote science learning through inquiry. Stating questions, planning methods to answer the questions, implementing plans and evaluating approaches, which compose the process of science inquiry, depend highly on skills and tasks about data managing that can be promoted through ICT. Overall, thanks to ICT it is possible for science teachers to go beyond teaching science as sum of information and development of skills and attitudes. Learners are lead to the desired level where they continuously ask, plan, experiment, inquire and construct knowledge continuously (Kellow, 2006). The continuous emphasis on the role of ICT in inquiry learning has generated the approach of *computer assisted inquiry* or even more specifically *computer assisted science inquiry* (Osborne & Hennessy, 2003; Sun, Looi, & Xie, 2014).

Evaluating Teaching Through Inquiry

Evaluation of teaching through inquiry can be neither simple nor quick. It is an on-going process, which examines if learners finally, started implementing inquiry, which means, asking questions, planning a methodology to answer them, experimenting, carrying out the plan, discussing findings (Ødegaard et al., 2014).

Harlen (2013) underlines that teaching through inquiry calls for both formative and summative evaluation. The former involves engaging learners to use knowledge, skills and other qualities to understand and express ideas, to take part in discussions about scientific topics. It is necessary to collect data during teaching, which can be benchmarked to initial goals of the teacher or curriculum. The teacher, based on this data, can conclude what has been gained, what the next step is and what the learners' strong and weak points are. Moreover, students by receiving continuous feedback, which is an important element of formative assessment, can have a better understanding of their achievement as well as the nature of science inquiry.

Evaluating peer work is a common activity of formative assessment. It gives useful insight of learners' understandings of the inquiry process, through comments they express about the work done (Ødegaard et al., 2014).

Summative assessment, though. is also necessary. It includes methods such as regular tasks, tests and revisionary exams. Although these means can distort the inquiry process, they provide significant records of learning. Perhaps, the most challenging factor in using summative assessment in inquiry teaching is to select the most appropriate techniques. These can be exercises, written essays, portfolio, artifacts,

learners' projects and other pieces of their work. Assessment criteria would be based on information, skills and evidence related to the inquiry process (Harlen, 2013).
When it comes to integrating science with ICT, to promote inquiry, it is crucial to include activities that reveal the knowledge constructed by learners in both subjects. Formative and summative assessment overlap each other in this case, as through both learners demonstrate in many ways their understanding in science and ICT individually, as well as their relationship within inquiry (Jarvis, 2012).

Challenges in Teaching Science Through Inquiry
Although teaching science through inquiry is supported as a beneficial approach for learners, its implementation is often accompanied by challenges. Some are common to any case of an innovative teaching approach. Others however, can be attributed to the characteristics and demands of science inquiry (Ødegaard et al., 2014).

With regards to the former, teachers who teach innovative practices frequently come across time pressure. Data analysis, presentation of findings and ideas cannot happen fast and easily. Another barrier would be lack of the appropriate school equipment. This also applies in inquiry teaching, as it depends on experimentation. These challenges are linked to the school and the curriculum demands. With regards to the latter, research states that teachers and learners maintain several misconceptions about inquiry. For example, many learners tend to overemphasize the hands-on activities and experiments. They pay less attention to discussion and findings analysis. Another barrier would be incompatibility with practices that learners are used to. Learners are not by default familiar with planning processes, testing hypotheses and constructing knowledge (Crawford, 2007; Harris & Rooks, 2010).

In short, the challenges are relevant to the school context and working conditions of the teacher. Similar challenges apply in promoting computer assisted inquiry in teaching. It is very common for science curricula to takes no in-depth consideration of the teaching potentials of ICT. Therefore, the teacher has to adjust ICT use to the demands of the curriculum. The school equipment may be insufficient, also. Additionally, learners need to become familiar with the "pedagogy of the Internet" (Twidle et al., 2006, p. 219). Learners need to understand how ICT can assist in learning, generally and specifically with regards to science inquiry. This is another point where the curriculum may cause barriers, as it may not contemplate the relevant qualities, as knowledge, skills and attitudes that learners may need.

Unless these issues are dealt with, there is a great risk for the intervention to be less successful. The teacher risks may need to deal with time pressure in order to help learners understand how to use ICT resources to gather data, analyze and present them. Learners may fail to understand the exact reason why they use the computer and consider it only as means of amusement and not learning. This may lead to the computer assisted science inquiry teaching losing its focus (McMahon, Garner, Gray, & Mulhern, 1999; Kellow, 2006).

Planning the Research Study

The planning of the study was based on the literature about computer assisted science inquiry, research methodology and the characteristics of the context.

The Context of the Study

Computer assisted science inquiry teaching is therefore justified to help science teaching, but, during its implementation, challenges may arise, due to the characteristics of teaching through inquiry. Learners are not used to the inquiry processes, since this approach is rather new. Teachers have to spend time to engage learners with the knowledge, skills and processes of the inquiry. This sometimes is difficult, as there is no provision for that in the curriculum. There are also challenges attributed to demands and restrictions set for teachers. Teachers may lack time, equipment and working conditions to teach science through inquiry either computer assisted or not (McMahon et al., 1999; Kellow, 2006; Twidle et al., 2006).

Bearing that in mind, a research study was planned to investigate the potential to promote teaching through computer assisted science inquiry in a context free of such restrictions. A context like that was found to be the science club of an elementary school in Greece. The clubs are for learners who express interest in a subject. The teacher responsible for the club has the flexibility to arrange the to arrange the syllabus, the time, and to plan and select the teaching approach to use, without requirement from curriculum. Research findings with regards to the subject of the club, which in this case is science, should not be neglected. The science club included learners interested in science (Law No. 3966/2011). It has been working since 2012. Forty two participants of the fifth or sixth grades, which are the final two of the primary school, have attended the club for two years. They have carried out tasks focusing on inquiry through evaluating hypotheses, justifying findings, planning experimental and scientific investigations, and, finally, asking questions. This was done through continuous data collection, analysis and discussion (Eastwell, 2009; Přinosilová et al., 2013).

Learners were introduced to tasks focusing on computer assisted inquiry science teaching. They worked in groups of three or four. Approximately eight to ten such tasks were carried out each year. The duration was three to six weeks.

Learners were shown ICT applications for such activities. They saw how to search websites, use spreadsheets for data collection, management and analysis. They were shown virtual experiments to use for testing. They were also shown software for data presentation or communication. Software selection was based on availability and appropriateness for the learners’ age (Kellow, 2006; Twidle et al., 2006; Jarvis, 2012). Tasks focusing on confirmation research included using websites and electronic resources mostly to collect information, about a known topic. Tasks focusing on structured research included search sites to collect information in order to confirm data and present them. Tasks focusing on guided research would include searching information online about experiments, simulations and possible equipment that can be used in order to plan scientific activities. They also included searching pages such as networking sites to see prepared materials of science inquiry, analyze them and understand how to plan them. Similar were the tasks focusing on open research, which however included less instruction by the teacher with regards to identifying the topic under study (Eastwell, 2009; Jarvis, 2012; Přinosilová et al., 2013).

The Research Questions

In order to identify if computer assisted science inquiry teaching was effective, it is necessary to evaluate if learners understood the elements of scientific inquiry and the level achieved. It is important to identify whether they became able to evaluate hypotheses and confirm findings to prove achievement of the confirmation level. Learners need to prove they can draw conclusions and explain phenomena to prove achievement at the structured level. They also need to show they can plan scientific investigations to prove achievement of guided level. Lastly, they must show they can state research questions and trigger investigation to prove achievement of the final level of open research (Eastwell, 2009; Přinosilová et al., 2013). Aside from that, learners need to show ICT efficiency, with regards to knowing benefits and risks of involving ICT in science inquiry processes and applying them (Jarvis, 2012; Sun et al., 2014).

The research questions were:

1. Did the learners use ICT to evaluate hypotheses?
2. Did the learners use ICT to draw conclusions?
3. Did the learners use ICT to plan scientific investigations?
4. Did the learners use ICT to ask questions?

These questions have dual aspects. They focus on determining if learners consolidated, first, levels and processes of science inquiry and, second, the potential of ICT to contribute to these processes. By answering these questions, it is possible to see if within the clubs, computer assisted science inquiry was taught effectively, or if challenges emerged in this context as well (McMahon et al., 1999; Kellow, 2006).

Research Methodology

The study is qualitative. Strauss and Corbin, (1997, p. 17) describe that qualitative research is "any kind of research that produces findings not arrived at by means of statistical procedures or other means of quantification." This study is an example of action research as there is the researchers' personal involvement as teachers in, the process. Action research involves reflection, collaboration and dialogue, as elements of empirical study to promote and evaluate teaching practices (Cohen et al., 2011). During each session, data were collected through documents, learners' projects and notes, observation of learners while working, reading and discussing and interviews with learners (Bell, 2001). This helps implementation of both formative and summative practices (Harlen, 2013).

The development of skills in all sessions was observed. At the same, time learners participated in group semi-structured interviews, which focused on themes relevant to inquiry such as data collection, data management and use, investigation planning and evaluating. Focus was also given on ICT use in such processes. In order to answer the first research question, learners' notes and projects were collected. Learners answered questions such as "What do you think will happen?" "Do you think this was correct or wrong?" "How will you prove it?" "Will you use the computer for that?" which gave insights of learners' ability to use ICT in order to confirm hypotheses.

To answer the second research questions data came from learners' notes and projects as well. By answering questions such as "Why do you think this happens?" "Would you use the computer to find out if your conclusion is correct?" learners would prove whether they could use ICT to explain phenomena and justify their explanations.

To answer the third research question, apart from learners' notes and projects, their portfolio was checked. Emphasis was given on the way they planned methods to answer a scientific question. Learners would reply when asked "What would you do to answer the question?" "Would you use a simulation on the computer for that?" and show if they developed the skills to plan investigation, with the help of ICT.

Lastly, to answer the fourth research question, notes, projects and portfolio, were used. Learners asked questions like "What do you think about this subject?" "What have you found out?" They were also observed, in order to see if they would use ICT, in order to form a research question that would trigger further research.

The data were transcribed and analyzed. These methods aimed to identify the development of computer assisted science inquiry skills in learners (Osborne & Henessy, 2003; Eastwell, 2009; Harlen, 2013).

Findings

The findings were overall positive, but there were points that called for improvement.

Question 1.: "Did the Learners Use ICT to Evaluate Hypotheses?"

With regards to the first question, findings were encouraging. The results show that pupils learned to evaluate the hypotheses stated and they also managed to use ICT easily and effectively in such tasks. Firstly, as seen from the interviews, pupils understood what evaluating a hypothesis includes. They were able to test thoughts set to them and implement findings to explain phenomena. When the task they were working on required that, learners would immediately reply with comments like "We need to check if that [hypothesis] we made is right or wrong," or "I can show that this is correct." Even though in the beginning, hypothesizing would sometimes be omitted, as the study progressed, this was less frequent. Testing a hypothesis was therefore a skill satisfactorily developed by learners (Harlen, 2013; Ødegaard et al., 2014). Secondly, learners showed that they understood the assistance of ICT in evaluating a hypothesis. Searching sites and seeking data online was most used. It was common for learners to explain, "We can use the Internet to check if that idea is right." Apart from that, there were replies about use of spreadsheets. These prove adequate knowledge of ICT assisted inquiry (Osborne & Hennessy, 2003; Sun et al., 2014). So, learners got the qualities needed in order to carry out confirmatory research with the help of ICT, as seen from the findings gathered (Eastwell, 2009; Jarvis, 2012).

Question 2.: "Did the Learners Use ICT to Draw Conclusions?"

Findings were equally encouraging for the second question. Most learners gradually understood the process of drawing scientific conclusions with assistance of ICT and carry it out as part of the inquiry (Kellow, 2006; Twiddle et al, 2006). More specifically, learners had initially shown difficult in stating an explanation of a phenomenon. For example, in a process that linked color and heat absorption, when asked to explain what they conclude based from the temperature measurements on similar objects of different color, learners would possibly give no answer. This however, changed at later stages. As the study progressed, learners would easily give replies such as "Black color objects absorb more heat." This improvement was apparent in many tasks. This shows steady overcoming the barrier of limited experience in forming conclusions from data (Harlen, 2013). Additionally, learners understood the potential assistance of ICT in drawing conclusions. Pupils would frequently suggest loading websites or using virtual experiments and simulations to get more data that would help them form, generalize or justify conclusions. When examining the link between color and heat absorption, learners suggested "to use the experiment on the computer to do more measurements with more colors and see what happens." Similar answers were frequently given, especially with regards to simulations. Hence, learners gradually learned how to carry out ICT assisted structured research (Eastwell, 2009; Jarvis, 2012; Přinosilová et al., 2013).

Question 3.: "Did the Learners Use ICT to Plan Scientific Investigations?"
Findings regarding the learners' ability to plan scientific investigation were encouraging, though only to a certain extent, as challenges were observed in several essential parts of the planning process (Ødegaard et al., 2014). On one hand, the searching and investigating aspects of planning were carried out effectively. Learners would show ease in searching online in order to collect information about phenomena, or even to search for possible experiments that could be carried out to answer stated scientific questions. They would also frequently suggest carrying out virtual experiments relevant to the topic. So learners became able to use ICT as a means of deciding about experimentation and carrying it out. These are significant parts of computer assisted science inquiry (Harlen, 2013). On the other hand, when it came to presenting their investigation and explaining how, why and what they planned, learners faced challenges. Sometimes, they could not justify the decisions they got. When explaining what methodological process they would carry out, they would present experiments that would not directly relate to the question they had to answer. There was improvement by the end of the study, but not that significant. In other words, they would lose focus, a challenge commonly seen (Kellow, 2006). In short, learners conquered aspects of the guided research level, along with relevant ICT benefits, but not totally (Eastwell, 2009; Jarvis, 2012; Přinosilová et al., 2013).

Question 4.: "Did the Learners Use ICT to ask Questions?"
Learners' ability to ask questions and clarify problems or areas for experiments with the use of ICT improved after participating in five or six tasks, but this improvement was rather limited. When learners were presented a topic and asked to discuss about it, most of the times learners would either give no answer, or would answer based on previous experience. Replies such as "We don't know about it," show that they would treat it as a question to test knowledge instead of suggesting questions and plans. Even though this is necessary for investigation, there was lack of identifying a subject to discuss and search further. This attitude was probably due to missing experience with activities that were of such a nature (Harlen, 2013). In relation to that, the learners' use of ICT in order to specify topics that call for study was not very extensive either. Even though several learners explained they were aware of using software to present study ideas, or social network sites to communicate with others, they could not use this in relation to science topics to question. In cases where they were encouraged to use the software or sites, it was difficult for them to stay focused on the topic. The challenge of focus lack is apparent in asking questions, as with planning investigations (McMahon et al., 1999; Kellow, 2006; Harlen, 2013). Learners faced common challenges in identifying topics to investigate and ask questions with the use of ICT. The open research level was not significantly attained by them (Eastwell, 2009; Jarvis, 2012; Přinosilová et al., 2013).

Table 1

The Findings

Question 1. "Did the learners use ICT to evaluate hypotheses?"	Question 2. "Did the learners use ICT to draw conclusions?"
✓ They understood what evaluating hypothesis includes. ✓ They were able to evaluate hypotheses. ✓ They used ICT for that purpose.	✓ They were able to draw conclusion. ✓ They understood the potential of ICT, especially simulations.
Question 3. "Did the learners use ICT to plan scientific investigations?"	**Question 4. "Did the learners use ICT to ask questions?"**
✓ They were able to collect information to plan and carry out experiments with help of ICT. ✓ Struggled in presenting and explaining.	✓ Struggled to point out questions. ✓ Could not understand how to use ICT in identifying questions. ✓ Sometimes lost focus when using ICT.

Conclusions

This research examined a case of implementation of computer-assisted science inquiry. This approach is known to be beneficial for learners as it promotes effective knowledge construction, skill development and attitude adoption about science, ICT and science learning. However, challenges arise as school culture and contexts are not ready to accommodate it. The reasons are lack of time, pressure of duties of teachers, and the fact that pupils are not used to learning through inquiry (McMahon et al., 1999; Kellow, 2006; Twidle et al., 2006; Harlen, 2013).

The aim of the research was to identify if these challenges could be alleviated when implementing teaching science through computer-assisted inquiry in a flexible context. The research took place in a primary school in Greece, where a science club is conducted. The teachers of clubs have no prescribed curriculum to follow. They have the opportunity to arrange the syllabus, to select what topics to teach, tasks to implement and teaching approach to use, and to manage time appropriately (Law No. 3966/2011). So the context of the clubs was flexible and appropriate for this research.

The classification of Eastwell (2009) about the four levels of science inquiry, in combination with the findings of Harlen (2013) about evaluating the effectiveness of computer assisted science inquiry teaching, was used. The findings showed that learners attained the level of confirmatory and structured research. This means they were capable of using ICT in science processes to collect data, test hypotheses and draw conclusions about phenomena and concepts. They did not completely attain the levels of guided and open research, as they gave limited proof of effective ICT use in, evaluating data, planning science investigations and forming questions.

There were encouraging results. It is possible to promote computer assisted science inquiry teaching in a flexible context although challenges that literature describes emerged. Learners' lack of general experience with that practice and losing focus were perhaps the most prevalent. In conclusion a flexible context can assist promoting computer assisted science inquiry teaching to some extent (Osborne & Hennessy, 2003; Twidle et al., 2006; Crawford, 2007; Harris & Rooks, 2010; Harlen, 2013; Sun et al., 2014). Before generalizing these conclusions, though, it is important to point out the limitations of this study, which have to do with the specific context, period of time and number of learners involved (Bell, 2001; Cohen et al., 2011).

References

Bell, J. (2001). *Doing your research project: A guide for first-time researchers in education and social science* (3rd ed.). Buckingham, United Kingdom: Open University Press.

Bingimlas, K. (2009). Barriers to the successful integration of ICT in teaching and learning environments: A review of the literature. *Eurasia Journal of Science, Mathematics, and Technology Education*, *5*(3), 235 – 245.

Cohen, L., Manion, L., & Morrison, K. (2011). *Research methods in education* (7th ed.). London, United Kingdom: Routledge / Falmer.

Crawford, B. A. (2007). Learning to teach science as inquiry in the rough of practice. *Journal of Research in Science Teaching*, *44*(6), 613–642.

Eastwell, P., (2009). Inquiry learning: elements of confusion and frustration*. The American Biology Teacher*, *71*(5), 263-264.

Harlen, W., (2013). *Assessment and inquiry based science education: Issues in policy and practice*. Trieste, Italy: Global Network of Science Academies.

Harris, C. & Rooks, D. (2010). Managing inquiry-based science: challenges in enacting complex science instruction in elementary and middle school classrooms. *Journal of Science Teacher Education*, *21*(2). 227-240.

Jarvis, T., (2012). *Integrating science inquiry across the curriculum: The Fibonacci project*. Retrieved from http://www.fondation-lamap.org/sites/ integrating_science_inquiry_across_the_curriculum.pdf

Kellow, J. (2006, January). *Inquiry learning in an ICT-rich environment*. Retrieved from http://www.efellows.org.nz/?q=report_blog/18

Law No. 3966. (2011, May 18). *Institutional framework of Experimental Schools. Foundation Institute for Educational Policy*, Organization of the Institute of Computer Technology and Office "DIOFANTOS" and other provisions.

McMahon J., Garner J., Gray C., & Mulhern, G. (1999). Barriers to student computer usage: staff and student perceptions. *Journal of Computer Assisted Learning*, 15, 302-311.

National Research Council (NRC). (2000). *Inquiry and the national science education standards*. Washington, D.C.: National Academy Press.

Přinosilová, J., Mechlová, E., & Kubicová, S. (2013). ICT on four levels of inquiry-based science education in environmental education. *ICTE Journal, 2*(1), 17–31.

Strauss, A., & Corbin, J. (1997). Grounded theory research: Procedures, canons and evaluative criteria*. Qualitative Sociology*, *13,* 3-21.

Ødegaard, M., Haug, B., Mork, S. M., & Sørvik, G. O. (2014). Challenges and support when teaching science through an integrated inquiry and literacy approach. *International Journal of Science Education*, *36*(18), 2997-3020.

Osborne, J., & Hennessy, S. (2003). *Literature review in science education and the role of ICT: Promise, problems and future directions*. London, United Kingdom: Futurelab.

Sun, D., Looi, C.-K., & Xie, W. (2014). Collaborative inquiry with a web-based science learning environment: when teachers enact it differently. *Educational Technology & Society*, *17* (4), 390–403.

Twidle, J., Sorensen P., Childs, A., Godwin, J., & Dussart, M. (2006). Issues, challenges and needs of student science teachers in using the Internet as a tool for teaching, *Technology, Pedagogy and Education*, *15*(2), 207-221,

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