Research paper

Investigating Physics teachers' beliefs about the use of ICT in Cyprus

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Contextualization

Teachers are likely to hold beliefs about teaching and learning, including beliefs about ICT tools, which are additional instruments considering teaching and learning practice. Levin and Wadmany (2006) highlighted that teachers' educational beliefs filter their decisions and determine classroom practice. From this perspective, teachers' role is really critical as teachers are the ones who have to decide whether to use or not the available ICT tools. Therefore, teachers are likely to have a significant influence on the introduction of ICT tools in teaching and learning.

My study is concerned with Physics teachers' beliefs about the use of ICT in Cyprus. Teachers' beliefs together with contextual constraints are likely to influence the use of ICT. In my study, I explore teachers' beliefs about the use of ICT in order to identify issues that influence the introduction of ICT tools and to highlight possible interaction between teachers' beliefs about the use of ICT and contextual constraints.

Abstract*: Investigating Physics teachers' beliefs in Cyprus about the use of technology in the classroom will illuminate how their choices of ICT resources might be influenced by their beliefs about technology and the nature of Physics teaching and the relationship of these to other constraints in practice. Physics teaching incorporates theoretical content teaching and laboratory activities and consequently teachers are required to decide whether and how to integrate ICT in their lessons.*

The small scale pilot study of ten Physics teachers has shown that the key issues regarding a successful introduction and use of ICT tools in the classroom are teachers' beliefs about both ICT and teaching and learning and the nature of Physics education itself. These issues might be important because Physics teachers consider ICT resources as supporting tools improving students' engagement and also enriching investigative practical work, both are expected to enhance students' understanding, whereas a range of constraints relating to teaching and learning seems to have an effect on their teaching and in some cases to determine their actual instructional practice in classroom.

Introduction-Purpose of the study

Teachers' beliefs regarding the use of ICT might be a critical factor for the successful introduction and use of ICT. Teachers hold beliefs about teaching and learning and these ''teachers' educational beliefs are considered a filter for teachers' instructional and curricular decisions and actions and therefore can promote or impede change (Prawat, 1992)'' (Levin and Wadmany, 2006, p 159). Charalambous and Karagiorgi (2002) state that the teacher's role is really critical since the teacher encompasses a particular dynamic, which supports either the failure or success of new information and communication technologies (ICT). In this perspective, teachers' educational beliefs regarding the use of ICT are expected to influence their decision whether to use or not a range of ICT tools and therefore support the implementation of ICT. There is also the possibility the teacher to attempt to fit his personal beliefs about the use of ICT to the actual educational situations, where different constraints might influence his decisions as well. In such a case, teachers' educational beliefs might

blend with existing constraints and despite teachers' beliefs these constraints might put off teachers and consequently not support the use of ICT in lessons. In this study, Physics teachers' beliefs regarding the use of ICT and the possible constraints of using ICT tools will be examined. The research aims to uncover teachers' beliefs about the use of ICT and to illuminate issues regarding the use of technology.

Context - Cyprus Educational System (General Information)

Cyprus Educational System might be regarded as highly centralised. It is administered by the Ministry of Education and Culture (MOEC) and therefore the Governmental authorities. Pashiardes (2004, p 256) reported that the Cyprus Educational System is characterised by the centralisation, conservatism and the influence from both governmental and teachers' organisations. The centralisation is illuminated by how teaching staff is appointed. Teachers, schools' headmaster and teaching personnel are selected by the MOEC based on teachers' experience and schools' needs always prior to the start of each school year. The local authorities are not responsible for teachers' appointments and other teaching aspects but they always collaborate with the schools. The curriculum for each subject is designed mainly by the education specialists working under the supervision of the MOEC. The Ministry is also responsible for the delivery and use of guidelines, textbooks and, in general, for the adoption of the decided educational policy in each level. In the case of textbooks, there is a collaboration scheme with the Hellenic Ministry of Education but there are also textbooks and educational resources, which are designed and prepared in Cyprus.

The educational sector in Cyprus is categorised as follows: Pre-Primary Education, Primary Education, Secondary Education (Lower-Upper) and Higher Education. Each stage in the Cyprus Educational System is free and compulsory excluding Higher Education. In this study, the examined level is upper secondary education, and specifically the Lyceum phase (Eniaio Likeio).

Lyceum phase has changed its name to Eniaio Likeio since the school year 2000-2001 while the other phase remained as Upper Secondary Technical and Vocational Education (MOEC, 2007, p 258). This study focuses on teachers working in Eniaio Lykeio level. According to the Ministry of Education and Culture (2007, pp 258-259), Eniaio Likeio is a flexible educational system, which allows pupils to choose different subjects according either to their future plans or to their skills and interests. Furthermore, MOEC reports that the appointed education specialists; teachers, policy-makers, inspectors and researchers work in order to support and improve the system and therefore to enable pupils to achieve the required knowledge and skills for the 21st century. In relation to the subjects, they are split into two categories; the core subjects, which are compulsory and the optional subjects. The core subjects are the same in every Eniaio Likeio across Cyprus but the optional subjects vary from school to school, sometimes in accordance with students' demand.

As it was mentioned earlier the Cyprus Educational System has particular characteristics (eg, centralisation and the framework of the phase; Pashiardes, 2004), which might influence teachers' practice. These characteristics might be additional elements to this study as teachers' beliefs are likely to be influenced by these features and perhaps teaching practice. Perhaps the fit between teachers' beliefs and policy demands made of them might be problematic and consequently affecting educational standards. For example, a teachers' approach in the classroom might diverge from official expectations, reflecting their own beliefs. A further factor is the need to prepare students for examinations. In such a case, teachers would feel constrained to follow official advice so as to minimise risks. Due to this, teachers might persist in Ministry's policy despite their beliefs so as to achieve Ministry's teaching standards. On the one hand it is important for teachers to follow the policy and the curriculum so that the Ministry can keep an order in schools and, in particular, on teaching quality. On the other hand there is always the case where a teacher might feel that a

particular teaching approach or use of ICT to fit much better his audience. Also, a teacher who delivers lessons in a different way to that which he/she might prefer, in practice teaches less effectively and with less commitment. In the same perspective, teachers' beliefs about the use of ICT together with teaching constraints and educational characteristics seem to be a critical element regarding its use in Cyprus schools.

ICT in Cyprus education

The plan for promotion and introduction of ICT in elementary schools initiated on 1991 (Karagiorgi, 2005, p 21) during which five phases took place and each one had a particular plan of action. Phase A was an experimental introduction of computers in geometry lessons in a particular school. These lessons were observed and evaluated and in a later stage a teacher training session was prepared. The next phases included additional intensive teacher training sessions during which computers were presented as teaching tools, equipment purchases and introduction of computers in schools. It seems that the plan attempted to promote the use of computers and in the next years to introduce new forms of information and communication technologies in schools. This was the first organised governmental attempt to train teachers at first and in a later stage to encourage them to take advantage of the use of ICT. Although the plan aimed the elementary schools, there were efforts to introduce ICT in secondary schools as well. Perhaps the most notable effort took place in the period 2004-2009. According to Pedagogical Institute (2009, PI-ICT) the cabinet-council of Cyprus passed a resolution regarding teachers' training for the use of ICT and launched a five year training plan, 2004-2009, aiming to educate and train both primary and secondary teachers.

The training sessions seem to have aimed for the development of basic computer skills so that the teachers became computer literate and second to enable teachers to use ICT tools during lessons. The plan focused on teachers' development of ICT skills and it seems that the training was developed to assist teachers and support them to start feeling comfortable and competent enough with technology. However, the available training sessions were not compulsory. The table (PI-ICT, 2009), below, shows the training programmes.

Code	Programme Description	Duration (Teaching Periods)
P1	Basic Skills	60
P2	Basic Skills + Excel and Databases	60 + 20 = 80
P3	Basic Skills + Educational Application of Information Science in Secondary Education	60 + 20 = 80
P4	Review of Basic Skills + Educational Application of Information Science in Secondary Education	20 + 60 = 80
P5	Training of Trainers in Educational Application of Information Science	70
P6	Training for Information Science Teachers	
	Ecdl Ctp	50
	Cisco	70

This information perhaps indicates the primary scope of the training; to focus on teachers' acquisition of basic computer skills and secondly on teachers' preparation for the actual use of ICT during lessons. It is noticed that there is no information regarding training sessions aiming to explore teaching and learning issues, which might interact with the use of ICT. Physics teachers have the opportunity to participate the training sessions and also to take part to different seminars where teaching approaches including the use of ICT are presented; however according to participants the interaction is minimal and consequently the sessions might not be regarded as constructive as they should be. Based on this information, it might

be assumed that teachers' beliefs are not taken to a great extent into account and that the sessions are developed following a specific seminar pattern. Consequently, fascinated teachers might feel disappointed and change attitude towards the use of ICT. An investigation of teachers' beliefs is required for the development of successful training sessions as the obtained knowledge will support Ministry's efforts for the actual introduction and use of ICT in Cyprus.

Review of the Literature

Defining Beliefs

There are debates for the definition of the term belief and different theorists have defined belief in different ways using other terms. This situation confuses research activities; therefore it is really important for this study to explore the term belief and follow a specific definition so as the study to be focused.

Firstly, it is necessary to make a distinction between general personal beliefs and educational beliefs in order the research to focus on the particular belief component which fits the study. Pajares (1992) indicated researchers should separate teachers' general beliefs and educational beliefs. Moreover, he extended this point stating that researchers should then focus on specific areas of beliefs, which are important for their study. Considering Pajare's indication, this particular study is focused on educational beliefs including the use of ICT and how this use might be interacted by different teaching and learning constraints either because of educational system's structure or teacher training and available equipment. However, a definition of the term belief is required so as to acknowledge the nature of the relationship between teachers' beliefs and actual classroom practice.

It is clear that the term belief refers to a range of other terms (eg, opinions, attitudes, actions) According to Abelson (1979) the term belief refers to how people manipulate knowledge. Brown and Cooney (1982) indicated beliefs as the dispositions to action and major determinant of behaviour. Further to this, Pajares (1992) expressed the view that belief:

> speaks to an individual's judgment of the truth or falsity of a proposition, a judgment that can only be inferred from a collective understanding of what human beings say, intend and do. (p 316)

According to Calderhead (1996) beliefs refer to suppositions, commitments and ideologies while knowledge deals with factual propositions and understanding. As Savasci-Acikalin cited (2009) Haney *et al* (2003, p 367) in an educational context defined beliefs in terms of a person's convictions, philosophy, tenets, or opinions about teaching and learning. Furthermore, in Kagan's work (1992, p 73) it is stated that teachers' beliefs is the reflection of actual nature of the instruction provided by the teacher. Yet, he indicates that teacher beliefs might vary as different subject teaching might require different teaching style; therefore different teaching philosophy and beliefs.

In this particular study, Calderhead's (1996) distinction is adopted. Following this view, it is assumed that after acquiring specific knowledge the individual still has the opportunity and the ability to select whether a proposition is true or accurate. In this perspective, Physics teachers might have attended available teacher training sessions and acquire knowledge and skills for using ICT but still not take advantage of it as they might believe something different. This indicates the strong correlation between knowledge and beliefs, which are both influential elements regarding classroom practice. According to Becker (2001) constructivist beliefs promote computer use in education. On the one hand, the use of ICT in Physics teaching might require a constructivist teaching approach in order for the teacher to

take advantage of technology. On the other hand, teachers following different teaching approaches might resist fitting ICT in their approach as it might not match with their educational beliefs. In this perspective, it is clear that teachers' set of beliefs is likely to determine whether teachers accept innovative changes in education such as the use of ICT in the classroom. In other words, teachers are expected to integrate changes (eg, teaching approaches, use of ICT) more easily if the changes fit their personal beliefs. Considering Physics teaching, constructivist teaching might support high-level of understanding; therefore enabling students to acquire knowledge and think about concepts on their own. In the Cyprus context, this type of teaching is promoted by the Ministry of Education and Culture. Yet, Physics teachers might face different constraints, which might adjust constructivist teaching approach and consequently the use of ICT. For this reason, the research aims to explore teachers' educational beliefs together with beliefs about the use of ICT. At a later stage a wider research activity is required to explore beliefs and knowledge in-more depth as belief systems appear to be linked with knowledge processes and systems.

Previous Research on Teachers' Beliefs

Teachers might be a key element regarding the introduction of ICT tools and consequently its use during lessons and their beliefs are likely to influence teaching practice and the use of ICT. ''Teachers' educational beliefs are considered a filter for teachers' instructional and curricular decisions and actions and therefore can promote or impede change (Prawat, 1992)'' (Levin and Wadmany, 2006, p 159). In this case, decision about the use of ICT by Physics teachers might be linked to their beliefs about both ICT and teaching and learning and the nature of Physics education itself. As ICT is already a part of teaching and learning practice across the curriculum it is expected that teachers have different beliefs regarding the use of ICT. On the one hand, an optimistic attitude might be an encouraging factor regarding the implementation of ICT tools in education and therefore the practice of teaching and learning with ICT. On the other hand, an unenthusiastic attitude towards the use of ICT, either because of the lack of ability and teaching and learning beliefs, or because the teacher might be right about ICT, as an element not essential for good teaching. Consequently, the teacher is expected not to support teaching and learning practice with ICT. Charalambous and Karagiorgi (2002) indicate that the role of the teacher is critical due to the fact that the teacher encompasses a particular dynamic, which supports either the failure or success of new information and communication technologies (ICT). Thus, teachers' beliefs about the use of ICT are a key factor regarding the use of ICT.

Over the last decades there were studies (Levin and Wadmany, 2006; Tsai, 2002; Hashweh, 1996; Brickhouse, 1991), which have investigated teachers' beliefs. The literature supports the view that teachers' beliefs do affect teaching practice and that they are likely to shape teaching and learning. In Tsai's study the science teachers who hold traditional- empiricist view of science tend to adopt traditional teaching, where the teacher delivers factual scientific content and there is plain knowledge transfer. In this case, perhaps teachers' beliefs were influenced by their own school experience or university training. Thus, it might be expected that teachers' personal experiences to shape their beliefs about teaching, learning and science. A similar situation might be happening in the case of teachers' beliefs about the use of ICT and consequently these beliefs are critical when a teacher comes to decide whether or how to adopt ICT in his lessons. Hence, teachers' beliefs regarding educational issues including the use of ICT might act either in a constructive or destructive way. In this study, Physics teachers' beliefs regarding the use of ICT are explored while at the same time there will be an attempt to illuminate issues regarding teaching constraints that might affect the use of ICT and therefore the successful implementation of ICT in secondary schools in Cyprus.

Physics teachers might use different technological tools in a range of teaching and learning activities either because they feel these tools will enhance their practice or because they are

instructed to do. In both situations, the teachers are responsible for choosing ICT tools for their class and it is likely to depend on their beliefs. Additionally, teaching is not only influenced by teachers' beliefs but also by other factors. For example, curriculum plan, available time, parents and classroom environment might influence teaching and learning. Therefore, teachers might not be able to practice according to their beliefs about teaching and learning. Thus, it might be too simplistic to explore teachers' beliefs regarding teaching and learning without taking into account other factors, which might as well influence their teaching and learning. The point is that in a real educational context these constraints do take place and in the case of Cyprus teachers often might face difficulties due to curriculum plans, inadequate teacher training and poor ICT equipment. Thus, if the constraints are not taken into account, the research might not capture the reality and this might have a less constructive consequence regarding the research results. The intention of this study is to present new knowledge and issues about Physics teachers' beliefs and the use of ICT and therefore illuminate how these issues might interact. The outcome of the study might inform the development and teacher training that aim to promote the use of ICT. Moreover, these findings might also illuminate possible constraints on teachers' efforts resulting from the interaction between ideas about Physics teaching, which includes teaching theoretical content and practical activities, and the use of computers.

Methodology

Research Questions

The main research question of the study is how teachers view the use of ICT and how teachers' beliefs influence teaching and learning with ICT. Additionally, the research investigates how contextual constraints interact with teachers' beliefs and consequently with the use of ICT. Following these questions, teacher training and ministerial support are investigated in terms of how and to what extent they take teachers' beliefs into account.

Method

The study examines upper secondary education level and specifically the level called Eniaio Likeio in Cyprus Educational System. The teachers were responsible for delivering Physics across different stages within Eniaio Likeio and having as well similar experience regarding teaching at the level of Eniaio Likeio.

This small-scale research is an investigation of ten subjects. Teachers were regarded as experienced and trained, teaching the last three years in the Lyceum phase and preparing students for their final state exams. They were selected according to teaching experience and school location so as to cover different areas. There was no relationship between researcher and participants. The fact that the researcher will probably be a future Physics teacher, consequently a new colleague; participants were feeling that the research might give a realistic picture of teaching and learning constraints and the use of ICT. The participants had attended basic courses for the development of computer skills and use of Microsoft Package (eg, Word, PowerPoint, Excel) offered by the Ministry of Education and Culture. Further to this, teachers attended seminars where the use of different simulation software and data-loggers were presented. During these seminars teachers had no opportunity to experiment with the software. As far as the available equipment and software, there is no report from the Ministry of Education and Culture indicating additional information about the equipment and software. Fortunately, the school authorities of the participating schools provided information about the availability of computers and a digital projector in the Physics laboratories. In terms of software, each authority informed that the computers had been installed with the Microsoft Package, Crocodile Clips and in some schools the data collection and analysis software DataStudio. This information is important as it is clear that the teachers have a range of tools so as to practice teaching and learning with ICT to some extent and therefore be able to discuss it during the interview.

On the one hand, the small number of the participants might be a source of unreliability and invalidity. On the other hand, due to Cyprus Educational System's structure, staff development and teacher training, which are both controlled and administered by the Ministry, teachers are likely to have very similar characteristics. Even though, a wider study including a larger sample of participants from different teaching levels taking into account issues like teachers' undergraduate studies and personal student experiences might reveal additional themes. This study has the potential to shed light on important issues and provide evidence that can be used for further studies investigating teachers' beliefs in a wider scale. A qualitative approach was used incorporating semi-structured interviews. Questions and teacher responses used in the paper were translated from Greek; however initial analysis of the interviews was made in Greek.

Initial Findings

Themes were identified in data after exploring and analysing Physics teachers' interview transcripts. The themes have indicated that Physics teachers hold beliefs about the use of ICT and that there might be a contradiction between Physics teachers' beliefs about the use of ICT and the existing use and of technology in Physics education in Cyprus. Physics teachers were found to use frequently the words 'support' and 'construct' during the discussion about the use of ICT. As the participants expressed very similar views in their responses they were presenting mainly the same idea.

Theme 1: ICT as a supporting tool for students' engagement and further investigations

Regarding the question:

> How would you use information and communication technologies if ICT equipment and resources were available in an excellent school environment?

A teacher responded:

> Technological tools are already being used in other EU countries and I feel that there are different tools, which might support students while trying to understand. You know that students like technology and they will probably engage easier to a teaching approach where ICT tools are used. In my view, this is the way that we [teachers] should use technology, to promote teaching and learning in an alternative way, where students engage by just having teacher's guidance.

Another teacher mentioned:

> I believe that a teacher should aim to assist students in a particular way. For example, helping them to tackle different topics, which for example are difficult to approach by just giving examples (eg, Solar system) or other descriptions and ICT might be a helpful tool to achieve this. But I think the teacher has to be able to orchestrate the equipment –if it is available- and approach the lesson in a different way, supporting students instead of giving instructions and at the end delivering the knowledge.

In general the Physics teachers in this study have mentioned that the technology and its tools have much to offer to the existing teaching and learning practice and that the students might benefit if the ICT tools are employed following an organised teaching plan.

Regarding the question:

> Are there specific ICT tools which you think are more supportive to Physics teaching and learning? How?

Physics teachers presented the belief that ICT tools can provide students the opportunity to explore in-depth different abstract topics by using specific tools (eg, simulations), which cannot be investigated in the laboratory for different reasons like inadequate equipment and lack of time. They have also indicated that ICT is perhaps a way of promoting investigative practical work, which might offer much more opportunities compared to illustrative practical work. In such a case, the students will have the opportunity of exploring a topic in-depth by actual experimental activity together with an abstract investigation while using ICT tools. Consequently, students' understanding is expected to be improved. However, it was clearly well-defined that teachers believe that laboratory and practical work cannot be replaced by virtual experiments and by the use of ICT, as the students are required to develop different investigative skills. Thus, they concluded that the use of ICT in Physics teaching should be an additional element in laboratory activities aiming to support and enhance practical work not to replace it.

The general feeling from the sessions was that Physics teachers believe there are tools which motivate students and enhance their scientific understanding by improving investigative practical work. Physics teachers pointed out that a successful Physics teaching requires the use of laboratory work during which the students are able to link theoretical understanding and a practical activity. Thus, the students and their teachers as well have the opportunity to evaluate and identify possible misconceptions or enhanced conceptual understanding. Thus, Physics teachers concluded that different ICT tools (eg, data loggers and simulations) could augment current practical activities and consequently offer the students additional supporting instruments regarding their understanding. However, the teachers were aware that the use of technology is not always beneficial for students and that on its own cannot solve existing problems regarding science teaching in Cyprus.

Theme 2: Interaction between teachers' beliefs about the use of ICT and constraints

Teachers expressed the belief that the organised plan has not helped them as much as it was expected. This illuminates elements of uncertainty regarding the current use of ICT, which is linked to the current educational policy and teacher training. Regarding the question:

> Can you describe the current conditions regarding the use of ICT in Physics Education?

A teacher responded:

> Using ICT? In my school is not possible as there are no technically prepared rooms for such use and the equipment is not sufficient. That is about the equipment. There is also a problem with myself. I know how to use a computer but I do not feel competent enough to employ ICT in my lessons. What about if I face a technical problem? Who is going to help me? The support team from Ministry visits schools once a year or two. What about everyday support? The Ministry states that there are training sessions but the majority of these are for basic skills development and for demonstration of the use of a specific software. There is no discussion about what we [teachers] think about ICT. Also, I feel that the current syllabus and books are not designed for use of ICT considering that both were prepared before the

> introduction of ICT. Unfortunately, the Ministry presents to public that there is a plan and teachers are already equipped to use ICT in lessons.

The majority of the teachers expressed similar beliefs indicating different aspects of the current conditions. According to teachers, governmental efforts for introduction of ICT seem not enough whereas the Ministry supports that teachers are trained and that there is available equipment. For this reason teachers feel that there is no concrete organised plan for ICT integration despite the governmental and ministerial proclamations. Thus, it seems that teachers' relationship with Ministry is not smooth and this causes communication problems and consequently the understanding of real teachers' needs is problematic.

Another teacher responded:

> The use of ICT is something good but being trained just how to use a tool is not the right way to do it. For example, a tool might not be good for my students as they are regarded as low-achievers. I need something very basic to engage them in the lesson for a start and then to move on using more complexed systems. I have no time and knowledge to set up something on my own. I am disappointed as I feel that nobody is listening what I think it is better for me and my class. The support group is a governmental body, works under instructions and it is the same with us [teachers]. If I do something much different than the expected this might result in getting a lower grade from my inspector.

It is clear that teachers' beliefs are not taken into account, despite that they are the ones who are going to employ ICT tools in lessons. As there is a variety of students in the schools teachers feel that there is a need for Ministry to explore the opportunity of allowing teachers to choose on their own ICT tools. In such case, a teacher will have the chance to decide whether to use an ICT tool and how to use it. Thus, the teacher is expected to be enthusiastic to support his own decision and perhaps more effective.

Physics teachers appeared to be more comfortable than expected, perhaps because the study was not carried out by a governmental research body or any other ministerial committee. At this stage there were teachers who have described different situations, which occurred to them in order to illuminate existing barriers of the use of ICT. Descriptors such as 'heavy curriculum', 'exams', 'tests', 'limited teaching periods compared to the appointed curriculum', 'problematic equipment', 'no actual support and training' were used by the teachers throughout the interview sessions.

In the question:

> What is your view about the Ministerial efforts for the introduction of ICT tools in Physics? How would you rate them? Why?

A teacher responded:

> There are efforts but I feel that there are other problems in the system, which need to be explored so as to change. The curriculum and the books need to be revised and in some cases completely changed. The available time for Physics in some levels is just not enough as the curriculum is really heavy. Imagine how stressed I feel while struggling to cover the curriculum and prepare my students for examinations. If they fail I will feel really bad and some parents will accuse me of not being a good teacher and perhaps this will influence my inspector's view about me.

Another teacher's response:

> Teaching Physics, the most difficult subject for students to understand, requires much more time than the available. Some teachers prepare their students to achieve high scores in the examinations and in order to do that they give them hundred of exercises and tests. In this way, students do not understand what they do as they do not understand scientific concepts. I believe this is caused due to the limited available time and the stress coming from the tests. This situation influence the use of ICT tools as it takes more time to employ a teaching plan using ICT. There are of course topics which are excluded from the examinations and you can spend some time experimenting with laboratory equipment and ICT. But, in this case there might problems with the equipment and the ICT tools as they might not be enough and sometimes not even working properly.

Teachers were really critical about the constraints as they feel that their achievements as professionals are obstructed not only regarding the practice of ICT in their teaching but also generally in the school context. The above mentioned keywords were assumed as limiting factors that Physics teachers regard as teaching and learning constraints. Even teachers, who stated that they often use ICT tools, have indicated that they orchestrate available ICT equipment or even bring from home on their own in order to take advantage of technology by ignoring curriculum instructions and other ministerial procedures. In such cases, Physics teachers do take advantage of technology but by following their own approach, which fits better to them and their audience. This situation might cause problems with school headmasters and educational inspectors as the teachers might be accused of ignoring ministerial instructions and policies.

Conclusion

Considering Physics teachers' responses during the interview sessions and their expressed thoughts it is apparent that although there is an on-going plan for introduction and promotion of ICT, teachers feel that nothing has been achieved. The existing plan seems disorganised with no definite goals as it seems that there is no prior preparation grounded especially on teachers' beliefs. Even though there is literature (Mumtaz, 2000; Charalambous and Karagiorgi, 2002; Levin and Wadmany, 2006) indicating teachers' beliefs as one of the critical catalysts for a successful implementation of ICT tools there is no evidence that they have been taken into account in Cyprus. Changes in education such as the introduction of ICT require the support of teachers as they are the individuals who will use or orchestrate computers and technology in schools. An in-depth understanding of teachers' beliefs will provide specialists the information about how to design ICT tools implementation and how to support teachers during these efforts. A failure to do so increase the chances of an ineffective implementation as the majority of teachers might resist using computers and technology in reality, as they will be unlikely to be supported as they would expect.

Physics teachers feel that the use of ICT might be an additional tool, which could support practical activities and theoretical content teaching. Different ICT tools can increase students' participation and transform them to active learners working towards the construction of their own understanding. These beliefs are consistent to literature (Velle, 2003; Loveless, 2003; Rogers and Finlayson, 2004), which indicates the use of ICT as an agent that facilitates teaching and learning practice, improves communication between students and teachers. Also, the evidence from these studies shows that the use of ICT can give the students additional opportunities for the investigation of the relationships between concepts and ideas. This evidence is consistent with Ainley, Banks, and Fleming (2002) study where the educational use of computers is categorised as follow: 'computers as information tools',

'computers as authoring tools' and 'computers as knowledge construction tools'. Although these categories illuminate the use of computer in education in general, in the case of Physics teachers in Cyprus these categories illuminate teachers' beliefs about the use of ICT in Physics teaching. Also, Baylor and Ritchie (2002) as cited in Tondeur *et al* work (2008) indicated types of computer educational use, where computer is considered as a collaboration tool or a tool for high order skills. This type of computer use might fit better with constructivist teaching approach as the students are individual learners collaborating with others and working to acquire knowledge on their own. This process is likely to help to student to develop analytical thinking skills and obtain high order skills. Constructivist teaching approach is supported and promoted by Ministry of Education and Culture, which expects that teachers will employ it in order students to achieve thinking skills and acquire knowledge avoiding memorising and surface learning. As far as the participants' responses, it is apparent that they view constructivist approach a well-match with the use of ICT in classroom practice. Even though, each category of computer and technology use might fit in a particular approach of Physics teaching depending on the topic. Additionally, there are constraints which might force teachers to change or to differentiate their teaching practice either is a constructivist approach or a traditional-knowledge delivery approach. As the teachers are aware of the possible support that ICT can offer, they feel that current ministerial efforts have failed, as they indicate that there is no actual practice of teaching and learning with ICT. The study has indicated that although Physics teachers consider ICT as an enriching teaching and learning tool, a range of limiting factors limit them either to impede the use of ICT or even to avoid it at all. However, there is always the possibility that these constraints are used as an excuse from incompetent teachers to cover themselves. In this study there were participants considered as equipped with the required skills and knowledge to use different ICT tools but due to different constraints were unable to take advantage of technology during teaching. Thus, the study indicates two elements; incompetent teachers and teaching constraints, which both require governmental specialists' attention and therefore an in-depth investigation so as to identify the actual factors resulting to teachers not using ICT.

The teachers feel that practical activities are the essence of Physics teaching and that laboratory – practical work- helps student to enhance their understanding and also to develop 'hands-on' skills. In a school context this is not feasible as the available time is limited and consequently students are likely not to work further on their own, to investigate and at the end analyse results; therefore to reflect on what they have achieved. The use of ICT might overcome the limited time as there are several technological tools (eg, data loggers) with which teachers and students can work more effectively. From this viewpoint, the use of ICT can enable students to investigate and analyse in more depth, as they will not be stressed with the data collection. Thus, the students might have more chances to think rather to collect data and in this perspective the teacher will be able to support and encourage his students to predict, check and analyse their predictions. These features are few of the advantages of the use of ICT during practical work and it seems that Physics teachers should take advantage of such tools, which aim to develop students' understanding. However, the use of ICT must not cover 'hands-on' activities as students are required to develop practical skills as well; therefore teachers are the ones who need to prepare teaching plans carefully so as to offer their students the best.

Practical work in Physics in Cyprus seems problematic. Apart from the limited time, Physics teachers have expressed the belief that there is a problematic structure of current practical activities, limited laboratory space, inadequate equipment and the heavy curriculum, which limit practical work. These constraints act as a barrier and Physics teachers are unable to work as effectively as they should. Thus, students have fewer opportunities either to see an experiment as a demonstration or to investigate on their own. In this perspective, there are problems that restrict teachers to practice traditional practical work in Physics and consequently the use of a range of technological applications during laboratory and practical activities. For this reason, there might be a need for investigation of Physics teaching in

Cyprus taking into account existing teaching and learning constraints, teachers' beliefs about teaching and learning, use of ICT and the nature of Physics education itself. In such case, the investigation would be expected to re-evaluate current situation in Physics education aiming to improve teaching and learning including the use of ICT in Physics teaching, which seems to be particularly low and problematic.

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Appendix

A sample of the interview questions:

1. Do you think the use of ICT is changing the nature of Physics teaching and learning? If, yes How?

2. How would you use information and communication technologies if ICT equipment and resources were available in an excellent school environment?

3. Are there specific ICT tools which you think are more supportive to Physics teaching and learning? How?

4. Do you think these days' teaching fits with the use of ICT? If yes, how? If no, why not?

5. Can you describe the current conditions regarding the use of ICT in Physics Education?

6. What is your view about the Ministerial efforts for the introduction of ICT tools in Physics? How would you rate them? Why?