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Differentiated Instruction in Information and Communications Technology Teaching and Effective Learning in Primary Education

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Abstract: This article presents the findings of an action research study that evaluated the effectiveness of differentiated instruction in the subject of Information and Communications Technology (ICT) in primary education in Greek primary schools. Effective teaching poses a challenge to all educators in all educational levels. The subject of ICT poses multiple challenges to educators due to its applied nature, the limited allocated time and the diverse needs of the students. A differentiated teaching intervention was designed and applied from January to March 2020 to 113 upper elementary students from two elementary schools in Athens. The findings of the research highlight the improvement of the quality of the students' assessment and the level of students' active participation due to differentiated instruction. Furthermore, the strategy of flexible grouping, the technique of "thumb it up" cards and the applied differentiated working routine proved to be highly effective. Lastly, the implementation of asynchronous working combined with hierarchical learning activities proved to be challenging to the educator due to its complexity. Based on these findings, the article discusses the importance of further research in the systematic implementation of differentiated instruction in mixed ability classrooms and in multiple subjects.

Keywords: *Differentiated Instruction, effective learning, Greece, ICT, primary education.*

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Introduction

Definition of differentiated instruction *and principles*

The term differentiated instruction (DI) was originally applied to a flexible and adjustable teaching methodology which aimed to respond to the different educational students' needs (Valiandes, 2013).Tomlinson (1999)defined differentiated instruction as a teaching method in which the content, the procedure and the learning product can be differentiated so as to respond to students' needs and personal characteristics. Watts-Taffe et al. (2012) state that differentiated instruction is "an approach to instruction that incorporates a variety of strategies" (p. 304), such as flexible grouping, adaptive instruction and detailed progress monitoring that enable teachers to facilitate students' learning (Deunk et al., 2018). Smale-Jacobse et al. (2019) refer to differentiation as "a philosophy of teaching rooted in deep respect for students, acknowledgment of their differences, and the drive to help all students thrive." (p. 1).

As classroom' populations steadily become more diverse in terms of ethnicity, language, culture, customs, socio-economical status, student motivation and educational readiness, differentiated instruction appears to be a practical and effective solution, as is shown by the increase in publications and citations in the field of differentiated instruction. But even among more homogeneous classrooms, students have different learning needs and abilities and shouldn't be restricted to a teaching addressed to the "average student". The implementation of differentiated instruction aims to ensure that each student is given equal opportunities to an effective education and that no one is excluded (Hall et al., 2003).

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Basic Axes of Differentiation

Content

By the word content we refer to the "what" of the instruction, the material and how it is presented to the students (Taylor, 2015).The quality and/or quantity of the educational material (the way in which information is presented) is varied based on their individual differences, while maintaining the same core learning objectives for all students. During the planning of a lesson, a teacher must define the core knowledge and skills that all students must acquire based on the curriculum. Afterwards, the teacher deliberately adjusts the content so that it addresses the same concepts (Hall et al., 2003) but varies the degree of complexity to suit students' diverse learning needs. The content should be challenging but also manageable so as not to discourage students (Pham, 2011). Teachers can differentiate content by selecting multiple ways of presenting information, creating learning braces for students below the classroom's average educational level and addressing students' interests.

Process

Differentiation of process addresses the "how" of the instruction (Taylor, 2015).Different activities (the way the student interacts with the content), techniques and teaching strategies are planned to ensure students' active engagement and their ability to work effectively. Process differentiation can be used as a means to help students exercise higher order thinking skills and should be organized in a logical sequence from simple to complicated (Pham, 2011; Sondergeld & Schultz, 2008). The activities are planned according to students' readiness, learning profile and other characteristics. Very often, differentiation of content and process are combined to maximize the desired academic outcome and to better address students' needs (Tomlinson & Allan, 2000; Valiandes & Neophytou, 2017).

Product

Product differentiation refers to the "evidence" of instruction and refers to products that exhibit major portions of learning (Taylor, 2015; Tomlinson, 1999). In a differentiated classroom, students are allowed to select from a given list or to suggest themselves the mode in which they will demonstrate their understanding of the material (Sondergeld & Schultz, 2008). Product differentiation increases students' engagement as it ensures that students can work on projects that they find interesting and allows them to display their new knowledge in a variety of ways (Hall et al., 2003; Tomlinson, 2005). Teachers assess student' projects to monitor their progress and provide students with feedback (Pham, 2011; Tomlinson & Imbeau, 2010). In monitoring student progress, teachers take into consideration the starting point of each student (educational readiness) and adapt the evaluation to match the students' abilities (Roy et al., 2013).

Evaluation

Differentiated evaluation is a continuous, consistent process based on accurate data collected in multiple ways, through which the teacher ensures that all students are engaged in the learning process, assess his/her students' learning needs and by which s/he is able to dynamically adjust his/her future lesson design to students' needs (Deunk et al., 2018; Kaldi & Konsolas, 2016; Parsons et al., 2013; Smale-Jacobse et al., 2019). Contrary to traditional teaching methods, it does not stop at the end of the lesson but is an on-going procedure that provides a wealth of information regarding students' progress, misconceptions, weaknesses and allows teachers to dynamically differentiate their teaching.

There are three types of evaluation: (a) Initial or pre-assessment, which serves as a guide for lesson planning. Prerequisite knowledge does not always exist, students haven't always acquired the basic knowledge from previous lessons. Therefore, before being able to construct new knowledge, they must "fill the gaps" and retrieve the prerequisite knowledge that is essential in the new lessons. Initial assessment informs teachers about students' entry points into a specific lesson in terms of their readiness, interests and learning style and highlights any misconceptions or gaps in their knowledge, allowing them to address these issues effectively (Cimer, 2007; Moon, 2005; Tomlinson & Imbeau, 2010). (b) Formative, which provides feedback throughout the lessons concerning student progress and participation, allows teachers to identify and correct students' misunderstandings and take remedial action (Cimer, 2007). Formative assessment strengthens the teacher's reflective role and enables him/her to dynamically adjust his/her teaching so that every student can master the basic knowledge and skills (as specified in the lesson's objectives). The evaluation is not limited to cognitive knowledge but encompasses emotions, attitudes and difficulties that students face (Tomlinson & Moon, 2013). (c) Final, by which students demonstrate their understanding and mastery of the content and teachers assess the level of knowledge and skills that they have acquired (Roy et al., 2013). It is important to note that in differentiated instruction teachers assess each student's personal progress taking into consideration his/her readiness levels and avoiding comparisons between peers. Different forms of assignments can be used in final assessment such as: a) projects, b) portfolios, c) essays, d) art exhibitions, e) debates etc. (Tomlinson & Moon, 2013).

Designing a differentiated lesson

Differentiation is a flexible and adjustable teaching method with the basic aim to better address students' needs and abilities (Clark & Callow, 1998). As any other method, it requires detailed planning and organization, given the variety of techniques and strategies it offers.

Before starting to design a lesson, a teacher must know what s/he is to teach, to whom and how to assess the outcome. Tomlinson (2003) defines three stages in differentiating a lesson: a) Teachers recognize key knowledge, concepts and skills in a lesson, b) assess students' needs and c) differentiate teaching to help students connect old knowledge with new. Koutselini (2006) describes in detail four stages in the design of a differentiated lesson giving emphasis on defining students' prerequisite, core and transformational knowledge and skills. Valiandes and Neophytou (2017) provide an adapted and more detailed figure of Koutselini's model (See Figure 1). The model enables teachers to focus on clear and precise goals and construct an effective differentiated lesson, especially in countries like Greece where the curriculum has a strong content focus and specifies the what and how of instruction (Breakspear, 2012). It is important to remember that "it is less the content of curricula that is important than the strategies teachers use to implement the curriculum so students can progress upward through the curricula content" (Hattie, 2009, p. 159).

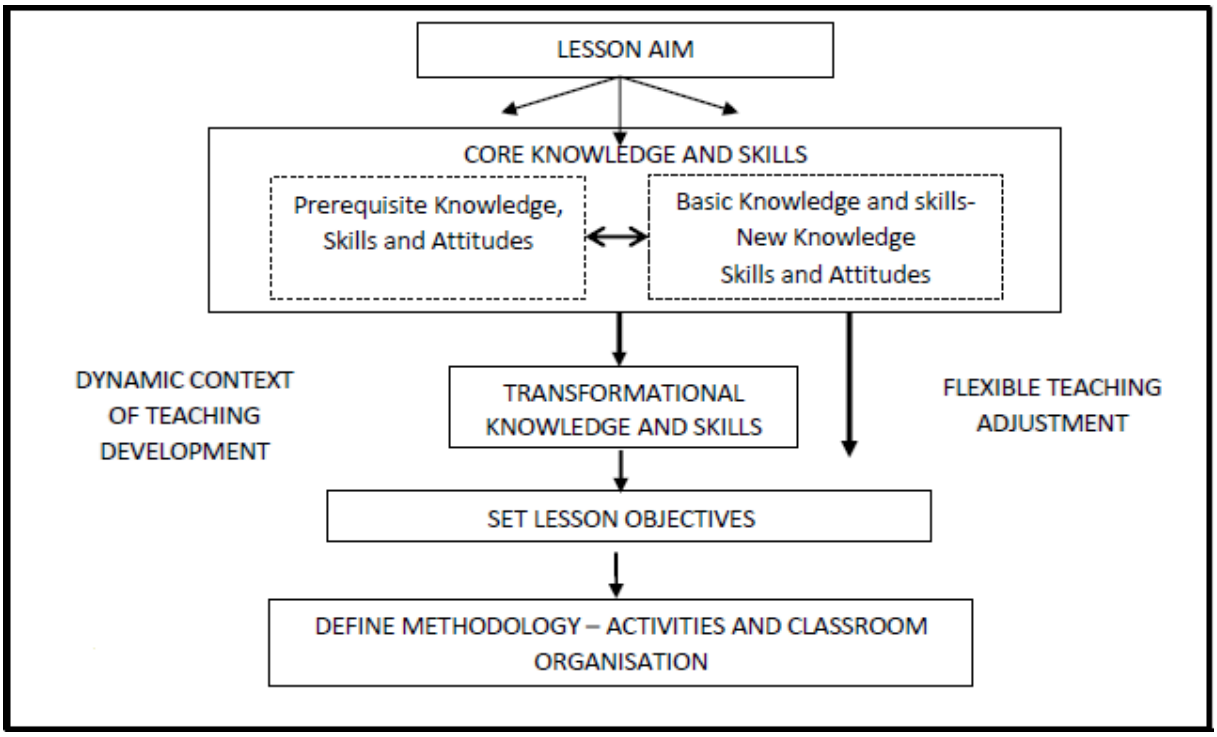

Figure 1: Preparation for the planning of differentiated instruction (Valiandes & Neophytou, 2017)

a) Specifying the lesson aim. Although each lesson has a basic aim that is defined in the curriculum, the teacher must adjust the lesson aim based on his/her pre-assessment of the classroom and the readiness levels of his/her students to respond to students' needs and abilities. Differentiation tends to be more effective when teachers are clear about their students' status concerning specific knowledge and skills prior to designing the lesson activities (Tomlinson & Moon, 2013).
b) Defining the core knowledge and skills. Core knowledge encompasses both prerequisite and basic knowledge. The term prerequisite knowledge refers to old knowledge, skills and attitudes that students have been taught in the past and are necessary to be able to acquire the new knowledge. As basic knowledge we define the new knowledge that all students should acquire by the end of the lesson. Teachers must be clear about students' current status and plan for "teaching backwards" to include students who lack old knowledge while moving the whole class ahead (Tomlinson & Moon, 2013).
c) Defining the transformational knowledge and skills. Transformational knowledge and skills address the gifted or/and more advanced students. Knowledge transformation requires higher order cognitive functions such as evaluation, analysis, synthesis, implementation of the new knowledge in a different frame and the ability to solve more complex problems (Valiandes & Neophytou, 2017).
d) Defining the methodology and the activities. After specifying the core and transformational knowledge and skills based on the curriculum and students' readiness, teachers must design the course of the instruction. Differentiated instruction offers a variety of techniques (entrance and exit slips, learning braces etc.) and strategies (hierarchical lesson activities, anchor activities, flexible grouping etc.) that can be employed by

teachers to create an effective learning environment which offers opportunities to every student to work and learn at his/her own pace and abilities. While all students work with the same "essential understandings" (Tomlinson & Moon, 2013), there are varied levels of complexity and support. It is important to emphasize that the lesson design should not be rigidly implemented but dynamically adjusted based on formative assessment and students' reactions (Valiandes, 2015).

The subject of Information and Communications Technology (ICT) in Greek primary schools

ICT is often synonymous with innovation and personal computers are considered a panacea to education. ICT is taught as a separate subject in Greek primary schools in appropriately equipped computer labs. Its aim according to the curriculum is to cultivate analytical and computational thinking (Ministry of Education and Religious Affairs, 2019). Moreover, students are to learn to find and evaluate information, to communicate, to express themselves and to take initiatives through the use of ICT tools.

Effective teaching can be a challenge due to many factors: a) the practical hands-on nature of the subject, b) the different students' readiness levels, c) the limited time and d) the students work in groups of 2-3 as there is no provision for one pc (personal computer)/per student.

An ICT teacher has to manage multiple students' groups, address technical issues, prioritize and respond to demands for assistance, ensure that all students actively participate and assess their personal progress. The report Eurydice (2012) states that the impact of ICT on students' learning experience and academic outcomes depends on the didactic method that is applied by the teacher. Teachers through their actions can maximize students' talents and effectively manage time and available resources. It is clear therefore that in order to teach effectively the selection of the appropriate teaching method is crucial.

Methodology

Research Goal

The main goal of the present study is to examine the improvement of effective teaching through the implementation of differentiated instruction in the ICT subject in primary education. More specifically, the study aimed to evaluate the improvement of the quality of student assessment and of the level of student engagement and active participation. Moreover, it aimed to identify effective tools and strategies of differentiated instruction and to specify difficulties that arose during the implementation of the differentiated lessons.

Sample

The study presented in this article was conducted during the school year 2019-2020. The participants were 113 upper elementary students, aged 11-12, from two elementary schools in Athens. A differentiated teaching intervention consisting of 5 sessions was designed and implemented in 6 classrooms.

Study Procedure

ICT is a transformative tool that can support student learning and prepare students for the future. The challenges that the teacher/researcher faced were: the diversity of student population in terms of readiness and motivation, the effective monitoring of student progress and the use of activities that were useful for everyone. DI is a teaching methodology that encompasses all mentioned aspects and provides a variety of strategies and techniques that enable teachers to meaningfully improve their teaching.

Action research was selected as the most appropriate method from qualitative research methods. Given the fact that the participants in the study were students aged 11-12, the researchers could not expect them to provide answers in theoretical questions, e.g., "what are the safe practices you use to protect your personal data when using electronic devices?" or "how do you protect your online accounts?". Thus, since researchers had to deal with children, they were obliged to design a plan of action, where the problem examined by the students (i.e., what are the safe practices for the protection of personal data and online accounts and how do we safely use our electronic devices?) was transformed into a series of actions (suitably adapted to children's interests and understanding) that were observed by the researchers who, then, reflected on their findings.

Cohen and Manion (1994) define it as "a small-scale intervention in the functioning of the real world and a close examination of the effects of such an intervention" (p. 186). In action research, practitioners pose an educational question or problem and through scientific study, try to evaluate and improve their practice (Corey, 1953).The scope of the questions can be very broad and include questions about teaching methods, learning strategies, evaluative procedures, continuing professional development and other fields. Action research is also reflective, action and reflection are combined with the intention of improving practice (Ebbutt, 1985).

Lewin (1946, 1948) outlined a four-stage action research model. Its key elements are planning, acting, observing and reflecting (See Figure 2).

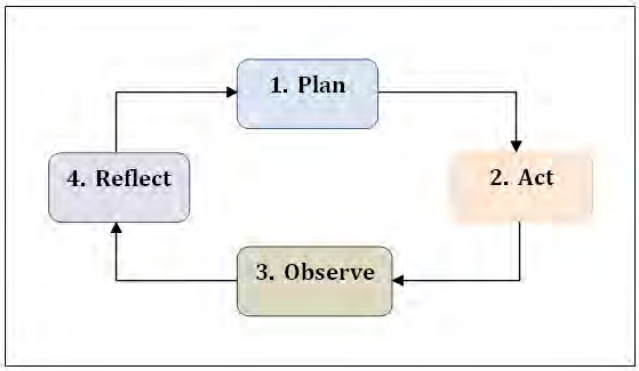

Figure 2: Basic Four-Stage Action Research Model (Lewin, 1948)

In our research this model was applied. After our research goals were set, a differentiated teaching intervention was designed. The design and planning of the differentiated instruction was based on the procedure as described by Koutselini (2006) and followed the working routine (See Figure 3) proposed by Valiandes (2013).

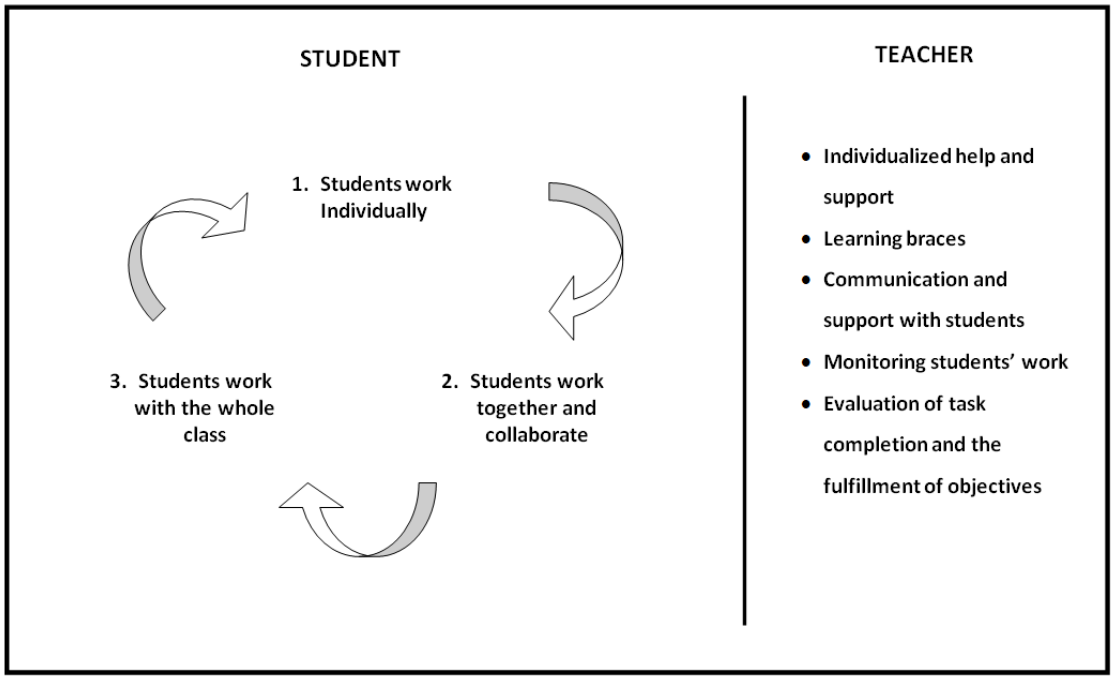

Figure 3: Working routine in classroom (Valiandes, 2013)

The working routine proposed by Valiandes (2013) consists of three separate phases: a) The individual phase during which students work alone. This phase allows students to regulate their learning and make connections between old and new knowledge. b) The collaborative phase during which they work in flexible groups and have the opportunity to exchange ideas, to communicate their thoughts and understandings. c) The presentation of their collaborative work in front of the whole class, which provides useful feedback and enables them to reflect on their work.

The differentiated intervention was implemented by the teacher/ researcher and in-class observations were conducted by four teachers. The researchers informed the teachers in brief sessions about the theoretical background of differentiation and the aims of the study. They also discussed the factors of the observation protocol that was used, designed by Cyprus' Pedagogical Institute. Researchers also had a meeting with students prior to the completion of the questionnaire given to them.

Data were collected from the teacher/researcher, the observers and the students. Reflection was based on the interpretation of the data and the results were published.

Differentiated intervention

The topic subject of the intervention was safe practices for the protection of personal data and online accounts and safe use of our electronic devices.

The teacher, based on the lesson aim and objectives, defined the core knowledge and skills that all students must acquire as well as the transformational knowledge, which aimed at the more advanced students.

Prerequisite knowledge: Students should have:

- basic computer skills
- collaboration and communication skills
- knowledge of the software Cartoon Story Maker

Basic Knowledge and Skills: Students should be able to:

- understand that personal data protection requires certain practices
- create secure passwords
- follow safe practices for the protection of their electronic accounts
- detect the symptoms of malware on their electronic device
- install and use antivirus programs

Transformational Knowledge and Skills: Students should be able to:

- understand the importance of backup files
- take backup files from their computer

The teacher prior to thoroughly designing the lesson plan assessed her students' readiness level through initial assessment. The students' working routine for DI was that students worked individually, then in groups and then presented their work in front of the class. The working routine was implemented twice, using different techniques and strategies of DI each time.

The first phase's lesson subject was secure passwords and protection of online accounts. The students worked individually on tasks and could use learning braces and/or "thumb it up" cards as an aid. "Thumb it up" are a visual tool that enables students to show their level of difficulty with a certain activity by showing the corresponding card (See Figure 4).For the collaborative part, students were grouped according to their readiness level and worked on the acquisition of the same knowledge through activities leveled by their complexity and difficulty (horizontal differentiation). In the third phase every group presented their work to the class and was able to interact with their peers and receive feedback on their work.

The second phase's lesson subject was the protection of electronic devices from malware. The same working routine was applied. Students worked individually in activities prioritized from simpler to more complex ones, without having to work on all activities. This hierarchical differentiation allows all students to actively participate to their fullest. The students worked in flexible groups during the second phase of their routine and presented their work to the class.

Overall, during the intervention entrance and exit slips, "thumb it up" cards, learning braces, anchor activities, horizontal and hierarchical differentiation, asynchronous working and flexible grouping were applied.

Figure 4: Thumb it up cards used in the differentiated intervention

The green card indicates no difficulty, the yellow indicates small difficulty that does not yet require any action form the teacher while the red indicates need for assistance. By showing their cards to the teacher, students quickly and efficiently convey their level of difficulty, allowing the teacher to assist accordingly.

Effective teaching

Effective teaching refers to a combination of different teacher factors that are associated with positive learning outcomes. Sanders et al. (1997) and Wenglinsky (2000) have shown that teacher effectiveness is measurable and is strongly associated with students' academic success.

The Dynamic Model of Educational Effectiveness (DMEE) is a comprehensive theoretical framework that refers to eight teacher factors that are related to student outcomes (Creemers & Kyriakides, 2008).The model is not based on a single approach to teaching (e.g. active teaching, constructivism etc.) but combines factors that are derived from different approaches. The factors are: a) orientation, b) structuring, c) questioning, d) teaching-modeling, e) application, f) the classroom as a learning environment, g) time management and h) assessment. Each factor is measured by five dimensions: frequency, focus, stage, quality and differentiation (Creemers & Kyriakides, 2008).

The observation protocol was designed by the Cyprus Pedagogical Institute (CPI, 2011) and is based on the DMEE (Creemers & Kyriakides, 2008). CPI (2011) states that the application of the basic principles of differentiated teaching in combination with the teacher factors of the DMEE is necessary for the maximization of student involvement and academic outcomes in mixed ability classrooms.

As our research goals focus on the quality of student assessment and active participation and involvement special attention was given to the proper structuring of the lessons, the application, the classroom's environment and the assessment. All sessions were observed by the corresponding teacher (See Table 1) and an observation protocol sheet was filled after each session.

Table 1: Observers per classroom

Classrooms	**Observers**
70th Primary School/ 1st class	Teacher B (Vice principal in the school)
70th Primary School/ 2nd class	Teacher A (Principal in the school)
70th Primary School/ 3rd class	Teacher B
70th Primary School/ 4th class	Teacher A
73th Primary School/ 5st class	Teacher C (Principal in the school)
73th Primary School/ 6ndclass	Teacher D (teacher with over 20years experience)

Continuous reflection is a basic axis of both differentiated teaching and action research. Reflective practices provide valuable feedback and enable educators to reevaluate their practices and take action (Koutrouba et al., 2020). Throughout the study the researcher kept a research diary in which she kept notes on the eight factors of the observation protocol as well as scenes from the classroom, students' reactions pertaining to the study and ideas (Altrichter et al., 2005). After each lesson, the teacher and the in-class observer discussed and reflected on the lesson, utilizing the specified criteria.

Data Collection

Various qualitative data sources were collected for triangulation, in order to increase the credibility and validity of the results. Four teachers (two of them Principals in the participating schools) observed the lessons and completed the observation protocol for each session they observed.

The teacher/researcher kept regularly a research diary (in which she made entries after each session) as a tool of reflection on the implemented practices (Koutrouba et al., 2020). The records included summaries of events, observations, reflections, plans of action and notes on the items of the observation protocol. The data collected were used for cross-validation.

Open-ended questionnaires were given to students after the completion of each lesson subject. The questions were integrated in the exit slips and their aim was to provide insight into students' responses to differentiated instruction, the difficulties they might face and the highlights of the teaching process.

Analyzing of Data

As all data were qualitative, multiple sources were used for data triangulation, decreasing the degree of interpretation and inference. Furthermore, different in-class observers participated minimizing the effects of selective attention, selective data entry and counter-transference. To ensure observers' reliability, the teachers that participated had many years of experience, received training on the completion of the observation protocol tool and had personal knowledge of the classroom's population.

Internal validity is concerned with the accuracy of the explanation of a certain event. It seeks to demonstrate that the results of a research can be sustained by the data (Cohen et al., 2008). In our research, internal validity was obtained through the authenticity of the data, the soundness of the research design, the credibility and confirm ability of the data (LeCompte & Preissle, 1993). Data triangulation which was used in this research is also a definite way of demonstrating concurrent validity, particularly in qualitative research (Campbell & Fiske, 1959). Data triangulation refers to the use of various methods of collecting data on the same topic, in an effort to capture and explain more fully certain behavior. By contrasting and comparing different accounts of the same situation and identifying differences in perspective, contradictions and discrepancies can emerge. These discrepancies can help in the interpretation of a situation and the development of practical theory (Altrichter et al., 2005). If the outcomes of the different methods used in a research correspond, the confidence of the researcher about the findings increases.

External validity refers to the degree to which the results can be generalized to the wider population, cases or situations (Cohen et al., 2008). To ensure the external reliability of the research we provide a detailed description of the process, the method, data collection and analysis we used in our research.

The analysis of the data was done by the researcher through descriptive analysis. In this method, categories are created and data are sorted according to shared characteristics. The sorted data are summarized and interpreted. The interpretation of the data provides the answers to the research questions.

Findings / Results

Key findings are presented from each data source that was used in our research. Findings from observers are first, followed by the teacher/researcher's observations and lastly students' opinions are presented.

Findings from observers

Improvement of the quality of student assessment

Assessing individual student work and participation in the ICT lab is challenging as there is a beehive of activity. Students work in groups, interact, exchange opinions and alternate freely in front of the computers to add or modify their work. The entry and exit slips proved effective as they assessed the personal prerequisite knowledge and progress of each student.

Students were surprised by the introduction of exit slips and were very careful in their answers. This is exemplified in the following notes:

> Some students asked whether their answers in the entry slips will affect their grades (Teacher A).

> There was a certain anxiety during the completion of the entry slips, two students asked for help from their teacher (Teacher D).

Entry slips did prove helpful in designing the lesson especially in a class, in which the students' readiness was very low. Teacher B stated:

> Students fidget and delay. They ask a lot of questions and have unknown words (Teacher B).

The teacher made special preparations in introducing the subject knowing that a large portion of the pupils didn't have the prerequisite knowledge. During the completion of the first exit slip, it was obvious that most of the students hadn't learned the mechanism for creating strong passwords.

> It is obvious that many pupils struggle with the activities. Three use learning braces that their teacher offered but the completion of the slips required double the time in comparison with class 3. (Teacher B).

Both entry and exit slips provide useful information that the teacher can incorporate in his teaching, maximizing the effectiveness of instruction. In this particular class the teacher decided to re-teach the mechanism as most of the class hadn't acquired the necessary knowledge.

They were also a useful tool in creating working groups according to ability. Although students were required to change more often than usual there weren't any complaints.

> Grouping according to ability is a big success. Students are very concentrated on their tasks and all members participate (Teacher A).

> Although the groups seemed a little odd to me, they proved to be effective. All students work actively without any problems or difficulties (Teacher C).

Observations were made about the effectiveness of the third phase of the working routine, the presentation of their work by each group in front of the classroom. Teachers A and D stated:

…the presentation, the interaction between the members of each group and the feedback they receive by the other pupils offer a wealth of information about what each student has learned. (Teacher A).

…what a useful tool! Students demonstrate their knowledge and level of understanding (Teacher D).

Students' engagement and active participation

A certain way to ensure that all students are engaged in the learning process is to create content and procedure that is adjusted to their needs and abilities. In the differentiated intervention several techniques and strategies were introduced with the aim of improving student engagement and participation. From the observers' notes, the strategy of grouping according to ability stands out for its effectiveness. While all groups worked on the acquisition of the same new knowledge, the activities they worked on differed in difficulty and complexity. Groups with low readiness levels on the certain subject worked on simpler activities while groups with high readiness levels worked on more complex activities. This horizontal differentiation of activities gives pupils the opportunity to work on projects that are stimulating, interesting and doable.

Students are totally absorbed in their tasks. They communicate in a low voice and are focused on the task at hand. Maybe it's the subject also that they find interesting … (Teacher C).

Asynchronous working is an effective strategy that allows students to work on their own pace and move independently to the next planned activity. It requires careful planning and monitoring from the teacher but creates a lively environment full of learning possibilities.

Students worked in an autonomous way and didn't have to wait for the whole class to finish an activity before moving to the next one. The teacher was challenged by the multitasking required… (Teacher D).

The third phase of the working routine e.g. the presentation in front of the classroom motivated pupils to work together to prepare their presentation and to publicly defend their choices. Also they received feedback from their peers that was both useful and positive.

… watching each group present their work was beautiful because the children embraced the whole procedure. All comments were to the point and it was obvious that pupils enjoyed both the roles of presenter and commentator (Teacher D).

the groups are effective and pupils are enthused to present their work. The vibe is very positive and all students participate (Teacher C).

… presentations in front of the classroom were concluded with the participation of all students, even pupils who normally don't talk in the classroom presented along with the other members of their group(Teacher D).

Anchor activities and transformational activities in the hierarchical differentiation kept the students' participation at a high level and minimized idle time. All students could work on a meaningful activity that either helped them practice what they had been taught or implement the new knowledge to more complex problems.

…students A., K. and L. finished the first activity very quickly. The teacher checked their progress and they proceeded to the next activity. A. finished the second activity and moved to the next one without aid. The rest of the classroom worked at a completely different pace (Teacher B).

the planning of activities requires quite a bit of time, but the classroom is actively engaged in an activity during the whole allocated time (Teacher A).

Effective tools and strategies of differentiated instruction

A new technique that was introduced during the differentiated intervention was the use of "thumb it up" cards. This technique allows the teacher to quickly and efficiently gather information about the students' level of difficulty with a certain task. "Thumb it up" cards were used with great ease by students and helped the teacher to prioritize the demands for help.

a group is waiting patiently after asking for help with the red "thumb it up" card (Teacher B).

when the groups were assigned their tasks, several pupils asked for the "thumb it up" cards in advance. The technique is quite popular among the students (Teacher A).

there is a playful side to the use of "thumb it up" cards and students respond eagerly to the prompts of the teacher when asked. The communication is silent and immediate (Teacher C).

Flexible grouping is a strategy that encourages the creation of temporary groups that are created based on the specific subject that is taught and students' needs. Flexible grouping allows different formations and cultivates collaboration as groups change frequently and students have to work with new peers.

…as the teacher announces the new groups K. complains as he is not teamed with his best friend. Other pupils intervene and tell him that the new groups will last only until the completion of the project. The issue is resolved without any intervention from the teacher (Teacher B).

it's the third time that students change groups and I have not yet seen any complaints or grudges from the students in regard to the new groupings (Teacher D).

groupings appear random to pupils but there is a reasoning that is based on the teacher' s observations (Teacher A).

Difficulties during the differentiated intervention

Learning braces are an effective tool that helps struggling students in the construction of new knowledge or the use of prerequisite knowledge that they have difficulty recalling. By preparing learning braces teachers promote autonomous learning, reduce the load of work for students with low readiness levels and their need for frequent teacher support. Despite their usefulness, the observers noted a certain hesitation in their use.

…students G. and M. obviously struggle with the activity but they haven't asked for a learning brace. When offered one by the teacher, they accept it and put it immediately to use… (Teacher C).

At the beginning of the activity the teacher said that she had learning braces at her desk, available freely for the students. No one asked or got up to get one. When the teacher approached the groups holding some, several pupils asked for them (Teacher B).

Asynchronous working is a basic strategy of differentiated instruction. It allows students to work at their own pace without having to adjust to a rigid timetable set by the teacher, determined by the pace of the "average" student. It requires careful planning by the teacher as the activities must move from the simple to the more complex and to the more challenging. Furthermore, the teacher must be aware of the students' progress and able to assist in this multitasking environment.

Pupils hesitate to proceed to the next activity and wait for confirmation from their teacher (Teacher A).

The teacher is swamped with requests for help. She stops all activities and reminds students of the new working routine (Teacher C).

Students haven't learned to work autonomously. They ask for help or confirmation from their teacher before moving to the next activity (Teacher D).

Diary entries

Improvement of the quality of students' assessment

Entrance slips proved to be highly effective in the structuring and time management of the lessons in each classroom as they showed large deviations in the readiness levels. There were classrooms in which most students lacked prerequisite knowledge while other classrooms had high readiness levels. Especially one classroom had high readiness levels in the first lesson subject that addressed the protection of online accounts but low readiness levels in the second lesson subject about the safe use of electronic devices. The teacher noted:

I have to monitor this class closely. Although the vast majority of the pupils have unsupervised access to electronic devices and online accounts, the answers from the entrance slips show gaps and misconceptions in their knowledge (Teacher/ Researcher).

Although differentiated instruction requires careful planning and organization, it also emphasizes that the teaching process is a dynamic process that should be modified and adjusted based on the students' understanding and participation. Exit slips were a very useful tool that provided feedback on the students' personal progress and difficulties and therefore enabled the teacher to make the required adjustments to her lesson design. Exit slips in one classroom showed that the majority of the students hadn't understood the mechanism for creating strong passwords. The teacher noted:

It is obvious that most students haven't acquired the mechanism. I shall re-teach this method and add a small activity to assess their understanding (Teacher/ Researcher).

In other classes, the teacher made targeted interventions to help struggling students based on the exit slips. The interventions were personalized to help students construct the new knowledge.

M. and M. have serious gaps in their knowledge. I will prepare a quiz for home practice (Teacher/ Researcher).

Several students in the classroom have not understood the functions of an antivirus program. During the next lesson I will readdress the subject. L., M. and K. can participate actively as they have completed all the transformative activities and have constructed the new knowledge (Teacher/ Researcher).

Assessment in the ICT subject is demanding and poses challenges to the teacher as all activities are completed in groups. The teacher used to take notes concerning the participation levels and knowledge construction of each student but the implementation of the differentiated working routine proved to be more effective and provided more detailed information about the personal progress of each pupil. The working routine consisted of three phases: individual work, work in groups and presentation in front of the class. The presentation in front of the class, an innovation, was particularly successful and provided information beyond the cognitive area.

K. and M. make very accurate remarks on their peers' work. Critical thinking and keen sense of observation (Teacher/ Researcher).

During the presentation, I had the chance to see I., G., D. and A. under a different perspective. Talkative, sociable, they answered at their peers' comments with arguments (Teacher/ Researcher).

The presentation confirmed that I has not participated in the group work. He can't present his part properly and asks for help from his teammates (Teacher/ Researcher).

Students' engagement and active participation

The working routine that was applied kept student participation and engagement levels high, according to the teacher's observations. Pupils generally like the ICT subject as they have the opportunity to work on personal computers and create digital content. Therefore, there is a high level of participation in the computer lab. The observations refer to the quality and end results of student participation, due to the differentiated routine that was applied.

Individual work was a novelty that allowed students to work on constructing the new knowledge alone and at their own pace. This phase gave a new dynamic to the group work that followed.

Pupils always work in groups that are the norm. But there is an energy and interaction between them that is new. I think this is due to the fact that they have prior knowledge on the subject they are working on, they have opinions and a vision (Teacher/ Researcher).

They are very focused on their work, and interaction levels are high. I think that the presentation that will follow is a big incentive (Teacher/ Researcher).

Presentation in the classroom was very popular among students who actively participated as presenters or commentators. The presentation also allowed them to actively engage with the material, to revise, to interact with their peers and accept criticism.

…groups are preparing for the presentation of their work. Per my instructions, every member of the group has to participate in the presentation, so they decide on who will say what etc.(Teacher/ Researcher).

I am truly surprised by the quality of students' remarks. They actually listen to the presentations and there isn't any negativity or bias in their critique (Teacher/ Researcher).

… several groups have made quite a preparation. They coordinate with signals and are very much enjoying themselves as presenters (Teacher/ Researcher).

Effective tools and strategies of differentiated instruction

"Thumb it up" cards are a visual tool that is easy to apply and contributes greatly to a relaxed yet effective classroom environment. Students can show whether they face difficulties with a certain activity, they have difficulties but don't require help or they are progressing without problems by simply showing the corresponding card. This technique allows the teacher to prioritize the help she provides and minimizes students' anticipation.

It's the first time I showed them the "thumb it up" cards and I let them experiment with them. It's obvious that they like this way of communication (Teacher/ Researcher).

I so much enjoy the new routine! Instead of the raised hands and the usual voices "Miss! Miss!", now I simply see a red card! And no agitation from the pupils! (Teacher/ Researcher).

As mentioned before, flexible grouping is a basic strategy in differentiated instruction that allows different groupings based on certain criteria that the educator has set for the specific lesson. The teacher noted that there were no problems in the implementation of flexible grouping, although the pupils weren't familiarized with this routine. Also, it improved the interaction between the whole classes, as students had to collaborate with different peers frequently.

From the teacher's diary notes, it is apparent that in all six classes that the differentiated intervention was applied, grouping according to ability was the most effective in terms of student participation and engagement. The requests for help were significantly reduced (compared to a typical non-differentiated lesson) and the interactions between the students were calm and on equal terms.

As this class has the lowest readiness levels, I expected that several groups would require help. But they worked diligently and very few asked for help (Teacher/ Researcher).

All groups are engaged in their work. I am glad that the activities are in accordance with their readiness levels. Only three times was I asked to help (Teacher/ Researcher).

The problem of idle time is usually present in every classroom. Students learn and work at different paces and the teacher usually sets a timetable based on the "average" student. High ability students that finish quickly an activity have to wait while low ability students rush and leave certain activities incomplete. Anchor activities as well as transformational activities provide a solution for the management of idle time. The teacher noted that the addition of such activities kept students' engagement levels high, as they didn't have to wait passively for the next phase of the lesson.

…students L., M. and K. have started working on the transformational activities. They are absorbed in the subject (Teacher/ Researcher).

…anchor activities kept fast paced students active, while the rest of the class worked on the basic activities. Basically, everyone is doing something… (Teacher/ Researcher).

Difficulties during the differentiated intervention

The differentiated intervention was applied without serious problems or difficulties. From the diary' entries, three issues were noted: entrance slips, learning braces and asynchronous working.

The teacher noted that entrance slips were considered by students to be a form of assessment and generated anxiety about their performance. It must be noted that the teacher had explained the usefulness of the entrance slips and the lack of any grade scale.

Learning braces were a tool that students were hesitant to ask for. Although the teacher had several struggling students, they didn't ask for a learning brace. The solution that was applied successfully was that the teacher offered learning braces while moving around the classroom. Most students, when offered, accepted the learning braces and put them to use.

Asynchronous working was quite tiresome for the teacher as the students' requests for help were significantly increased. From the diary entries, it is shown that students weren't asking for help but wanted confirmation for their actions. Most of the time they wanted to be certain of their task or verify their answers.

Students' opinions

Students were asked to answer questions added in the exit slips about what they liked in the lesson or what they found difficult. In the last exit slip, after the completion of the differentiated instruction, they were asked to name their favorite novelties (things that weren't done in previous lessons) and whether they preferred the "new" (differentiated) teaching method or the traditional.

All students answered that they preferred the new teaching method and that they would like to continue with the same routines. Flexible grouping and presentation in front of the classroom (the third phase of the applied working routine) were the most popular strategies, as stated in their answers.

During a school year, groups in the ICT lab are altered periodically, but not very often. The number of groups is the number of available computers (if the computer lab has ten personal computers, then the pupils will be divided into ten groups of the same size). During differentiated instruction, students were grouped into formations of different size, composition and duration, some groups worked together for a whole hour while others for 15 minutes. Despite their initial awkwardness, students embraced the new strategy. Their answers focus: a) on the effectiveness of the groupings, that they were very satisfied with the quality of their work and b) the chance they had to interact with their peers, often with pupils they hadn't been grouped with before.

I liked that I worked with students that weren't my mates (I.)

It was hard to work with the boys in my group (I was the only girl). But we managed to make a very good project (S.)

I liked that we got to work with different students, it was like an experiment (M.)

I didn't like that I had to work with people that weren't my friends. But the students in my new group listened to me and our project was really good (K.)

Presentation of group work in front of the classroom was very enjoyable for the students. They had the opportunity to assume a more active role and also receive a lot of attention from their peers. It must be noted that in all classes, the atmosphere was very friendly without demeaning comments from the pupils but rather an open discussion on the pros and cons of each project.

What I liked most was that we presented the projects we made (M.)
I liked that we presented our projects and everyone could say his opinion (M.)
I liked that our projects were different and that we presented them… (K.)
I liked that we presented our work and that we could comment on all projects (P.)

Discussion

This discussion addresses the main results regarding the quality of student assessment, students' active participation and engagement as well as effective techniques and strategies of DI and difficulties in the implementation of differentiated instruction.

Whilst in most educational theories, assessment is viewed as the final procedure in the teaching process, which identifies whether students have acquired the new knowledge, in differentiated instruction its role is more complex. In DI, it has two axes: a) the reflective role, with the aim of constant evaluation, adaptation and flexible adjustment of the teaching process and b) the multi-level and continuous student assessment that takes into account students' educational readiness and especially their starting point as a measure of their progress (Parsons et al., 2013; Pham, 2011; Valiandes & Neophytou, 2017).

The findings of this research are in accordance with the findings of other research in the field of differentiated instruction. Initial assessment proved to be very useful as it allowed the teacher to adjust the content and the structure of the lesson plan according to the preexisting knowledge of each class (Moon, 2005; Tomlinson & Moon, 2013). It also allowed for the understanding of students' skill profiles and their needs in terms of the amount and type of instruction (Watts-Taffe et al., 2012). Furthermore, it allowed the teacher to make connections between the preexisting and the new knowledge (Cimer, 2007) rendering the teaching more effective.

Formative assessment can provide useful feedback and can lead to a more focused and effective teaching (Hattie & Timperley, 2007). This proved to be the case in our research. The teacher collected various forms of information in the form of exit slips, anchor activities, working routine and was able to dynamically adjust the lesson plan (Pham, 2011) so that it was more effective for all students. The adjustments / interventions could be focused on certain pupils, groups or the whole class (Cimer, 2007). Formative assessment also known as "assessment for learning" proved valuable in improving effective teaching and learning outcomes (Wiliam, 2011). Faber et al. (2018) state that DI cannot be strictly preplanned but should allow for responsive teaching practices according to students' progress.

The differentiated working routine (Valiandes & Neophytou, 2017) proved to be a very powerful tool in keeping the students involved and motivating them. As Spitulnik et al. (2005) stated working in groups allows students to correct errors, to receive feedback and to make connections between the old and new knowledge. This was verified in our research, as all data showed that group working was very effective in constructing the new knowledge and in cultivating social skills (Wulf, 2005). Presenting the final product in front of the classroom was a great incentive as all students strived to present original and flawless products. Our findings are in accordance with the findings in the research of Valiandes (2015).Additionally, the use of anchor and transformational activities minimize idle class time and keep the students' participation levels high (Hansen et al., 2016).

Flexible grouping is a "non-negotiable effective strategy" of DI according to Valiandes and Neophytou (2017) but it must be ensured that differentiated instruction is indeed offered to groups (Deunk et al., 2018). Its effectiveness was clearly shown in our research as it ensured that all students worked and learned in an effective environment. In DI, teacher has the flexibility to adjust student groupings according to the students' needs and the particular objectives of each lesson (Tomlinson & Imbeau, 2010). Grouping according to ability combined with horizontal differentiation of activities was highly effective. This combination allowed students to work independently, thus strengthening their sense of autonomy and self-regulation, provided them with the opportunity to work on activities that were meaningful to them and within their abilities which maximized the students' engagement time. Similar findings in numerous researches (Gentry & Owen, 1999; Sondergeld & Schultz, 2008; Taylor et al., 2000; Watts-Taffe et al., 2012) emphasize the importance of grouping according to students' needs and strengths. It is crucial, however, that the teacher maintains high expectations from all students (Gentry & Owen, 1999), regularly reevaluates student progress and dynamically adjusts groupings based on the evaluation to avoid the Pygmalion effect (Prast et al., 2015; Sondergeld & Schultz, 2008).

"Thumb it up" cards are a technique that allows students to show in a visual and playful way their level of understanding or difficulty. Its easy application and acceptance from the students allowed the teacher to dynamically

adjust the activities, to offer personalized help and to cultivate metacognitive skills in students (Valiandes & Neophytou, 2017).

Learning for all is the basic aim of DI. Thus, student support plays an important role in the implementation of DI. Learning braces is a technique that can take many forms (e.g. bookmarks, notebooks, visual aids) and help students retrieve prerequisite knowledge or get additional support. Students use these learning aids when they face difficulties during the course of an assignment. As Pozas and Schneider (2019) state, there is a lack of empirical research in this field. In our research, the teacher and the observers noted a hesitation on behalf of the students in asking for the learning braces. One possible explanation is the lack of familiarity with this technique and a misconception that the use of learning braces is an admission of difficulty.

Asynchronous working is a strategy that allows students to work independently on a series of activities. Each student can proceed to the next activity at his/her own pace, without being confined to an inflexible timetable. Through asynchronous working the teacher can engage all students and allow weaker students to work on constructing basic knowledge and skills, while more advanced students can move to more complex and challenging activities. This strategy is very challenging for the educator as s/he is called to manage a multi-tasking environment and respond effectively to student needs. Valiandes (2015) reported that teachers who implemented asynchronous working stated that they had difficulties in overseeing and supporting students due to the complexity of the strategy. However, it must be noted that the difficulties that were reported may derive from a lack of experience by both the teacher and the students. Filippatou et al. (2016) state that for the successful implementation of asynchronous working both the students must be adequately prepared and the teacher must develop the necessary skills to effectively manage the different processes that simultaneously occur in a differentiated classroom.

The abovementioned results deriving from the present research, also, confirmed that the "Basic Four-Stage Action Research Model" was a suitable instrument for examining views, attitudes, cognitive and affective outcomes and deeper understanding and assimilation of knowledge, when little students are expected to provide information on theoretical issues during the carrying-out of the research. Obviously, the restrictions of the implementation of the specific model focus on the intervention of the researchers themselves, who have to transform theoretical questions into practical actions adapted in the cognitive and affective level of the participants and, then, to observe mindfully and interpret in a coherent way the data collected. Despite its deficits, the model used in the present research proved that children can actually be successful providers of valuable information that can effectively be used for further research in the future.

Conclusion

This study aimed to provide an in depth insight into the effectiveness of differentiated instruction in computer lab subjects, such as the ICT subject in Greek primary schools. Computer lab subjects pose several challenges to educators due to their applied nature and student grouping to stations. Different techniques and strategies of differentiated instruction were implemented and the findings of the research informed us that DI was indeed effective in improving teaching effectiveness.

The implementation of DI provided useful, detailed and continuous student assessment that enabled the teacher to dynamically adjust the lesson to student needs and make focused interventions.

Another striking contribution of DI was the improvement of student engagement with the learning process. The differentiated working routine (Valiandes & Neophytou, 2017) and the flexible grouping strategy that were implemented proved to be highly effective in engaging students and provide meaningful interactions with the learning content and their peers.

The findings also informed us about the difficulties that teachers may face during the implementation of DI. Asynchronous working was very challenging to the teacher due to its complex nature. Also learning braces, a technique that encourages independent student learning, were not easily accepted by students. It must be noted though that most difficulties appeared to arise from lack of familiarity of both students and teacher with the new techniques and strategies.

Differentiated instruction may appear daunting to novice educators due to the multitude of its available techniques, strategies and axes of differentiation. This variety can be seen as an advantage as each teacher can select certain elements and apply them to his/her teaching, critically analyzing the results and adjusting his/her actions.

Recommendations

The findings of the study emphasize the need for further longitudinal studies that will highlight the dimensions of differentiated instruction effectiveness. Although there are numerous researches documenting the effectiveness of differentiated instruction on student learning and engagement (Anderson, 2007; Broderick et al., 2005; Lewis & Batts, 2005; Valiandes, 2015; Wormeli, 2011) only a small number is focused on mixed ability classrooms and not on specific groups of learners (Valiandes, 2013). The growing interest in differentiated instruction highlights the need for further

research in the effectiveness of differentiated instruction in the everyday learning process of mixed ability classrooms and the different operationalizations of DI that are useful to students and teachers (Smale-Jacobse et al., 2019).

DI combines multiple practices, has many techniques and strategies and appears often daunting to teachers. A supportive environment in which groups of teachers collaborate and exchange ideas and experiences, can promote the implementation of DI and further their professional development. Future researchers should be careful to include not only information on the fidelity of the research but also a detailed description on the differentiation practices used to allow the interpretation of their value (Deunk et al., 2018).

Efforts should also be conducted in the development of a repository of differentiated lessons available online to educators, based on the curriculum of each subject. This repository would allow educators to access a rich reservoir of materials and use them with adjustments to the needs of their class. Furthermore, it would alleviate the anxiety of having to prepare a differentiated intervention on their own as well as limit the time for the preparation of a differentiated lesson, which is one of the greatest difficulties that concern teachers (Tomlinson, 1995).

Limitations

Besides the contribution of this research to the field of differentiated instruction, it should be noted that the study suffers certain limitations as it is an action research study and therefore it is difficult to generalize findings for a larger population. Despite the undoubtedly limited sample of the present research, its findings can provide researchers with useful conclusions about differentiated instruction in ICT teaching and effective learning.

Authorship Contribution Statement

Palieraki: Conceptualization, design, analysis, writing. Koutrouba: Conceptualization, editing/reviewing, supervision.

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