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A MOBILE APPLICATION TO IMPROVE MATHEMATICAL COMPETENCE FOR STUDENTS WITH LEARNING DIFFICULTIES

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Abstract:
This study aims at the design and evaluation of an educational Android application that is expected to help Greek gymnasium students with learning difficulties to acquire extra skills in mathematics. Firstly, the attitudes and perceptions of Greek special education teachers about the use of ICTs in class have been searched via a questionnaire. The results show that all teachers are familiar with the use of ICTs and recognize the importance of ICTs in education of pupils with SEN. Additionally, they could very easily accept and use a new mobile educational app in the learning process. We then created an application that was first evaluated by 7 mathematicians and informatics' teachers. Their evaluation showed a positive attitude toward the application. During the 2021-2022 school year, the application was implemented in two secondary Greek schools. 16 students with learning difficulties, tried the app under the supervision of 3 special education teachers. Students, answering a questionnaire with both closed-ended and open-ended questions, appear enthusiastic about the application with no differentiation according to their gender and type of difficulty. Positive points of view towards the application are also observed in the answers of the 3 special education mathematicians who were interviewed.

Keywords: learning difficulties, behaviorism, mobile learning, android apps, integration/inclusion departments

1. Introduction

Today's schools need to provide appropriate education to every student. The educational system also should adopt an educational strategy that cares for the needs of all students. New technologies can offer support that assists the diversity and inclusion of students with special educational needs (Tomé, 2023).

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Christensen & Knezek (2018) state that teachers should have positive attitudes, enthusiasm, and willingness as well as technological skills for integrating ICTs or mobile devices successfully in the classroom. Numerous studies prove the positive attitudes and perceptions of secondary school teachers on the use of mobile devices in school. Subsequently, we tried to ascertain the Greek teachers' attitudes and readiness to accept and integrate ICTs into their teaching practices.

It is inevitable that students with learning difficulties face huge problems in participating in the educational process. We consider that they are treated unfairly by the educational policies.

Assuming that the potential benefits of a mobile application for children with special educational needs will be enormously great, we decided to design an application that aims at improving children's learning skills in Mathematics with the use of Mobile Learning technology.

The research problem that this study deals with is: Can we improve mathematics' learning of students with learning difficulties by designing and using a mobile application?

For the purposes of the study, clarification of the levels of readiness and attitudes of special education teachers in the area of our research is estimated as necessary. After that, we proceeded with the designing and use of the application in the classroom and finally, we moved forward to its evaluation. All the above-mentioned steps highlight the following research questions:

1. Are special education teachers familiar with the use of ICTs and what are their attitudes and perceptions about the existing applications and about a new Android application for mobile devices?
2. Does the app include the appropriate educational content in order to help students in learning?
3. Is the app well-designed, child-friendly, functional, and usable?

'Love2LearnMaths', as we named it, is an app that can support both formal and informal learning by providing students the option to use it at school or out of the classroom, for instance at their home.

2. Literature Review

2.1. Characteristics of Children with Special Educational Needs and Learning Difficulties

Our application intends to help students with SEN in general, irrespective of their diagnosis, by triggering their interest, helping them stay more focused, presenting knowledge in a more simplified way, and helping them gain confidence.

Students who tried 'Love2LearnMaths' were diagnosed with Dyslexia, Dysgraphia, Dyscalculia, ADHD, Generalized Learning Difficulties in language and in mathematics, and Complex Cognitive and emotional Difficulties.

Dyslexia is one of the most common disabilities. Huang et al. (2020) state that "*Children with dyslexia have poor academic performance, and they suffer from low self-esteem, anxiety, and emotional instability due to long-term experience of learning frustration, which further affects their learning motivation and emotional state*".

Another disorder that is frequently presented with dyslexia is mathematics disorder or dyscalculia. Dyscalculia is classified as a specific learning disorder in DSM5 (American Psychiatric Association, 2013). Many aspects of mathematics depend on verbal skills, e.g., number knowledge, counting, and problem-solving. That's the reason why Dyscalculia often co-exists with Dyslexia (Snowling et al., 2020).

Persons with dyscalculia perform poorly in all areas of mathematics, particularly in the processing of numbers and quantities and in basic arithmetic operations. Other symptoms and disorders that may co-exist with dyscalculia, are dyslexia, attention deficit/hyperactivity disorder (ADHD) and disorders such as anxiety, depression etc., or disorders in behavior such as aggression (Haberstroh et al., 2019).

Dysgraphia may occur by itself but is also presented with dyslexia and other disorders. Many children with Dysgraphia have reading problems, as well. Moreover, difficulty in writing can be seen with other conditions such as ADHD and autism spectrum disorder (Chung et al., 2020).

Harpin et al. (2016) claim that ADHD is one of the most common mental disorders among students. ADHD can lead to poor self-esteem and poor social function in children. Moreover, Austerman (2015) states that many students with ADHD have other additional problems such as depression, or behavior disorders.

2.2. Behavioral Learning Theory and Applications for Students with Learning Difficulties

Learning means acquiring knowledge through instruction. The process of learning is based on various theories describing it, such as behaviorism, cognitivism, etc. (Korompili & Togia, 2015).

As stated by Mannheimer et al. (2016), for the design of an educational application it is very important to include characteristics that integrate learning theories with practice. Our educational software includes features relevant to the theoretical base of the theory of behaviorism.

The didactic design model introduced by Gagné is very important in the context of behaviorism. In this model, the teaching methods are predetermined and students are evaluated by answering to tests, identifying their progress (Komis, 2004; Styliaras & Dimou, 2015). This idea has been implemented in our application.

Table 1 presents the characteristics of the behavioral theory, its main representatives, and the learning technology according to behaviorism's principles.

Table 1: The basic Elements of the Behavioral Learning Theory

Characteristics of Behavioral Theory	**Main Representatives**	**Learning Technology**
• Predetermined teaching and activities, practice and feedback • Giving stimuli - Waiting for student's response (change in behavior) • Student tends to become a passive learner	• Pavlov: classical conditioning • Skinner: reinforcement and punishment • Gagné: neo-behaviorist with constructivist ideas-programmed instruction	• Information is presented linearly • Drill and practice activities • Multiple-choice questions quizzes, jigsaws • Tutorials • Feedback

Behavioral Theories are the first Learning Theories, which were used to theoretically support the implementation of technology in education (Solomonidou, 2006; Komis, 2004). The software that incorporates this theory, tutorials and drill & practice are considered sufficient: to provide supervisory teaching, for the evaluation and personal work of the students and in special education.

Our application follows the behavioral learning theory's principles, which are appropriate to be implemented in the sensitive area of special education.

2.3. Use of M-learning technologies for students with learning difficulties

Nowadays, rapid changes in learning have led to a new era of modern education, where e-Learning (Electronic Learning), d-Learning (Distance Learning), m-Learning (Mobile Learning) are increasingly adopted by educational institutions, teachers and students.

According to Behera (2013), d-learning is an extension of e-learning, while m-learning is included in both the e-learning and d-learning areas as a subset. The below image describes the above statements.

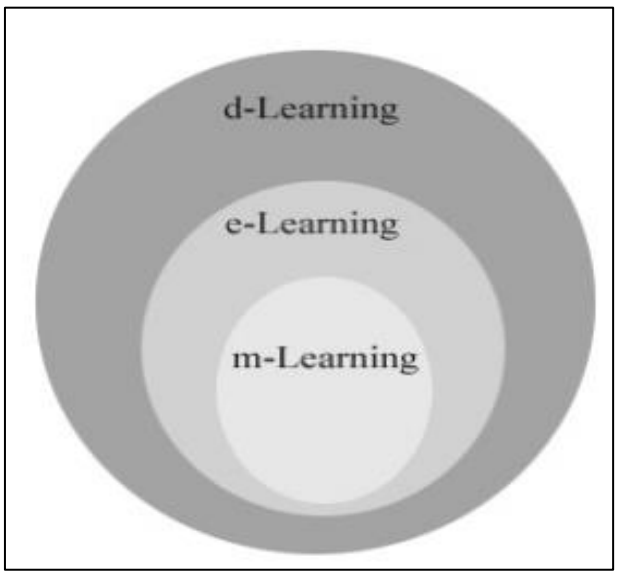

Figure 1: Relationship between d-learning, e-learning, and m-learning

Klimova (2019) states that m-learning includes benefits such as accessing learning content anytime and anywhere, adjusting content to students' needs and providing feedback.

Romero-Rodriguez et al. (2020) state that m-learning employs the use of mobile devices to carry out the teaching-learning process. Smart mobile devices can be used by supporting certain aspects of children's teaching and learning process such as Literacy and Mathematics (Kyriakides et al., 2016; Neumann & Neumann, 2015).

Table 2 below presents some research's findings that indicate the positive effect of learning using mobile devices in Special Education.

Table 2: Research Indicating the Positive Effect of Mobile Learning in Special Education

Researchers	**Learning Difficulty**	**Tool**	**Results**
Fernández-López et al. (2013)	- Autism - Down syndrome - ADHD with mental retardation - Pervasive developmental disorder	Tablets	- Improvement of students' learning abilities on mathematics, language, sensitivity, autonomy and sociability - Development of students' behavior
Campigotto et al. (2013)	Dysgraphia-Dysorthographia	- Tablets - Mobiles	- Feel important - Gain confidence - Communicate and cooperate with each other - Increase of motivation and interest in learning
Berninger et al. (2015)	- Dysgraphia - Dyslexia - Difficulty in oral and written speech	Computer	Students made great progress after completing 18 hour lessons
Rivera et al. (2016)	Mental disabilities	Mobile devices	Impressive progress in language skills
Zhang et al. (2016)	Mathematical learning difficulties	Web-based program	Significantly higher scores on their final mathematical examination
Kamaruzaman, et al. (2017) Novack et al. (2018)	Autism	- PDAs - Tablets - Smartphones - Mobile application	- Support for learning basic numbers, attraction in practicing and doing exercises, attainment of learning interests, and achievement of self-independence - Demonstration of high rates of learning
Pitchford et al. (2018)	Children with Special Educational Needs and Disabilities SEND	Interactive apps on touch-screen tablets	Promotion of Learning of Basic Mathematics in Children with Special Educational Needs and Disabilities

The above research proves the immense positive outcomes of the use of mobile devices in Language's and Mathematics' teaching and learning processes. Thus, we proceeded in

design of the application 'Love2LearnMaths' considering that Students can benefit from its use in Math.

2.3.1. Design of the Application 'Love2LearnMaths'

The application 'Love2LearnMaths' can be installed and operated on Android smartphones or tablets. Android is a complete, open and free platform for mobile phones that includes an operating system (OS), the necessary middleware, libraries and core applications and can easily be extended to any compatible device and modified to keep up with and adopt the latest technologies and developments.

The application was developed using Android Studio software with Java programming language and was configured for Internet access so as to be synchronized with the database and new data to be registered and become available to all users.

For app's development, we used Android Studio, DB browser (SQlite) and Firebase (real-time database and authentication). Its implementation required the use of a series of separate tools, techniques and technologies, while the Firebase platform was used for the authentication of the application and for the data's storage.

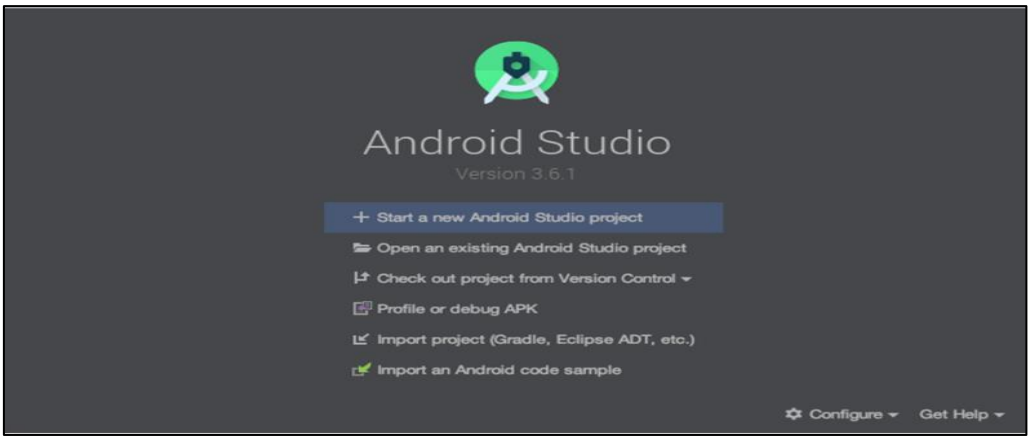

Figure 2: Android Studio's Home Page

For the purposes of the application, 18 databases were created through the DB Browser SQLite program. The Firebase platform (https://firebase.google.com/) has been used for the authentication and real-time database functions.

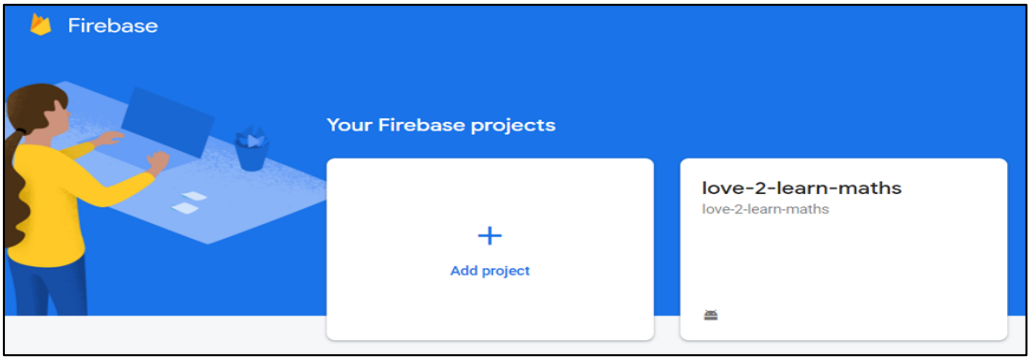

Figure 3: The Appearance of 'Love2LearnMaths' app in the Firebase Platform

In order for a student to log in to the application, it is required to enter the email and password they used in their registration and to do the authentication with email and password, which means checking that the information they provided is correct. After the above, every time a user logs in to the application, the authentication will be done with their e-mail and personal password. In this way, every students' progress can be saved so they can return any time and see the areas where they are behind. Thus, they can exercise more in those areas to achieve better scores. Teachers also can evaluate students' progress from a distance, at any time. Once someone enters in the application the first screen that appears has only the option **Mathematics A' Gymnasium's**. On the next screen, students can choose a lesson, either **Algebra** or **Geometry.** They can also choose either theory or exercises.

If the student chooses the theory, the corresponding text is displayed for the user to study. If the student selects the exercises, multiple-choice questions will appear. In each chapter, there is a different number of questions that appear each time in random order. As soon as the student answers one question, the next one automatically appears. Based on the number of correct answers, a Score is calculated which is displayed to students. Every time the highest score is displayed and students are motivated to beat it. Based on the score, a message is displayed. In case of incorrect answers, mild remarks are used to avoid students' disappointment and encourage them to continue further practicing.

3. Methodology

3.1. Research Objectives

This study's focus is to evaluate the functionality of a new educational Android Application that could help pupils with learning difficulties who study in the Integration departments or receive Parallel Support from two Greek schools in the field of mathematics.

In the study's framework, the attitudes and perceptions about the existing applications and about a new Android application for mobile devices should be clarified along with their competence and familiarity referring to the use of ICTs. Additionally, another objective involving the app's evaluation is to make sure that the app includes the appropriate educational content in order to help students in learning, and that it is well designed and characterized by functionality and usability.

3.2. Type of Method and Design of the Research

Our study is an evaluative one and includes 3 stages.

In the first stage, we identify via structured questionnaires the attitudes of special education teachers about ICT applications because according to Ilçi (2014), the mobile learning readiness of students and teachers is emerging as an important area of research. Five-Likert scale questions were used and the participants were defined.

The second stage includes the design and the use of a new educational android application that intends to help gymnasium students with learning difficulties (who attend integration department classes or receive parallel support) in acquiring extra skills in mathematics.

After a two-month trial period of the application, we proceeded to the third stage of our research which is the overall evaluation of the project. The evaluation was made using Questionnaires and Interviews.

Five-Likert scale questions formulated the Questionnaires of the study and the participants were defined. Questionnaires' processing and data analysis were done using the Statistical Package for Social Sciences (SPSS) 24.0 software for Windows.

3.3. Participants

3.3.1. Participants who Answered Questionnaires about Teacher's Readiness

The survey was conducted in April-May 2020. The sample consists of 35 women (72.9%) and 13 men (27.1%). Demographic characteristics of the sample are presented in Table 3, below.

Table 3: Demographic Characteristics of the Sample of Teacher's Readiness Questionnaire

Variables	Categories	Frequency (N)	Percent (%)
Gender	Male	13	27,1
	Female	35	72,9
Age	22-30	3	6,3
	31-40	28	58,3
	41-50	12	25,0
	51 and more	5	10,4
Academic Level	Pedagogical Academy	0	0
	Technological Institute	3	6,3
	University	9	18,8
	Master	32	66,7
	PhD	4	8,3
Years of Experience	Not at all (1st year)	1	2,1
	A little (2-5)	12	25,0
	Moderately (6-10)	20	41,7
	Sufficiently (11-15)	7	14,6
	A lot (more than 15 years)	8	16,7

3.3.2. Participants for App's Evaluation -Educators Who Tested the App

The sample population is 7 mathematicians and IT teachers who taught at Greek gymnasium schools during the 2020-2021 school year, installed the app on their mobiles and assessed it.

Table 4 below presents the Demographic characteristics of the sample.

Table 4: Demographic Characteristics of the Sample of Teachers' Evaluation Questionnaire

Variables	Categories	Frequency (N)	Percent (%)
Gender	Male	5	71,4
	Female	2	28,6
Age	22-30	1	14,3
	41-50	5	71,4
	51 and more	1	14,3
Academic Level	Technological Institute	2	28,6
	University	2	28,6
	Master	3	42,9
Years of Experience	A little (2-5)	2	28,6
	Moderately (6-10)	2	28,6
	A lot (more than 15)	3	42,9
Experience with Android applications	Not at all	1	14,3
	A little	1	14,3
	Sufficiently	4	57,1
	A lot	1	14,3

3.3.3. Participants for App's evaluation- Special Education Teachers Who Used the App

The sample consists of one male and two female special education math teachers. All of them (100%) had previous experience with Android applications, they had all (100%) a master's degree in Special Education. What is more, they all (100%) had 3 to 6 years of total experience as teachers. Two of them (66,6%), the male and one of the female teachers were teaching at the integration departments of two gymnasiums. The other female teacher (33,3%) provided parallel support to two students of the Students' Sample, as stated in section 3.3.4., who were diagnosed with ADHD.

3.3.4. Participants for App's Evaluation- Students with Learning Difficulties Who Used the App

The sample population of the students' questionnaires is defined as 16 students, who studied at the integration departments or were receiving parallel support, of two Greek secondary schools during the 2021-2022 school year. Demographic Characteristics of the students' sample are displayed in Table 5.

Table 5: Demographic Characteristics of the Students' Sample

Variables	Categories	Frequency (N)	Percent (%)
Gender	Male	13	71,4
	Female	3	28,6
Learning Difficulties	Dyslexia	3	18,8
	Dysgraphia	3	18,8
	ADHD	2	12,5
	Dyscalculia	2	12,5
	Generalized Learning Difficulties in Language and in Mathematics	5	31,3
	Complex Cognitive and Emotional Difficulties	1	6,3

3.4. Dimensions of the Evaluation

The Graded Criteria Scale for the Evaluation of Educational Mobile Applications for Preschool Children (REVEAC - Rubric for the Evaluation of Educational Apps for Preschool Children) by Papadakis et al. (2017) was used as an evaluation tool, which helped us to formulate the questions of both the questionnaires and the interviews as well. We also decided to evaluate the same four main areas: **educational content**, **design**, **functionality** and **technical characteristics** and we finally formulated the questions of our research.

3.5. Instruments to Collect Data

A) Teachers' levels of readiness to adopt and use mobile applications in their classes have been examined via structured questionnaires. 48 special education teachers of both primary and secondary education of the region of Western Macedonia and some nearby areas answered structured questionnaires including 19 questions that are divided into the following sections: ICT Knowledge, Use and utilization of Information and Communication Technologies (ICTs) in class, Attitudes-perceptions of teachers about a new android application for mobile phones and tablets. The correlation coefficient (a) of Cronbach was calculated, which was found to be a=0.902, as shown in Table 6, suggesting that the internal coherence of questions is excellent.

Table 6: Cronbach's a=0,902 for Teachers' Readiness Questionnaires

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
,902	,906	19

B) The overall evaluation of the project involves:

A. Questionnaires for 7 specialists in the area of informatics and mathematics, as both specialties of teachers can teach Mathematics in Greek Gymnasiums. They answered structured questionnaires including 22 closed-ended questions divided into four main areas: educational content, design, functionality, and technical characteristics. The internal coherence of all the concepts and variables of the questionnaire was checked and the correlation coefficient (a) of Cronbach was calculated. The Cronbach's Alpha index was calculated to be a=0.873, as shown in Table 7, suggesting that internal coherence is very good.

Table 7: Cronbach's a=0,873 for Teachers' Evaluation Questionnaire

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
,873	,882	22

B. Interviews with the three special education teachers, who used the app in their Integration departments of mainstream schools, or provided Parallel support. They were interviewed answering 22 closed-ended and 4 open-ended questions.

The 22 closed-ended questions were the same as those of the 7 educators. The 4 open-ended questions were the same as the students' open-ended questions.

C. Questionnaires addressed to the students who have tried the app in their integration classes. 16 Students with learning difficulties attending integration department classes, who tried and used the app answered structured questionnaires including 16 closed-ended and 4 open-ended questions the same as the ones of the 3 teachers. The Cronbach's Alpha index was calculated to be a=0.901, suggesting that internal coherence is excellent as displayed below in Table 8.

Table 8: Cronbach's a=0,901 for Students' Evaluation Questionnaire

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
,901	,899	16

Questionnaires' processing and data analysis were done using the Statistical Package for Social Sciences (SPSS) 24.0 software for Windows. Validation of the questionnaires and interviews was conducted via pilot studies in each phase.

4. Results

4.1. Teachers' Readiness Results' Analysis

The second part of the questionnaire (Questions 1-3), which follows demographics, concerns **ICT Knowledge** of the Special Education teachers that compose the sample of the research.

Table 9: Frequencies and Percent of Answers about ICT Knowledge

	Not at all		A little		Moderately		Sufficiently		A lot	
	N	%	N	%	N	%	N	%	N	%
Q1: Knowledge of ICTs	0	0	3	6,3	13	27,1	27	56,3	5	10,4
Q2: Ability of adapting new software	0	0	1	2,1	9	18,8	27	56,3	11	22,9
Q3: Knowledge of electronic devises	0	0	2	4,2	11	22,9	27	56,3	8	16,7

Knowledge of most of teachers about ICTs is sufficient, a necessary prerequisite for accepting M-learning in education.

The third part of the questionnaire (Questions 4-7), concerns the grade of the **Use and utilization of Information and Communication Technologies (ICTs) in class**.
From their answers, it is obvious that all teachers are familiar with the use of ICTs. They use ICTs in class either for Motivation, or as Educational software for Maths/Language, etc.

The second Subcategory of the fourth part of our research tool refers to the **Attitudes-perceptions of teachers about a new Android application for mobile phones and tablets.** Table 10 which is presented below, shows Frequencies and Percent of

answers to the questions about the attitudes and the perceptions of teachers about a new Android application for mobile phones and tablets.

Table 10: Frequencies and Percent of Answers about Attitudes-perceptions of Teachers about a New Android Application for Mobile Phones and Tablets

	Not at all		A little		Moderately		Sufficiently		A lot	
	N	%	N	%	N	%	N	%	N	%
Q18: Teachers could accept a new mobile educational app	0	0	1	2,1	20	41,7	21	43,8	6	12,5
Q19: Students could accept a new mobile educational app	0	0	0	0	6	12,5	20	41,7	22	45,8

According to answers teachers and students could easily accept and use a new mobile educational app in the learning process.

4.2. Evaluation of the App

4.2.1. Teachers' Questionnaires Analysis

Firstly, the answers of the 7 mathematicians and IT teachers who taught to Greek gymnasium schools during 2020-2021 school year will be analyzed. They all became familiar with the app's functions under the designer's directions and they answered the questions to evaluate it before it was used by students and teachers of the integration departments. Teachers' answers to selected questions are presented below.

Table 11: Distribution of Teachers' Answers in the Sector "Educational Content"

	Not at all		A little		Moderately		Sufficiently		A lot	
	N	%	N	%	N	%	N	%	N	%
Q1: Does the system aim to provide guidance in learning?	0	0	0	0	0	0	5	71,4	2	28,6
Q2: Does the system aim at attracting attention and information about the objectives of the course?	0	0	0	0	0	0	3	42,9	4	57,1
Q3: Does the system aim at improving learning interest?	0	0	0	0	0	0	3	42,9	4	57,1
Q5: Does it offer a good presentation of mathematics material?	0	0	0	0	1	14,3	3	42,9	3	42,9
Q8: Does the course content correspond to the curriculum?	0	0	0	0	0	0	2	28,6	5	71,4
Q10: Can you evaluate the child based on his / her performance in the program exercises?	0	0	0	0	0	0	4	57,1	3	42,9
Q11: Could children using the program increase their learning abilities in Maths?	0	0	0	0	0	0	4	57,1	3	42,9

As shown in Table 11 by the answers given in the first main sector **"Educational content"** of the teachers' questionnaire:

Teachers agree that the app provides guidance in learning, that attracts attention and provides information about the objectives of the course, that the system improves learning interest, that the presentation of math is good, that the course content corresponds to the curriculum a lot, that they can evaluate the students based on their performance in the apps' exercises and that children can increase their learning abilities in Math using the program.

The second main sector of the teachers' questionnaire **"Design"** and it consists of four questions. The questions were generally answered as described below:

The vast majority of teachers state that the system is characterized by elegance and minimalism in the provided information to avoid user confusion. Teachers agree that feedback employs meaningful graphics and sound, that navigation menus are simple and understandable and that the application provides alternative navigation routes between its screens.

Table 12 presents the third main sector of the teachers' questionnaire **"Functionality"** and it consists of four questions. Selected questions were answered as described below:

Table 12: Distribution of Teachers' Answers in the Sector "Functionality"

	Not at all		A little		Moderately		Sufficiently		A lot	
	N	%	N	%	N	%	N	%	N	%
Q16: Is the text of the navigation options (menus, buttons etc.) simple and understandable?	0	0	0	0	1	14,3	1	14,3	5	71,4
Q17: Are the instructions for using the application clear?	0	0	0	0	1	14,3	4	57,1	2	28,6
Q18: Does the application provide the appropriate comments?	0	0	0	0	0	0	5	71,4	2	28,6
Q19: Is the application child friendly?	0	0	0	0	0	0	3	42,9	4	57,1

Teachers agree that the text of the navigation options is simple and understandable, that the instructions for using the application are clear, that the application provides the appropriate comments and that the application is child friendly.

The fourth main sector of the teachers' questionnaire **"Technical Characteristics"** consists of three questions. The questions were answered as described below in Table 13:

Table 13: Distribution of Teachers' Answers in the Sector "Technical Characteristics"

	Not at all		A little		Moderately		Sufficiently		A lot	
	N	%	N	%	N	%	N	%	N	%
Q20: Is it possible to select specific functions?	0	0	0	0	1	14,3	5	71,4	1	14,3
Q21: Does the application use simple and natural dialogs?	0	0	0	0	0	0	1	14,3	6	85,7
Q22: Is the application efficient and reliable?	0	0	0	0	0	0	3	42,9	4	57,1

Teachers basically agree that it is possible to select specific functions when using the app. There is also agreement that the application uses simple and natural dialogs and that the application is efficient and reliable.

4.2.2. Students' Questionnaire Analysis

16 students with learning difficulties answered the questions.

Below Table 14 displays the students' answers in the first main sector of the students' questionnaire **"Educational content"** which consists of 6 questions. The answers of the selected questions are described below.

Table 14: Distribution of Students' Answers in the Sector "Educational Content"

	Not at all		A little		Moderately		Sufficiently		A lot	
	N	%	N	%	N	%	N	%	N	%
Q1: Does the system aim to provide guidance in learning?	0	0	0	0	2	12,5	5	31,3	9	56,3
Q3: Do the graphics strengthen your attention?	0	0	0	0	6	37,5	9	56,3	1	6,3
Q5: Do the elements of the program match your prior knowledge	0	0	0	0	2	12,5	4	25,0	10	62,5
Q6: Could you increase your learning abilities in Maths by using the program?	0	0	0	0	1	6,3	6	37,5	9	56,3

Students agree that the system provides guidance in learning, that the system offers a good presentation of mathematics' course, that the graphics strengthen their attention, that the elements of the program match their prior knowledge, and that they could increase their learning abilities in Maths by using the program.

Table 15 below, presents the second main sector of the students' questionnaire **"Design"** which consists of two questions. The questions were answered as described below:

Table 15: Distribution of Students' Answers in the Sector "Design"

	Not at all		A little		Moderately		Sufficiently		A lot	
	N	%	N	%	N	%	N	%	N	%
Q7: Does feedback employ meaningful graphic and sound capabilities?	0	0	0	0	6	37,5	9	56,3	1	6,3
Q8: Are the available navigation menus simple and understandable?	0	0	0	0	1	6,3	5	31,3	10	62,5

Feedback employs meaningful graphic and sound capabilities and the available navigation menus are simple and understandable

Table 16 displays the students' answers in the third main sector of the students' questionnaire **"Functionality"** and it consists of 5 questions. Answers to selected questions are presented below.

Table 16: Distribution of Students' Answers in the Sector "Functionality"

	Not at all		A little		Moderately		Sufficiently		A lot	
	N	%	N	%	N	%	N	%	N	%
Q9: Is the text of the navigation options (menus, buttons) simple and understandable to you?	0	0	0	0	1	6,3	4	25,0	11	68,8
Q10: Are the instructions for using the application clear?	0	0	0	0	0	0	9	56,3	7	43,8
Q11: Does the application provide the appropriate comments?	0	0	0	0	3	18,8	9	56,3	4	25,0
Q13: Is the application friendly to you?	0	0	0	0	0	0	2	12,5	14	87,5

Students regardless of their diagnosis find the text of the navigation options simple and understandable.

Students find the use instructions of the app clear, with no difficulty in understanding, agree that the application provides the appropriate comments, and find that the application is friendly to them.

Table 17 which follows, presents the fourth main sector of the students' questionnaire **"Technical Characteristics"** and it consists of three questions. Answers to selected questions are described below:

Table 17: Distribution of Students' Answers in the Sector "Technical Characteristics"

	Not at all		A little		Moderately		Sufficiently		A lot	
	N	%	N	%	N	%	N	%	N	%
Q15: Does the application supports shutdown at any time you want?	0	0	0	0	2	12,5	13	81,3	1	6,3
Q16: Is the application efficient and reliable?	0	0	0	0	0	0	8	50,0	8	50,0

According to students' answers, the application supports shutdown at any time a user wants and is efficient and reliable.

The students' questionnaire also includes four open-ended questions that will be analyzed in relation to the similar questions of the special education teachers' interviews in section 4.2.4.

4.2.3. Special Education Teachers' Interviews Analysis

The first main sector of the interviews' questions **"Educational content"** includes 11 questions.

All the teachers (100%) believe that the app provides guidance in learning, that the system attracts students' attention and gives information about the course's objectives, that their students' learning interest has been improved, that the app motivates the students internally and externally and that the presentation of maths offered by the app is very well organized.

Teachers (100%) state that the provided feedback enriches the course content and the system employs built-in rewards, the course content is sufficient according to the curriculum and corresponds directly to the curriculum.

One teacher (the male) (33,6%) states that the program is not accompanied by strategies for extending learning, while the two females (66,6%) agree that the program is accompanied by strategies for extending learning, because it encourages students and extends their learning through repetition.

The three teachers (100%) agree that they can evaluate the students, after the system has evaluated them. They also state that the students could increase their learning abilities in Maths, (one says that they need more time practicing with the app, while the other two state that the students have already made progress).

The second main sector of the interviews' questions **"Design"** includes 4 questions. The three teachers (100%) declare that the system is elegant and minimal in the provided information, so users are not confused, that feedback employs meaningful graphic and sound capabilities that the available navigation menus are simple and understandable, while each of the teachers explains why they think that the navigation menus are simple and understandable. Teachers (100%) also agree that the application provides alternative navigation routes between its screens.

The third main sector of the interviews' questions **"Functionality"** includes 4 questions. It is stated by the teachers (100%) that the text of the navigation options is simple and understandable, that the instructions for using the application are clear, that the application provides the appropriate comments, and that it is very child friendly.

The fourth main sector of the interviews' questions **"Technical Characteristics"** includes 3 questions. There is an agreement of teachers (100%), that it is possible for a user to select any function of the app, that the application uses simple and natural dialogs and that the app is efficient and reliable.

Special education teachers' interviews included four open-ended questions as well as students' questionnaires, which are both presented in the following table 18.

4.2.4. Open-ended Students' and Special Education Teachers' Questions Analysis

Table 18 below displays the open-ended questions' answers of both Integration Departments' students and Special Education Teachers. The areas in which students and teachers agree are displayed, as well.

Table 18: Open-ended Questions' Answers of Teachers and Students and Areas of Agreement

Open-ended Questions	**Integration Department/ Parallel Support Students' answers**	**Special Education Teachers' answers**	**Areas of Agreement**
Students' question: How do you feel when you use the app? Teachers' question: How do the students feel when they use the app?	5 students (39,2%) like the app and feel anxious to use it. 11 students (68,8%) feel happy and excited	All the teachers (100%) state that students feel positively towards the use of the app: "excited, enthusiastic, eager, anxious and willing to use it".	Teachers and students agree that students have positive feelings
Did you like the app and find it helpful?	All students (100%) like the app and find it very helpful	All the teachers (100%) found the app very helpful. Help for managing the class (33,3%) and avoiding students' distraction (33,3%). An alternative teaching and learning method (33,3%)	Both students and teachers liked the app and found it helpful
What possible improvements would you suggest to strengthen the app's effectiveness?	4 students (25,0%) ask for more graphics such as animations to be more interesting and motivating 8 students (50,0%) ask for a variety of music and songs 4 students (25,0%) ask for more time to answer each question 4 students (25,0%) ask not to include difficult questions 7 students (68,8%) find the whole project very interesting and enjoyable	Employment of funnier & impressive graphics (33,3%) App's installation to tablets. (33,3%) App's extension with the addition of more lessons (33,3%) Distribution of the application through the Google Play Store Distribution to schools (33,3%) Adaptation of the content to the students' special needs (33,3%) Simpler content and exercises (33,3%)	Both students and teachers ask for more graphics Ask for simpler content and exercises
Students' question: Would you continue using the app after the trial period? Teachers' question: Would you continue using the app in your classes after the trial period?	Students (100%) wanted to use the app for a longer period than it was planned	Teachers would use the app after the trial period (100%) Help in managing the class (100%) Improvement of students' behavior and level of knowledge (66,6%)	Both students and teachers want to use the app for a longer period

According to Table 18 both students and teachers who tried the app state that the students have positive feelings about it, they like the app and find it helpful, they ask for more graphics and for simpler content and easier exercises.

Concerning teachers' answers, teachers find the app very helpful in managing the class and in avoiding students' distraction and they think that it is an alternative teaching and learning method.

Teachers also propose the app's installation to tablets, its extension with the addition of more lessons, and distribution of the application through the Google Play Store and to schools.

Finally, they suggest that the app's content should be adapted to meet the students' special needs, irrespectively of their learning difficulties.

5. Recommendations

The positive results that became apparent after the analysis of the questionnaires and interviews data encouraged us to continue researching some other aspects that came about. Thus, we came up with many plans that we intend to fulfill for the students' best interest. Upgrading some of the apps' features based on the feedback that we have received from teachers and students has already been planned. Some of the app's intended modifications are:

- App's extension with the addition of more lessons. In this case, we think that students in integration or inclusion departments would greatly benefit.
- Design of an App's new edition that could be installed on tablets, so that readers or students would be able to enjoy a larger screen and text, if they prefer so.
- Design of another edition including a more synoptic outline of the theory content and easier exercises, hoping that in this way the content will be adapted to the needs of a wider student population with more severe learning difficulties.

6. Discussion and Conclusions

This research indicates the importance of Mobile learning readiness and acceptance of mobile devices by teachers. Such positive attitudes of teachers are stated in the research of: Mahat et al., (2012), Ekanayake & Wishart (2011), Chen (2017), Seralidou & Douligeris (2015), Kousloglou & Syrpi (2018), Nikolopoulou & Kousloglou (2020), Nikolopoulou et al. (2021), and Nikolopoulou (2021) who state that most of the school teachers accept the use of mobile phones for educational purposes.

On the other hand, similar to our research's findings, positive attitudes of students towards mobile technologies are stated by Flewitt et al. (2015) saying that children quickly become enthusiastic and capable users, by Seralidou & Douligeris (2015) stating that there is rapid acceptance and diffusion of smartphones by 98% of students, by Nikolopoulou & Kousloglou (2020) arguing that Mobile technology's use in the classrooms inspires positive high school students' emotions such as joy, excitement, and contentment and by Nikolopoulou (2021) stating that there are many positive views of Secondary education students about the advantages of mobile education.

As for the course of math similar to our research's positive results have been presented by Audi & Gouia-Zarrad (2013), Drigas & Pappas (2015), Neumann & Neumann (2015), Kyriakides et al. (2016), Al-Mashaqbeh (2016) and Chen et al. (2017).

Considering the use of apps in teaching and learning math there are also similar to our survey's positive results noted by Carr (2012), Riconscente (2013), Zanchi et al. (2013), Drigas & Pappas (2015), Al-Mashaqbeh (2016), Piatt et al. (2016), Pitchford et al. (2018), and Outhwaite et al. (2019).

Referring to similar to our research's results indicating that mobile learning in Special Education has a positive effect Campigotto et al. (2013), Skiada et al. (2014), Rivera et al. (2016), Zhang et al. (2016), Kamaruzaman, et al. (2017), Pitchford et al. (2018) and Novack et al. (2018) state that students with various learning difficulties made progress in language and mathematics, were motivated and interested in learning, felt important and gained confidence, were attracted to practicing and doing exercises, attained their learning interest and achieved self-independence.

We can, generally speaking, argue that mathematicians and informatics' teachers have a positive point of view towards the application 'Love2LearnMaths'. The same positive feelings are observed in the answers of the interviewees, who are special education mathematicians.

Students of integration departments or parallel support on the other hand, appear positively enthusiastic about the use of the application. We can assume that special education teachers and students find the educational content of 'Love2LearnMaths', excellent because it offers many positive capabilities, such as: attracts students' attention and motivates them, makes students' evaluation easier, increases students' learning abilities in Math, provides guidance in learning, attracts students' attention and gives information about the course's objectives, provides feedback that enriches the course content, employs built-in rewards and provides elements that match students' prior knowledge. At this point we consider that our study's main objective has been fulfilled as, according to teachers, students' learning abilities in Math have been improved.

The evaluation of the application, among others, showed an easy-to-use, stable and quite effective application. From a technical point of view, the application is stable, efficient in options and functions, easy-to-use and inspiring enthusiasm to users.

According to the holistic results of the evaluation, the opinion of teachers and students who participated in the evaluation process regarding the accuracy, usefulness, usability, functionality, and effectiveness of the application appears to be positively excellent. Thus, we assume that the app's ultimate goal has been conquered, because students have been assisted in math's learning process, irrespective of their type of learning difficulty.

Therefore, the design and development of an application which includes the above features, can provide the right tool for teachers and students by offering new flexible ways of teaching and learning, providing immediate and great convenience to all stakeholders.

For the near future, we decided to attempt the re-evaluation of the app by many students and teachers. Through a more extensive statistical analysis of a larger sample of the educational population of many students and teachers, we shall be able to extract better evaluative results that could possibly be generalized by representing the views of a larger part of the population.

At last, we consider creating a new series of mobile applications that can be used for certain categories of learning difficulties. We intend to specialize the content of the app, so as each specialty to meet the corresponding students' needs. This is the ultimate goal that we are hoping to accomplish for the best benefit of a wider SEN community.

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Conflict of Interest Statement

The authors declare no conflicts of interest.

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