Mathematics and Blended learning. A Secondary School Case Study

Lamprini Alexiou
Math Teacher in secondary school, M.ED. in Educational Technology
labrinale@gmail.com

Abstract

The present study examines the views of 18 secondary school students on a blended learning approach used in the exploration of an interdisciplinary topic that includes mathematical concepts. Moodle's digital collaborative environment was used for the online part of the educational practice. Students' perceptions of Moodle's online environment are also examined. The students' attitude towards the possibility of participating in a course, which explores how mathematical concepts apply to life, was positive. The study indicated that the students were satisfied with the blended learning approach. They find Moodle useful, but a percentage of the participants maintain a neutral attitude towards possibly using it in the future. Although Moodle's wikis supported student collaborative cross-curricular activities, Moodle's forums and emails were not utilized by the majority of participants.

Keywords: Blended Learning, Maths, Moodle, interdisciplinary, secondary school.

Introduction

The stress that students often experience when dealing with mathematics is a major obstacle to their engagement with the subject. The tension they experience due to the management of numbers and problem solving is experienced not only in their academic career but also in everyday life (Richardson & Suinn, 1972). They often avoid mathematical activities, which results in them facing difficulties in their daily occupations that require mathematical thinking, as well as losing opportunities presented to them in the professional field (Hilton & Pedersen, 1980). The entrenched negative beliefs about their mathematical abilities are so deeply rooted, that they influence their behavior and attitudes (Lester, Garofalo, & kroll, 1989), even leading them to the rejection of whatever is considered to be related to mathematics. Their negative emotions lead them to failure, which reinforces their initial perception of inadequate mathematical abilities. This notion is reinforced by the firm belief which exists in society, that not all humans are intelligent and capable of engaging in mathematics (Papert, 1980). We can, however, help students eliminate these ideas by using alternative ways of teaching (Harper & Dane, 1998; Papert, 1980).

As Papert (1980) points out, the mathematics that students are taught at school do not have the beauty of research. The use of symbols without taking the concepts they contain into consideration, the unconnected meanings, the knowledge that is isolated from the students' world, help reduce the motivation for engaging in mathematics (Kaput, 1989). The National Council of Teachers of Mathematics (NCTM) argues that emphasis should be placed on the interdependence of mathematical ideas and that students should engage in interdisciplinary activities through which they will understand the indissoluble relationship of mathematics with other sciences (NCTM, 1989). Teaching mathematics can be effective when interdisciplinary connections are achieved, when students engage in culturally relevant activities, solve real-life problems by applying mathematical concepts in realistic contexts (Harper & Dane, 1998; Furner, Holbein, & Scullion, 2000; Papert, 1980; Slavin, 2007). History, arts, and cultural elements can be studied in the light of mathematics, arousing the interest of even reluctant students (Furner et al., 2000). When mathematics is treated as a coherent set of ideas, students realize its usefulness, understand the meanings in depth, and this knowledge lasts over time (NCTM, 2000). When students rely on solid foundations, they feel safe, secure and value their abilities (Papert, 1980).

The active participation of students, the group work to achieve a goal and the sharing of responsibilities enhance creativity, excitement, and cultivation of positive feelings about the subject (Rossnan, 2006). They develop close relationships with group members, promoting their self-esteem. They gradually take more initiatives, which is the case with a learning community. A microcosm of mathematical culture is being created. The sense of community and the interactions among the members contribute to students working the way mathematicians do, and therefore to the development of an accurate insight of what mathematics is (Schoenfeld, 1987). The participation in learning communities, the interdisciplinary exploration of a problem using different sources, the connection of theory with practice, the multi-faceted study of a real-context problem, and the collective or individual reflection are characteristics of authentic learning (Cardet, 2012; Lombardi, 2007).

Authentic learning is not only achieved in the natural environment. Many features of authentic learning can be incorporated into the design of online environments, bringing benefits to the learning process (Herrington et al., 2004). According to the NCTM (2000), the use of technology is considered essential in the teaching of mathematics. It can support reasoning, reflective thinking, problem solving and inquiry. Internet use provides multimedia information, virtual workshops, visualization of complex phenomena, synchronous and asynchronous communication, tools that support collaborative inquiry-based learning and the monitoring of student performance, providing them with the necessary feedback (Lombardi, 2007). Internet can be used in mathematics instruction, reducing the tension and transforming traditional instruction of mathematics into an interesting and enjoyable process (Furner & Duffy, 2002). As Papert (1980) points out, technology can help teach coherent mathematical topics that will be meaningful to the students, making it easier for them to manage mathematical concepts.

An educational approach that uses technology is blended learning. This article is a case study of an instructional practice in which a blended learning approach was implemented for the negotiation of an interdisciplinary topic. Moodle's digital collaborative environment was used for the online part of the educational practice. The present study examines the perceptions of 18 secondary school students about the blended method of teaching, as well as whether this method can support the teaching of mathematical concepts applied in real contexts. It also examines students' perceptions of Moodle's online environment regarding its usefulness and usability, as well as their attitudes towards using it in the future.

Theoretical Framework

The most common definition of blended learning is that which indicates combination of virtual and physical learning experiences (Stacey & Gerbic, 2008). Classroom teaching is combined with computer-mediated teaching (Graham, 2006). Students are exposed to different methods and means of instruction (Ahmad, Shafie, & Janier, 2008). Blended learning also refers to the combination of online with face-to-face teaching (Garrison & Vaughan, 2008; Harding, Kaczynski, & Wood, 2012; Staker & Horn, 2012). A part of teaching is provided online with the supervision of the teacher. The two learning environments are strongly interconnected, to the point that they are integrated providing unique learning experiences that are consistent with the learning objectives (Garrison & Vaughan, 2008). The student is provided with controls on the place, time, manner and pace of learning. Teaching is not limited to school hours and classrooms. A more personalized learning can be offered for the students (Horn & Staker, 2011). Students are enabled to interact with multimedia and interactive software which is tailored to their needs, contributing to the improvement of their performance and to their motivation (Staker & Horn, 2012; Horn & Staker, 2011).

Several studies indicate the positive impact of blended learning on teaching (e.g., Abramovitz et al., 2012; Ahmad et al., 2008; Awodeyi, Akpan, & Udo, 2014; Lin, Tseng, & Chiang, 2017). Students are offered authentic learning experiences where knowledge is not abstract but directly related to the physical and social environment (Parkes, Zaka, & Davis, 2011). With the help of the online part of the instruction, a student has access to digital resources, web 2.0 tools, links, thus being given the opportunity to connect knowledge to action, treating it as an integral part of life (Parkes et al., 2011). Students understand the subject more deeply - which helps improve their performance in mathematics- (Ahmad et al., 2008; Awodeyi et al., 2014; Lin et al., 2017) and gain real-world problem solving skills (Groen & Carmody, 2012). The different way of teaching, the visualization of students' concepts, the ability to adapt the instruction to the students' pace of learning according to their particular characteristics (Ahmad et al., 2008), contribute to this. Students acquire the skills needed for lifelong learning (Awodeyi et al., 2014; Iozzi & Osimio, 2004). They cultivate elements of independent learning (Abramovitz et al., 2012), improve their technological skills as well as their ability to use computers maturely and collectively (Groen & Carmody, 2012; Parkes et al., 2011).

The use of blended learning enhances collaborative learning (Lin et al., 2017) and offers the possibility of better management of time and syllabus (Parkes et al., 2011). The curriculum is particularly demanding. Blended learning can help eliminate problems caused by the loss of teaching hours, the uneven level of students, as well as the fact that they are often absent (Stasinakis & Kalogiannakis, 2015). It is noteworthy that 90% of students in a research by Lin et al. (2017), argued that online teaching complemented classroom learning. Several scholars have shown that interpersonal interaction is enhanced (e.g., Chandra & Fisher, 2009; Iozzi & Osimio, 2004; Lin, et al., 2017; Μπούμπουκα κ.ά, 2017; Σκιαδέλη, 2008) by cultivating student cooperative skills and improving their attitudes towards exact science subjects, making them most enjoyable (Chandra & Fisher, 2009; Lin et al., 2017). Social interaction is seen as an essential element of a cognitive lesson, such as mathematics (Engelbrecht & Harding, 2005). A careful combination of online with face-to-face teaching can contribute to more effective mathematics teaching than learning achieved with face-to-face teaching alone (Abramovitz et al., 2012; Awodeyi et al., 2014). According to Awodeyi et al. (2014), this happens because students have more opportunities for feedback and interaction with additional media and material, which they themselves control. A thorough combination of the physical and virtual environments will manage to combine the best characteristics of these two worlds regarding the most effective educational practices, flexible methods of access to knowledge, opportunities for social interaction and personal development (Graham, 2006). Their combination goes beyond the capabilities of each of these two separate environments (Garrison & Vaughan, 2008; Harding et al., 2012).

The role of the teacher in a blended learning classroom is crucial (Condie & Livingston, 2007; Engelbrecht & Harding, 2005; Hughes, 2007). If the teacher transfers traditional methods of teaching conventional classroom mathematics to the online environment, then the results will not be as expected (Engelbrecht & Harding, 2005). Basic technology skills, such as knowing how to create and edit documents, handling emails and surfing the Web, are not enough to effectively integrate an online instruction in the classroom (Condie & Livingston, 2007). The design must be based on modern pedagogical principles. Teachers need to possess both technological and collaborative online activities planning skills (Hughes, 2007). As Groen & Carmody (2012) and Florian & Zimmerman (2015) characteristically point out, the time required for a teacher to integrate the online part of an instruction into face-to-face teaching is important. But, along the way, it is rewarding because the online environment can function as a kind of library, where diverse learning resources can be used and expanded in the future, as long as accessibility is provided (Groen & Carmody, 2012).

Moodle is a virtual environment that can handle the online part of the blended learning. Its design was based on the pedagogical principles of socio-construction to serve educational purposes (Psycharis, Chalatzoglidis & Kalogiannakis, 2013; Zenha-Rela & Carvalho, 2006). The teacher can add pages that include text, image, video audio and links. He also has the ability to assign individual or group interactive activities by setting schedules and can also provide feedback, create quizzes and educational games, as well as structure and organize his course into modules. Students can submit their works individually or as a group. They can participate in real-time discussions or publish their opinions in forums. By using wikis, they can collaboratively create content for topics specified by the teacher. The teacher monitors the student's actions in the digital environment and has a picture of their performance. Teacher-centered instruction is transformed into student-centered instruction. Because Moodle is based on the constructive learning model, the learner becomes the focus of the learning process and is provided with opportunities for active participation (Florian & Zimmerman, 2015).

The learner constructs knowledge in an environment that supports communication and the sharing of ideas (Ayse, 2008; Martín-Blas & Serrano-Fernández, 2009; Stasinakis & Kalogiannakis, 2015). He is involved in a process of self-reflection and evaluation of his own and his classmates' actions, reviewing and revising his work (Lu & Law, 2012). This procedure can be helped by the work on wikis, which give new perspective on the design of activities that focus on active student participation (Chandra, & Fisher, 2009). Wiki environments can be used for exploratory interdisciplinary work, providing students with formal and non-formal learning experiences (Αλεξίου, 2018; Schaffert et al., 2006). A student can contribute to his group by producing content or modifying and expanding a classmates' content. Wikis' environment keeps the history of changes made. The teacher has a clear picture of their collective and individual student effort by comparing the different changes that the page has undergone by the students.

Several studies show the participants' positive attitude towards the integration of Moodle into the lesson (e.g., Ahmad & Al-Khanjari, 2014; Azevedo et al., 2009; Hsu, 2012; Νατσιόπουλος, Χατζηκρανιώτης, & Καριώτογλου, 2010; Σκιαδέρη κ.ά, 2008; Stasinakis & Kalogiannakis, 2015). It is a useful tool that helps better understand the content of the course as well as prepare students for exams (Ahmad & Al-Khanjari, 2014; Azevedo et al., 2009; Martín-Blas & Serrano-Fernández, 2009). The Moodle platform can host a variety of materials, which are difficult to be presented in the classroom, for interaction in the teaching of exact sciences, (Azevedo et al., 2009; Martín-Blas & Serrano-Fernández, 2009; Μπούμπουκα κ.ά, 2017). Studies have also shown that it is useful for the management and the organization of the course (Stasinakis & Kalogiannakis, 2015; Martín-Blas & Serrano-Fernández, 2009; Μπούμπουκα κ.ά, 2017). It provides easy access to learning resources and stands out, because it's easy for students to use it, since no additional software is needed (Ahmad & Al-Khanjari, 2014; Hsu, 2012; Stasinakis & Kalogiannakis, 2015). Indeed, the participants in the study of Νατσιόπουλος et al. (2010), expressed the desire to expand the use of the Moodle environment to other courses.

However, both Stasinakis & Kalogiannakis (2015) and Azevedo et al. (2009), argue that students need some time to become familiar with the digital environment and the different teaching method (Martín-Blas & Serrano-Fernández, 2009). A similar conclusion was reached by Psycharis et al. (2013) on the use of Moodle forums. In order for students to use the forums to solve scientific problems and work with the inquiry method, they need to gain experience. Finally, a stable network is needed. Slow or weak Internet connection disrupts the flow of the course (Zenha-Rela & Carvalho, 2006).

Methodology

At the beginning of the school year the topics that were to be explored during the school year were announced and the students chose the one that best suited their interests. One of the topics that was proposed to be studied was the "Golden ratio in arts and nature". Some students were forced to participate in this course because the classes of their original preferences had already been filled by the necessary number of people. Students met for one hour a week during school hours in the classroom and the Moodle platform was used for the online part of the blended teaching. The blended lesson was implemented for about 8 months in a Greek secondary school, for 18 students. Students had no prior experience either with blended teaching, or the Moodle environment. They had the opportunity to study how the mathematical concept of the golden ratio is found and applied to the real world. The classroom was instructed to enroll in the online course, and, throughout the school year, terms and concepts were clarified and questions were answered. Also, constructions following the golden ratio were made in the classroom. Indicative references, such as documents and videos were posted on the Moodle platform. The students were divided into four groups of 4-5 people and created 4 collaborative wikis in the Moodle environment. Team members recorded their findings on the wikis. Additional supportive videos for the navigation of the students in the Moodle environment were created by the classroom teacher, who is also the author of this article . As Ahmad & Doheny (2013) report, when videos are created by the classroom teacher, a connective link is built between the student and the teacher

Mainly at the end of the blended course, the 18 students completed questionnaires using the 5-point Likert scale. Only one question was answered at the beginning and at the end of the blended lesson. The questions were intended to capture the students' views on the interdisciplinary lesson, the blended teaching model, and their experience on the Moodle platform. In detail, the purpose of this study is:

A) to study students' satisfaction with their participation in the interdisciplinary blended course, which includes mathematical, historical and artistic concepts

B) to study students' perceptions of the Moodle platform, regarding its usefulness and prospect for future use.

C) to study the students' attitudes towards the possibility participating in a course, which includes mathematical concepts applied in life, before and after the implementation of the blended lesson.

Results

Students' perceptions of the blended course

Table 1 provides information on students' satisfaction with their participation in the blended course. Table 1 shows that students were very satisfied with the combination of online and face-to-face teaching ($\bar{x}$= 4.28). In fact, students' responses on the Likert scale (from 1 = not at all to 5 = very much), which relate to the satisfaction with the blended learning model, show the lowest standard deviation (S.D = 0.57, range= 2). The mean of the satisfaction with the organization of the syllabus which was achieved in the virtual and physical environment of the classroom, is high ($\bar{x}$= 3.61, SD= 0.78), as is the case with the satisfaction with the course content ($\bar{x}$= 3.50), the way mathematical concepts were explored in the real world ($\bar{x}$= 3.11), and the collaboration achieved within ($\bar{x}$= 3.50) and out of the classroom ($\bar{x}$= 3.28). The mean of student satisfaction with the interaction with technology tools is lower ($\bar{x}$= 2.83). The 5-point Likert scale responses regarding the satisfaction with technology tools are also the most widely dispersed (S.D = 1.42, range= 4). The overall mean of the satisfaction with the characteristics of the blended course is high ($\bar{x}$= 3.44).

Table 1: Descriptive statistics elements for student satisfaction with the blended course

Factor	$\bar{x}$	S.D
I was satisfied with the lesson content	3,50	1,38
I was satisfied with the combination of mathematical concepts with real-world elements	3,11	1,41
I was satisfied with the organization -layout of the syllabus	3,61	0,78
I was satisfied with the combination of online and classroom teaching	4,28	0,57

I was satisfied with the collaborative learning in the classroom	3,50	1,10
I was satisfied with the collaborative online learning	3,28	1,32
I was satisfied with the acquaintance with the technological tools	2,83	1,42
Cronbach α=0.832; 7 items; five-point Likert scale (1-5); mean=3.44, N=18		

As far as the possible reasons for the difficulties that the students faced are concerned, a fairly high percentage did not have any difficulty with the mixed instruction at all (77.8%), as shown in Table 2. 100% of students had a little or not at all difficulties during the instruction of the mathematical concepts, which apply in real life. Although the course about the golden ratio wasn't the first choice for 12 of the 18 students, only 2 of them found it difficult to participate in the blended course, due to the fact that the golden ratio was not of their immediate interest. A very notable percentage, 50% of students faced a lot or extremely many difficulties due to the fact that they did not have enough free time to negotiate the topic. A significant percentage of 33.3% had a lot or extremely many difficulties due to poor internet connection or PC problems.

Table 2. Descriptive statistics elements regarding difficulty factors for students during blended teaching

Factor	Not at all	A little	Enough	A lot	Extremely Many
Insufficiency of time	22,2% (4)	22,2% (4)	5,6% (1)	33,3% (6)	16,7% (3)
Lack of interest for the topic	55.6% (10)	27.8% (5)	5.6% (1)	0.0%	11.1% (2)
Combination of mathematics with real-life elements	66.7% (12)	33.3% (6)	0.0%	0.0%	0.0%
The online part of the instruction	72.2% (13)	22.2% (4)	5.6% (1)	0.0%	0.0%
The combination of online with classroom teaching	77.8% (14)	11.1% (2)	11.1% (2)	0.0%	0.0%
Inefficient internet connection/old PC	44.4% (8)	22.2% (4)	11.1% (2)	11.1% (2)	11.1% (2)
Insufficiency of technology-related knowledge	83.3% (15)	16.7 (3)	0.0%	0.0%	0.0%

When asked how they overcame the difficulties encountered during the implementation of the assignments, 10 out of 18 students responded that they tried to overcome them on their own or called on the teacher in the classroom. 8 out of 18 students called on their classmates or teacher during the face-to-face teaching. Only 3 out of 18 chose to seek help not by using the ways mentioned above, but through the Moodle forum or email.

Students' perceptions of Moodle's online environment

Students' perceptions of the Moodle platform are studied in two dimensions, the perceived usefulness (Table 3) and their attitudes towards using it in the future (Table 4). Students' perceptions of Moodle's usability are studied in two sub-dimensions, which relate to the quality-organization of their assignments and overall course, and the student-to-student and student-to-teacher interaction (Table 3).

The mean of Moodle's usefulness regarding the course quality and organization is higher ($\bar{x}$= 3.40) compared to the average score of the interaction-related usefulness ($\bar{x}$= 2.62). The mean of the answers related to the organization of the lesson ($\bar{x}$= 3.72, S.D = 1.22) and the monitoring of tasks ($\bar{x}$= 3.67, S.D = 0.84) is high. Specifically, 66.1% agree or strongly agree that Moodle contributed to the organization of the course. A fairly significant percentage (64.7%) agree or strongly agree that Moodle helped them complete the assignments more quickly ($\bar{x}$= 3.44, S.D. = 0.98). The mean of the responses related to Moodle's contribution to the quality of students' work is lower, however it is quite high ($\bar{x}$= 3.06, S.D. = 0.94). Regarding Moodle's usefulness in terms of the offered student-to-student and student-to-teacher interaction, the highest mean is related to the contribution of the wikis ($\bar{x}$= 3.00, S.D. = 1.33). The mean of the responses related to the view that the email service and Moodle forums have contributed to communication is smaller ($\bar{x}$=2,11 and $\bar{x}$=2.39 respectively).

Table 3. Descriptive statistics elements about students' perceptions regarding Moodle's usefulness

Dimension	Questions	$\bar{x}$	S.D
Usefulness	*A. Quality-Organization*		
	Moodle helped me improve the quality of my work	3,06	0,94
	Moodle helped me track the assignments better	3,17	1,10
	Moodle helped me complete my assignments faster	3,44	0,98
	Moodle helped me organize my assignments better	3,33	0,77
	Moodle helped me track my tasks better	3,67	0,84
	Moodle contributed to the course's organization	3,72	1,22
	B. Interaction		
	Moodle helped me cooperate with my group's members	3,00	1,55
	Moodle facilitated my communication with the teacher	2,61	1,29
	The use of collaborative wikis helped me at my work with my group's members.	3,00	1,33
	The use of forums for communication helped me	2,39	1,64
	The use of e-mails via Moodle helped me	2,11	1,57
A. Cronbach α=0.847; 6 items; five-point Likert scale (1-5); mean=3.40, N=18			
B.Cronbach α=0.873; 5 items; five-point Likert scale (1-5); mean=2.62, N=18			

In Table 4 we notice that regarding their attitudes, 50% of the students agree or strongly agree that the lesson became more interesting with the use of Moodle ($\bar{x}$ = 3.33, S.D. = 1.28). There is a smaller percentage of students (38.4%) who would like to use the Moodle platform in the future a lot or extremely much ($\bar{x}$ = 3.06, S.D. = 1.16). A very significant number of students, namely 7 out of 18, are undecided, maintaining a neutral attitude (39%). It should be noted, however, that 6 out of the 7 students who were cautious about the prospect of using Moodle in the future, faced some or many difficulties due to Internet access or technical problems on their personal computers.

Table 4. Descriptive statistics elements about students' perceptions regarding Moodle's usefulness. Students' attitudes.

Dimension	Questions	$\bar{x}$	S.D.
Attitudes	The lesson became more interesting with the use of Moodle	3,33	1,28
	I would like to participate in a course that uses the Moodle platform in the future	3,06	1,16
Cronbach = 0.731; 4 items; five-point Likert scale (1-5); mean=3.194 , N=18			

Additionally, a new variable called "attitudes", which resulted from the mean of the two individual questions related to the "Attitudes" dimension (Table 4), was created for the in-depth study of students' attitudes. Based on Spearman's rho non-parametric test, this new variable has a strong negative, statistically significant correlation with the "technical problems" (r = -0,725, p = - 0.001 <0.05) and "shortage of time" variables. (r = -0,711, p = - 0.001 <0.05). As the difficulties that students face increase because of internet connection or technical computer problems, and lack of time, their attitude towards a Moodle course becomes less positive. There is also a strong negative, statistically significant correlation between the "technical problems" and "the course became more interesting with Moodle" variables (r = -0.658, p = 0.03 <0.05). On the contrary, there is a strong positive, statistically significant correlation between the "attitudes" variable and the "Improvement of the quality" and "wiki was useful" variables, as shown in Table 5. Students' attitudes towards a Moodle course have a strong positive, statistically significant correlation with students' perception that Moodle contributed to the improvement of the quality of their work (r = 0.746, p = 0.01) and with the perception that Moodle's wikis contributed to the collaborative completion of their assignments (r = 0.737, p = 0.00).

Table 5: Correlations based on the non-parametric test Spearman's rho

			attitudes	Technical problems	Improvement of the quality	Wiki was useful
Spearman's rho	attitudes	Correlation Coefficient	1,000	-,725**	,746**	,737**
		Sig. (2-tailed)	.	,001	,001	,000
		N	18	18	17	18
	Technical problems	Correlation Coefficient	-,725**	1,000	-,353	-,509*
		Sig. (2-tailed)	,001	.	,165	,031
		N	18	18	17	18
	Improvement of the quality	Correlation Coefficient	,746**	-,353	1,000	,545*
		Sig. (2-tailed)	,001	,165	.	,024
		N	17	17	17	17
	Wiki was useful	Correlation Coefficient	,737**	-,509*	,545*	1,000
		Sig. (2-tailed)	,000	,031	,024	.
		N	18	18	17	18

*. Correlation is significant at the 0.05 level (2-tailed).

Students' attitudes towards participating in a lesson that links mathematical concepts to authentic environments

Students were asked to answer the question: "To what extent would you like to participate in a course that links mathematical concepts to real life elements" through the 5-point Likert scale at the beginning and the end of the program. The mean of the responses before the students' participation in the blended learning, although high ($\bar{x}$= 3.5, SD = 1.24), is lower than the after-participation mean ($\bar{x}$= 3,72, SD = 1.07). Due to the data of the variable are not normally distributed, the non-parametric Wilcoxon Signed Ranks test was applied. The test showed that we accept the null hypothesis (Z = -0.997, p = 0.329> 0.05). Specifically, we accept that there is no statistically significant difference between the medians in the 5-point Likert scale responses to the previous question, which were given before and after the implementation of the blended learning. Students also find the suggestion to participate in a course that examines the mathematical concepts connected to real life, equally interesting before and after the implementation of the blended course.

Discussion

According to the literature review, blended learning can support the teaching of mathematics (Ahmad et al., 2008; Awodey et al., 2014; Groen & Carmody, 2012; Lin et al., 2017). The present study is in agreement with the results of the research above. Although students did not have previous experience in a lesson that combined face-to-face with online teaching, they were very satisfied with blended learning. Not only wasn't the content of teaching a difficulty factor during the implementation of blended learning, but the students were satisfied with it, as well as with the way mathematical concepts were combined with real-life elements. In addition, the blended teaching supported the structure and organization of the lesson. This notion is supported not only by the students but also by the classroom's teacher, which is also the author of this article. This conclusion has been demonstrated by other studies, too (e.g., Parkes et al.,2011; Stasinakis & Kalogiannakis, 2015; Μπούμπουκα κ.ά, 2017). The course was structured in sections and subsections containing graded polymorphic material, timelines were set, and there was multiple feedback on the effort. However, the teacher in charge was required to devote considerable effort and time. The view that valuable time needs to be allocated is supported by both Groen & Carmody (2012) and Florian & Zimmerman (2015).

It should be noted that the main factors contributing to the difficulty in implementing the blended lesson were that students did not have enough time due to the increased workload and highly demanding curriculum. Psycharis et al. (2013) report that students' positive attitude is associated with their need for leisure time, a conclusion which is confirmed by our own study. Also, a proportion faced technical problems. I myself consider that the technical problems negatively affected the students' satisfaction with the technological tools used.

Although a large percentage of students are uncertain about their attitude towards Moodle, students still have the perception that it has contributed to the organization and improvement of the course. The perception of Moodle usefulness is in agreement with several studies (eg Ahmad & Al-Khanjari, 2014; Hsu, 2012; Martín-Blas & Serrano-Fernández, 2009; Stasinakis & Kalogiannakis, 2015). However, it should be noted that although Moodle wikis supported student collaborative activities, Moodle forums and emails were not utilized by the vast majority of participants. I think that students need time to become familiar with the different ways of teaching, as mentioned in the study of Psycharis et al., (2013). It would be interesting if the same students participated for the second consecutive year in a course which uses the platform so that their perceptions could be studied again by comparing them with the previous ones.

It is of particular importance that many scholars strongly argue that the teaching of mathematics should contain interdisciplinary links, that mathematical concepts should be treated as a coherent whole and that students should solve genuine problems, triggering their interest and helping them understand the value and usefulness of mathematics (eg Harper & Dane, 1998; Furner et al., 2000; Papert,1980; Slavin, 2007). This study showed that students seek to engage in activities that explore how abstract mathematical concepts are linked to everyday life, art, nature, and history. It is noteworthy mentioning how positive the student attitude towards their participation in a course that explores mathematics in life was, after the students were informed, during the first lessons, of the way mathematical concepts would be approached throughout the school year. This attitude was equally positive before and after the application of blended teaching.

In conclusion, blended teaching can support the exploration of interdisciplinary topics. Real and digital experiences can be combined, bringing significant benefits to reflective, exploratory and independent learning. By taking advantage of the positive characteristics of the two environments we can create dynamic virtual and physical learning communities. As Garrison & Vaughan, 2008, typically point out, "We must begin to break down the notions of what is "real "and what is "virtual" (p. 48). We need to understand the strengths of the two learning environments in order to accept the existence of new innovative learning methods. But as educators, we need to give time not only to ourselves, so that we become accustomed and gradually improve through the design, development and implementation of student-centered learning environments, but also to the students, so that they learn to act on their own, experiment, and build new knowledge, activating collective and individual thinking in physical and digital learning communities.

References

Abramovitz, B., Berezina, M., Bereman, A.,& Shvartsman, L. (2012). A blended learning approach in mathematics. In A. Ajuan, M. A. Huertas, S. Trenholm, and C. Streegmann (Eds), *Teaching mathematics online: Emergent technology and methodologies* (pp. 22-42).

Ahmad, N., & Al-Khanjari, Z. (2011). Effect of Moodle on learning: An Oman perception. *International Journal of Digital Information and Wireless Communications (IJDIWC)*, *1*(4), 746-752.

Ahmad, T. T., & Doheny, F. (2013). Six key benefits of screencasts in learning Maths: An Irish case study. *Innovation, Communication and Engineering*, 283.

Ahmad, W. F. B. W., Shafie, A. B., & Janier, J. B. (2008, December). Students' perceptions towards Blended Learning in teaching and learning Mathematics: Application of integration. In *Proceedings 13th Asian Technology Conference in Mathematic (ATCM08), Suan Sunanda Rajabhat, University Bangkok, Thailand*.

Awodeyi, A. F., Akpan, E. T., & Udo, I. J. (2014). Enhancing teaching and learning of mathematics: Adoption of blended learning pedagogy in University of Uyo. *International Journal of Science and Research*, *3*(11), 40-45.

Ayse, K. O. K. (2008). An online social constructivist tool: A secondary school experience in the developing world. *Turkish Online Journal of Distance Education*, *9*(3), 87-98.

Azevedo, J., Torres, C., Lopes, A. P., & Babo, L. (2009). Enhancing Math Skills with Moodle. In *Proceedings of ICERI 2009-International Conference of Education, Research and Innovation* (pp. 2367-2377).

Cardet. (2012). *Ανάπτυξη Αυθεντικών Περιβαλλόντων Μάθησης μέσω της Συνεργασίας Σχολείων και Επιχειρήσεων*. Λευκωσία.

Chandra, V., & Fisher, D. L. (2009). Students' perceptions of a blended web-based learning environment. *Learning Environments Research*, *12*(1), 31-44.

Condie, R., & Livingston, K. (2007). Blending online learning with traditional approaches: changing practices. *British Journal of Educational Technology*, *38*(2), 337-348.

Engelbrecht, J., & Harding, A. (2005). Teaching undergraduate mathematics on the internet. *Educational studies in mathematics*, *58*(2), 253-276.

Florian, T. P., & Zimmerman, J. P. (2015). Understanding by design, moodle, and blended learning: A secondary school case study. *MERLOT Journal of Online Learning and Teaching*, *11*(1), 120-128.

Furner, J. M., & Duffy, M. L. (2002). Equity for all students in the new millennium: Disabling math anxiety. *Intervention in School and Clinic*, *38*(2), 67-74.

Furner, J., Holbein, M. F. D., & Scullion, K. J. (2000). Taking an internet field trip. *TechTrends*, *44*(6), 18-22.

Garrison, R., & Vaughan, H. (2008). Blended learning in higher education: Framework, principles and guidelines. San Francisco: Jossey-Bass

Graham, C. R. (2006). Blended learning systems: Definitions, current trends, and future directions . In Bonk, C. J., & Graham, C. R. (Eds.), Handbook of blended learning: Global perspectives, local design (pp. 3–21). San Francisco, CA: Pfeiffer Publishing

Groen, L., & Carmody, G. (2012, October). Blended learning in a first year mathematics subject. In *Proceedings of The Australian Conference on Science and Mathematics Education (formerly UniServe Science Conference)* (Vol. 11).

Harding, A., Kaczynski, D., & Wood, L. (2012, October). Evaluation of blended learning: analysis of qualitative data. In *Proceedings of The Australian Conference on Science and Mathematics Education (formerly UniServe Science Conference)* (Vol. 11).

Harper, N. W., & Daane, C. J. (1998). Causes and reduction of math anxiety in preservice elementary teachers. *Action in Teacher Education*, *19*(4), 29-38.

Herrington, J., Reeves, T., Oliver R., & Woo, Y. (2004). Designing authentic activities for Web-based courses. Journal of Computing in Higher Education, Vol, 16(I) (Fall 2004), 3-29.

Hilton, P., & Pedersen, J. (1980). Reviews. The American Mathematical Monthly, Vol. 87, No. 2 (Feb., 1980), pp. 143-148.

Horn, M. B., & Staker, H. (2011). The rise of K-12 blended learning. *Innosight institute*, *5*.

Hsu, H. H. (2012). The acceptance of Moodle: An empirical study based on UTAUT. *Creative Education*, *3*, 44

Hughes, G. (2007). Using blended learning to increase learner support and improve retention. *Teaching in Higher Education*, *12*(3), 349-363.

Iozzi, F., & Osimio, G. (2004). The virtual classroom in blended learning mathematics undergraduate courses. *ICME10.*

Kaput, J., (1989). Information Technologies and Affect in Mathematical Experience. In Pullman, W., & Douglas B. M. (Ed.), *Afffect and Mathematical Problem Solving(*pp. 89-103). Springer-Verlag New York Inc.

Lester, K.L., Garofalo, J., & Kroll, D.L. (1989). Self-Confidence, Interest, Beliefs, and Metacognition: Key Influences on Problem-Solving Behavior. In Pullman, W., & Douglas B. M. (Ed.), *Afffect and Mathematical Problem Solving(*pp. 76-88). Springer-Verlag New York Inc.

Lin, Y. W., Tseng, C. L., & Chiang, P. J. (2017). The Effect of Blended Learning in Mathematics Course. *Eurasia Journal of Mathematics, Science&Technology Education*, *13*(3).

Lombardi, M. M. (2007). Authentic Learning for the 21st Century: An Overview. (pp.1-12).

Lu, J., & Law, N. W. Y. (2012). Understanding collaborative learning behavior from Moodle log data. *Interactive Learning Environments*, *20*(5), 451-466.

Martín-Blas, T., & Serrano-Fernández, A., (2009). The role of new technologies in the learning process: Moodle as a teaching tool in Physics. *Computers & Education*, *52*(1), 35-44.

NCTM (1989). *Curriculum and evaluation standards for school mathematics*. Retrieved July 26, 2019, from http://csmc.missouri.edu/PDFS/CCM/summaries/standards_summary.pdf

Papert (1980). Mindstorms: Children, Computers, and Powerful Ideas. United States of America. Basic Books, Inc.

Parkes, S., Zaka, P., & Davis, N. (2011). The first blended or hybrid online course in a New Zealand secondary school: A case study. *Computers in New Zealand Schools: Learning, Teaching, Technology*, *23*(1), 1-30.

Psycharis, S., Chalatzoglidis, G., & Kalogiannakis, M. (2013). Moodle as a learning environment in promoting conceptual understanding for secondary school students. *Eurasia Journal of Mathematics, Science & Technology Education*, *9*(1), 11-21.

Richardson, F. C., & Suinn, R. M. (1972). The mathematics anxiety rating scale: Psychometric data. Journal of Counseling Psychology, 19(6), 551-554

Rossnan, S. (2006). Overcoming math anxiety. *Mathitudes*, *1*(1), 1-4.

Schaffert, S., Bischof, D., Bürger, T., Gruber, A., Hilzensauer, W., & Schaffert, S. (2006, June). Learning with Semantic Wikis. *In Proceedings of the First Workshop on Semantic Wikis-From Wiki to Semantics* (pp.109-123), Budva. Retrieved June 8, 2020, from https://core.ac.uk/download/pdf/20881256.pdf

Schoenfeld, A. H. (1987). What's all the fuss about metacognition. *Cognitive science and mathematics education*, *189*, 215.

Slavin, R. (2007). Εκπαιδευτική Ψυχολογία. Θεωρία και μάθηση. (Επιμέλεια Κ.Μ. Κόκκινος). Αθήνα. Μεταίχμιο

Stacey, E., & Gerbic, P. (2008). Success factors for blended learning. Retrieved July 1, 2020,from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.467.6933&rep=rep1&type=pdf

Staker, H., & Horn, M. B. (2012). Classifying K-12 blended learning. *Innosight Institute*.

Stasinakis, P., & Kalogiannakis, M. (2015). Using Moodle in secondary education: a case study of the course "Research Project" in Greece. *International Journal of Education and Development using ICT*, *11*(3).

Tobias, S. (1978). Overcoming math anxiety. New York: W.W. Norton and Company, Inc.

Zenha-Rela, M., & Carvalho, R. (2006, October). Work in progress: Self evaluation through monitored peer review using the moodle platform. In *Proceedings. Frontiers in Education. 36th Annual Conference* (pp. 26-27). IEEE

Αλεξίου, Λ. (2018). Μέσα κοινωνικής εκπαίδευσης και εκπαίδευση. *Πρακτικά 4ου Διεθνές Συνέδριου για την Προώθηση της Εκπαιδευτικής Καινοτομίας*, τόμος Α, σελ. 759-766. Λάρισα.

Μπούμπουκα, Μ., Παλαιογιαννίδης Δ., & Φαλαγκάρας Α. (2017). Μια εφαρμογή μικτής μάθησης για τη διδασκαλία των μαθηματικών στο γυμνάσιο με τη βοήθεια του Moodle. *Πρακτικά 5ου Πανελλήνιου Συνέδριου «Ένταξη και Χρήση των ΤΠΕ στην Εκπαιδευτική Διαδικασία», σελ 393-403.* Αθήνα.

NCTM (2000). Principles and Standards for School Mathematics. Retrieved July 7, 2020, from https://www.nctm.org/uploadedFiles/Standards_and_Positions/PSSM_ExecutiveSummary.pdf

Νατσιόπουλος, Γ., Χατζηκρανιώτης, Ε., & Πέτρος Καριώτογλου Π.,(2010). Απόψεις μαθητών για την πιλοτική εφαρμογή της ηλεκτρονικής πλατφόρμας Moodle. *Παρουσιάστηκε στο 7ο Πανελλήνιο Συνέδριο με Διεθνή Συμμετοχή «Οι ΤΠΕ στην Εκπαίδευση», τόμος ΙΙ, σ. 267-270.* Πανεπιστήμιο Πελοποννήσου, Κόρινθος.

Σκιαδέλη, Μ. (2008.)Αξιοποίηση του Moodle στη διδασκαλία μαθημάτων πληροφορικής του Ενιαίου Λυκείου. *Πρακτικά 4ου Συνέδριου Διδακτική της Πληροφορικής.* Πάτρα.