

Learning Theories and teaching Mathematics online: The Case of the Hellenic Open University

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Abstract

The utilization of pedagogical principles and learning theories is essential for improving the quality of education provided in online learning environments. In the field of mathematics, the utilization of the appropriate pedagogical approaches and techniques should be based on grounded and practically established theories. The Hellenic Open University (HOU) has been at the forefront of distance education in Greece, providing students with the opportunity to study a variety of scientific subjects remotely. This study aimed to investigate the extent to which learning theories are utilized by instructors/tutors in mathematics courses of HOU. The research methodology followed the qualitative approach of a case study. Semi-structured interviews were conducted with ten participants (instructors/tutors and instructional design experts). The results revealed that the utilization of pedagogical approaches and techniques based on learning theories was not consistent nor widespread. The findings emphasize the importance of providing training and support to instructors/tutors of HOU as well as clear guidelines integrating pedagogical approaches and learning theories into the learning material, the educational activities and the course structure.

Keywords: e-learning; Hellenic Open University; mathematics; learning theories; Teaching approaches and techniques

Introduction

E-learning requires competences by the instructors/tutors to implement and support appropriate pedagogical practices and techniques based on learning theories (Bates, 2019). The utilization of learning theories for the design of distance learning material in the discipline of mathematics is of particular importance for how students learn and the development of their mathematical logic and thinking as well as for their problem-based and critical thinking skills. In order for educational institutions to continue to promote and support successful curricula, they must strengthen their teaching staff through continuous training in teaching and learning methods, approaches, techniques and tools (Harasim, 2012).

The subject matter of mathematics is characterized by complexity due to a plethora of axioms, theorems and sequences of rules that constitute it. E-learning in the field of mathematics requires from the instructor the competences to support both scientific knowledge and pedagogical approaches (Elrais, 2020). The rapid development of technology and the increased educational needs have given multifaceted dimensions to the role of the instructor (O'Neil, 2006). The goal in designing distance learning materials for mathematics is twofold. On the one hand, it should include the necessary scientific theories and appropriate activities related to the subject matter and on the other hand, it should be based and follow

appropriate pedagogical theories and approaches in order the expected learning outcomes to be achieved.

The importance of learning theories or/and instructional design models in the design of distance learning material has been recognized by the educational community (Saba, 2016). However, many teaching practices are still plagued by shortcomings, which can often be traced to the ineffective utilization and implementation of one or more learning theories (Dimitriadis, 2015; Saba, 2016). Lionarakis (2008) supports that in the context of distance education, a well-structured theory provides insights into what should happen, why it happened, and what should have happened. Creating educational materials requires careful preparation and appropriate pedagogical design (Lionarakis et al., 2020). In distance learning, these materials are designed to be clear, engaging, and supportive, allowing for independent study while promoting active participation of students and feedback. As Lionarakis et al., (2020) said, learning material aims to foster interaction, self-evaluation, and the acquisition of knowledge and skills. These materials should serve to answer the "what," "how," and "why" of learning in appealing and effective ways.

The Hellenic Open University (HOU), being the first Greek distance learning institution, has established innovations in the field of education by providing the ability of studying in any scientific subject remotely. Specifically, in the field of mathematics, it has developed courses at both undergraduate and postgraduate levels. The study of the attitudes, the educational practices and the pedagogical approaches applied in the first Greek distance education institution becomes of great importance for the development of good practices in the educational community (Niari, Manousou & Lionarakis, 2016).

The purpose of the present study was to investigate whether and how learning theories are being utilized by the instructors/tutors teaching mathematics in online courses at the HOU. The research was carried out during the academic year 2022-2023 and specifically in the winter semester. The study relied on a qualitative approach with the development of a semi-structured interview. Two instructional design experts and eight instructors who teach mathematics at the HOU participated. Based on the analysis of the qualitative data, the research findings emerged which are expected to be supportive for improving the educational practices used for online courses in mathematics.

Learning Theories and Mathematics

Teaching mathematics, with the primary role of the rules and theorems governing mathematical science, can be performed within a variety of educational environments based on different learning theories. Apostolopoulou, Panagiotakopoulos and Karatrantou (2014) point out that it is important for educators at any level of education, to be able to identify specific features of an educational application that relate to utilized learning theories in order to use the application pedagogically effectively, especially in subjects as mathematics and physics. The distance teaching of mathematics requires appropriate planning and organizational arrangements by the educational institution as well as by the instructors, as the role of the instructor is pivotal for the acquisition of knowledge (Cassibba et al., 2021). Although at the beginning of the 20th century the theory of behaviorism was established in the teaching of mathematics (Laurillard, 2001), the technological development and the widespread use of computers changed the data in instructional design and the utilization of learning theories.

DePruiter's (2013) research shows that both the use of behavioral methods and constructive applications can bring significant benefits in teaching mathematics by distance. The research suggests that both the use of rules and behavioral processes as well as the interaction that is developing in collaborative environments in distance education contribute to the acquisition of knowledge for learners. The same point of view is supported by Stoilescu (2016) who demonstrates the necessity for a multifaceted design regarding learning theories

in teaching mathematics and the important contribution that each learning theory can provide to the educational process.

Kumar and Sharma (2021) found that e-learning environments that adopt basic learning theories have higher rates of achievement of the expective learning outcomes. If the principals and the fundamental features of learning theories are not integrated into an educational environment, then success in students' learning cannot be guaranteed. In e-learning courses that are designed to achieve specific learning objectives based on either behavioral or constructivist approaches, communication between those involved can be facilitated and the learning process can be motivated. Also in the study by Lessani et al. (2016), the importance of adopting a constructivist approach and promoting inquiry learning in teaching mathematics is highlighted. These strategies are mainly aimed at cultivating students' critical thinking in their everyday experiences and enhancing both their cognitive and problem-solving skills and encouraging their active involvement in their learning. In this way, an e-learning environment that is properly designed under appropriate theories and pedagogical approaches could promote the learning experience among learners by maintaining their interest and effort in building knowledge (Kumar & Sharma, 2021).

HOU provides opportunities for individuals to pursue both undergraduate and postgraduate studies in the field of mathematics. According to Hatzinikolaou (2012), the postgraduate study program of the HOU, entitled "*Master's Studies in Mathematics*" offered since 2006 and is based on learning theories of cognitive psychology with the aim of integrating mathematical modeling in mathematics education. In research by Velentzas and Doukakis (2020), it appears that the development of educational material based on learning theories that promote active learning and collaboration activates students' interest and provides them with motivation for knowledge. Especially, the polymorphism of distance learning material with the simultaneous implementation of various learning theories principals and the participation of students in forums enrich the learning process (Velentzas & Doukakis, 2020; Giossos et al., 2009). Velentzas and Doukakis (2020) also showed that the utilization of constructivist theories and techniques promoting collaborative learning seems to be preferred by students.

In the research by Ahn and Edwin (2018), the contribution of learning theories, and especially social constructionism, to the distance teaching of mathematics is highlighted as well as the need for instructor's training in issues related to the utilization of learning theories in their teaching is highlighted. In the same research, the preference shown by the students for extracurricular activities and projects designed based on constructivist learning theories that promote cooperation and communication among the learners is emerged. Furthermore, online learning materials should include activities based on different learning theories, so that learners can choose the preferred ones according to their own needs (Ally, 2004; Alzaghou, 2012). Finally, activities based on constructivism seem to lead to effective learning in the mathematics field as they promote the interaction of learners with their studying materials (Bozkurt, 2017; Ahn & Edwin, 2018).

Aim of the study and research questions

The aim of the study was to investigate whether and how learning theories are being utilized by the instructors/tutors teaching mathematics in online courses at the HOU. Through the study of the relevant literature, the theoretical framework was formed, which then led to the formulation of the following research questions:

1. *Are learning theories utilized in the design and delivery of online mathematic courses according to the instructors/tutors?*
2. *In what ways are learning theories integrated into the practices of instructors/tutors in online mathematics courses?*

Methodology

The method utilized to collect and analyze the data of the present study concerns qualitative research. In particular, the methodology was chosen based on the needs of the research topic and the research questions and was that of the case study which offers a flexible qualitative research plan. According to Gay, Mills and Airasian (2017) the case study methodology is used in order to investigate the conditions, processes and situations concerning a research topic allowing it to be explored, analyzed and understood.

It is a fact that case studies are often characterized by a lack of clarity, as the researcher incorrectly applies the research process or is led astray by data that is not comprehensive, resulting in many times being led to hasty and ambiguous conclusions (Gay, Mills & Airasian, 2017). Furthermore, the generalization of the conclusions cannot easily be done through case study research. However, case study research enables researchers to highlight good practices or shortcomings that exist in a particular system aiming not to generalize conclusions (Gay, Mills & Airasian, 2017).

The research tool was a semi-structured interview. The interview questions formulated by the research team based on the literature trying to collect valuable information to answer the research questions. The interviews were transcribed, and the researcher carried out a content analysis with the theme as the unit of the analysis (*thematic analysis*) for the responses of all participants per question (Isari & Pourkos, 2015; Creswell, 2016).

The rules of conduct and ethics of the participants were followed. It was already ensured by the researcher's first communication with the participants, that was done via e-mail, and in which information about the purpose of the study, the protection of the confidentiality of the participants' personal data, their anonymity and respect for their opinions were offered. (Gay, Mills & Airasian, 2017). For these reasons, a coding of the participants was carried out, in order to avoid their personalized identification with the real persons. The coding of the participants is done using an appropriate identifier that informs about the scientific specialization and the number of the participant as well as the gender (Male: M / Female: F) (for example M1.M.= Mathematician1.Man., C1.F.=Computer's_Science1.Female., I1.M.= Instructional_Designer1.Man.)

Research tool

The research tool was a semi-structured interview. The questions were shaped by considering the findings from the literature review and the study's purpose. The semi-structured interview questions were organized into two sections. The first section gathered personal information from the participants, including age group, marital status, occupation, specialty, academic training, teaching experience, place of residence, and experience with e-learning courses. The second section delved into the use of learning theories in e-learning for mathematics. It contains five questions regarding *whether, which and in what ways* learning theories are utilized in the educational process. After conducting a pilot interview with an instructor, the final version of the questions formulated.

Validity and reliability of the research tool

For the needs of conducting the research, it was necessary to check the validity and reliability of the research tool (Rovinelli & Hambleton, 1977; Panagiotakopoulos & Sarris, 2017). To check the content validity of the interview questions, a two-member panel of experts (*one expert in instructional design in distance learning environments and one expert in technologies in distance learning environments*) was established, which checked the questions for appropriateness and completeness to cover the subject in breadth and depth according to the purpose of the research and the research questions and suggested corrections where this was deemed necessary.

A pilot interview was carried out with an instructor who teaches mathematics in the HOU, who did not participate in the research but has a similar profile to the participants. The pilot

interview, aimed to check the face validity of the research tool as the purpose was to check whether the questions were clear and understandable by the participant and whether the flow of the questions was smooth. It also gave the ability to determine the duration of the interview and other practical issues (Panagiotakopoulos & Sarris, 2017), contributing to the formulation and finalization of the interview framework.

All interviews were conducted via Skype. Both the detailed recording of the individual stages by the researcher during the qualitative research, as well as the review of the data during the qualitative analysis, contribute to ensuring the validity of the study (Panagiotakopoulos & Sarris, 2017). By detailed and accurately transcribing the interviews and unbiased analysis of the qualitative data, possible biased beliefs of the researcher were avoided.

To ensure the reliability of the qualitative data, the strategic process of collecting data from people with different characteristics was followed (Isari & Pourkos, 2015; Panagiotakopoulos & Sarris, 2017). With this method, the reliability of the study is ensured, as the information is based on different participants, of different ages, specialties, professional experience, and gender.

Validity and reliability of the data analysis

The data arose from the answers of the participants per question were transcribed and a thematic content analysis carried out (Isari & Pourkos, 2015; Creswell, 2016). In order to test the reliability of the content analysis, a simple procedure based on code reproducibility testing was utilized (Krippendorff, 2004). Two researchers acted as coders. The two researchers in collaboration (authors of the paper) contacted a thematic content analysis of the pilot interview in order to set up the coding procedure and agree on basic elements of the procedure. After that, each coder analysed and coded the data independently. At the end they compared the codes and discussed any disagreement in order to make common decisions. The percentage of agreement between the two coders was high indicating code reproducibility and content analysis reliability (Krippendorff, 2004).

Findings

The participants

A total of ten people participated in the research. Of these, six were men and four were women. Of the ten participants, six were instructors of mathematics at the HOU, two were computer scientists who teach mathematics in the HOU, and two were instructional designers who have been involved in the design of educational materials in the HOU.

Four of the participants had 11-20 years of experience in education, four participants 21-30 years and two had 1-10 years. The majority of the instructors had completed doctoral studies, while only two were master's degree holders and doctoral candidates. Finally, the participants selected for interview resides mainly in Patras, one in Ioannina, one in Agrinio and one in Crete. All the above conditions contribute to and strengthen the unbiased selection of the research sample, eliminating sampling factors that could affect the results of the research.

Data Analysis

The importance and contribution of learning theories in e-learning courses related to the course of mathematics was demonstrated through the literature review. Therefore, instructors should be aware of the basic pedagogical principles as well as follow and apply the basic principles underlying learning theories. However, this trend is not clearly observed in the HOU.

Through the interviews, it revealed that only six out of the ten participants based on the principles of specific learning theories to design and organize their educational activities in

such courses. Of these six participants, only three were mathematicians and two of them were women. The other two were educational design specialists and one was a computer scientist.

Among the four participants who answered that they have not utilize any learning theory, three were men and mathematicians and one was a computer scientist. Based on their answers, two patterns seem to have arisen: One of them does not care about learning theories and just follow guidelines but the other three seem to utilize principles of learning theories and design learning activities based to them without realizing it and working in a not organized way.

According to their answers they don't utilize any specific learning theory but they:

- use many examples to support students' understanding: *"No, I haven't applied any specific theory to the design of the material and the teaching activities. What I use were enough examples that support a particular subject so that students understand and acquire knowledge."* (M1.M.),
- try to adapt the learning material according to the specific needs of e-learning,
- update often the learning material based on the experience gained, the needs of the students expressed and students' attitudes-behaviors, as they derived during delivering the course,
- try to adapt the learning material according to the feedback from the students: *"No, I haven't used any specific learning theory. When I started to create the digital learning material I initially adapted the material for the needs of e-learning. Essentially, this material was updated every year and every semester based on experience, the needs of the students and their attitudes-behaviors. I find that the way I designed the teaching activities and improved them over time based on the feedback I got from students helped and made the material quite constructive. This can be seen from the performance of the students in the various activities-assignments and also from their feedback."* (M5.M.),
- try to offer to their students an intuition of what is happening behind the theory and why it is happening (*what is happening in practice and why*): *"Speaking in the narrow sense of the concept, no I have not used any specific learning theory. While teaching I use some things indirectly but what I am mainly interested in is to give an intuition of what is happening behind the theory and why it is happening."* (M6.M.),
- just follow the guidelines and the material offered by the HOU without thinking or designing anything more or different: *"On purpose, no. I have not studied the theories of learning. The truth is that as far as teaching is concerned, the HOU followed procedures that existed before. As an instructor/tutor, I joined a module related to mathematics that already had a way of functioning and I work in this way."* (C4.M.).

All the six participants who supported that they utilize principles of learning theories seem to be based on constructivist theories implementing constructivist approaches.

In particular, four of them supported the utilization of principles of the learning theory of behaviorism in combination with principles of constructivist theories: *"We usually use behavioral theories to get students into numerical analysis, to see, to get stimuli and to create or program themselves. But constructivism principles are also elements included in educational planning."* (M4.F.). A combination of different approaches based on different learning theories is emerging and this agrees with results in the literature.

The factors that led the participants to choose a particular learning theory are based on:

- the profile of the learners (*age, educational level, learning background*),
- the specific subject to be taught,
- the aimed degree of involvement of the learners in the educational process,
- the time available for designing learning activities and planning the lesson,
- the time available for implementing the learning activities: *"[...] with the age of the learners, with the specific subject and the way you will teach it, how much time do you have to plan and implement."* (M3.F.),

- the complex nature of mathematics,
- way each instructor/tutor would like to teach/work with the student. That depends on the beliefs and attitudes of the instructor about teaching and learning: “[...] *the age of the learners, their educational background and the way we want to teach them mathematics.*” (I2.F.),
- the attitude that the learner can understand several concepts through an experiential way,
- the belief that a student should develop many skills studying in an environment of graded difficulty.
 “[...] *In mathematics, through projects, the learner can understand several concepts through an experiential way, developing many skills in an environment of graded difficulty.*” (I2.F.)

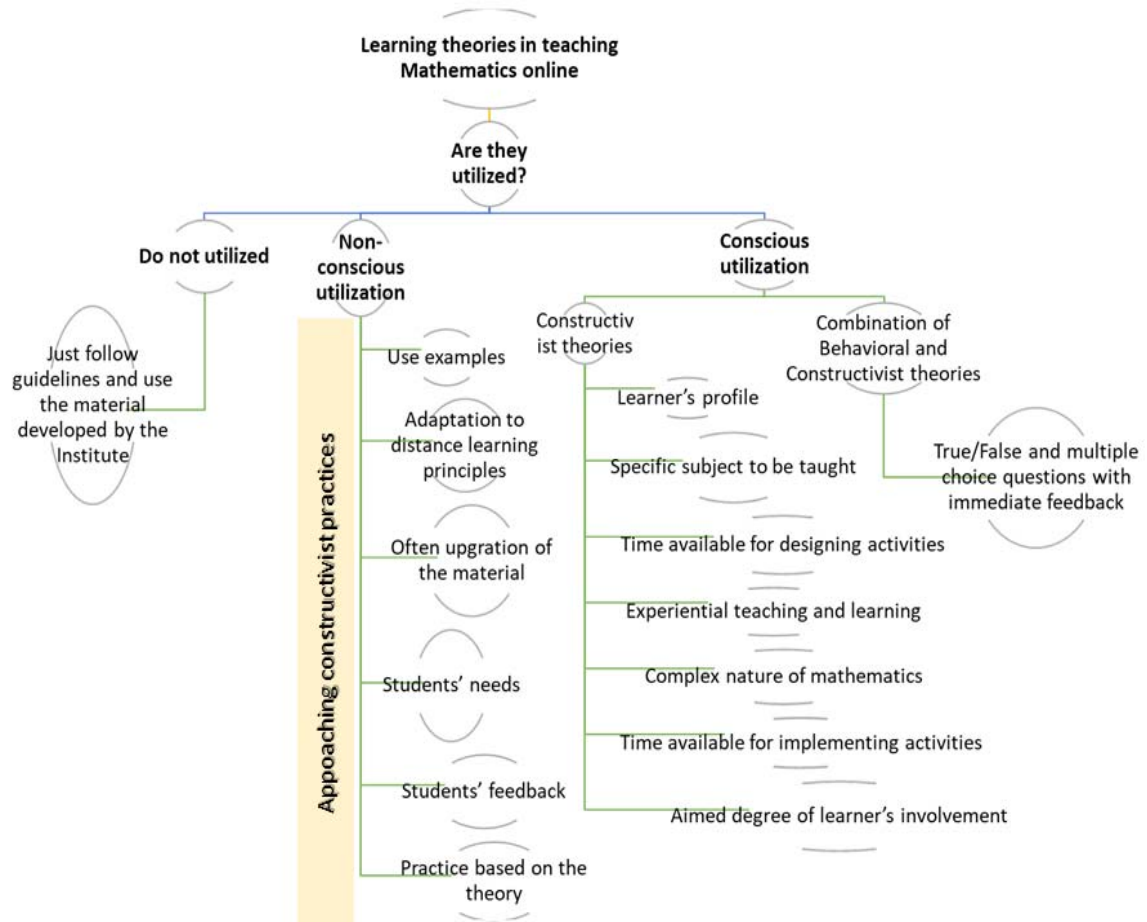


Figure 1. Thematic map of the analysis of the interview data concerning the 1st research question

According to the participants, the utilization of learning theories into distance learning material is feasible through:

- appropriately designed activities with specific learning objectives, guidance by the tutor, evaluation and feedback on the acquired knowledge: “*Through several properly designed learning activities, with a specific objective and appropriate feedback and guidance from me to check whether they have acquired knowledge of each unit.*” (C3.M.),
- many examples and case studies from the real world: “*Through learning activities, examples, case studies that correspond to real and not theoretical problems.*” (M3.W.),
- group learning activities for students calling them to interact and share knowledge and experiences: “*It is good to have group activities where students will use either remotely or face-to-face working in groups to have interaction and it is good that these activities make use of their experience.*” (M3.W.).

Furthermore, the participants highlighted the connection between the expected learning outcomes for an educational procedure and the suitable learning theory for that: *“depending on the expected outcomes, we also choose the use of the appropriate learning theory.”* (M3.W.), describing the added value that learning theories can provide in educational design and practice.

At the same time, the importance of fostering cooperation and communication skills for students, that can be accomplished through the effective utilization of suitable principles and approaches of learning theories is underscored. *“The acquisition of knowledge helps students satisfy their personal goals and fosters a sense of belonging to a group through teamwork activities involved in the learning process. It also encourages the development of autonomy, initiative, critical thinking, and creativity, allowing students to master skills across the entire range of cognitive abilities, from the simplest to the most complex.”* (I2.W.)

Participants considered that it is very important to *“lead the learners to self-acting based on their own previous experience to build the new knowledge, with or without support from the instructor depending on the nature of the e-learning program.”* (I1.M.), recognizing the importance, the effectiveness and the added value of the utilization of the constructivist learning theories in teaching and learning by distance.

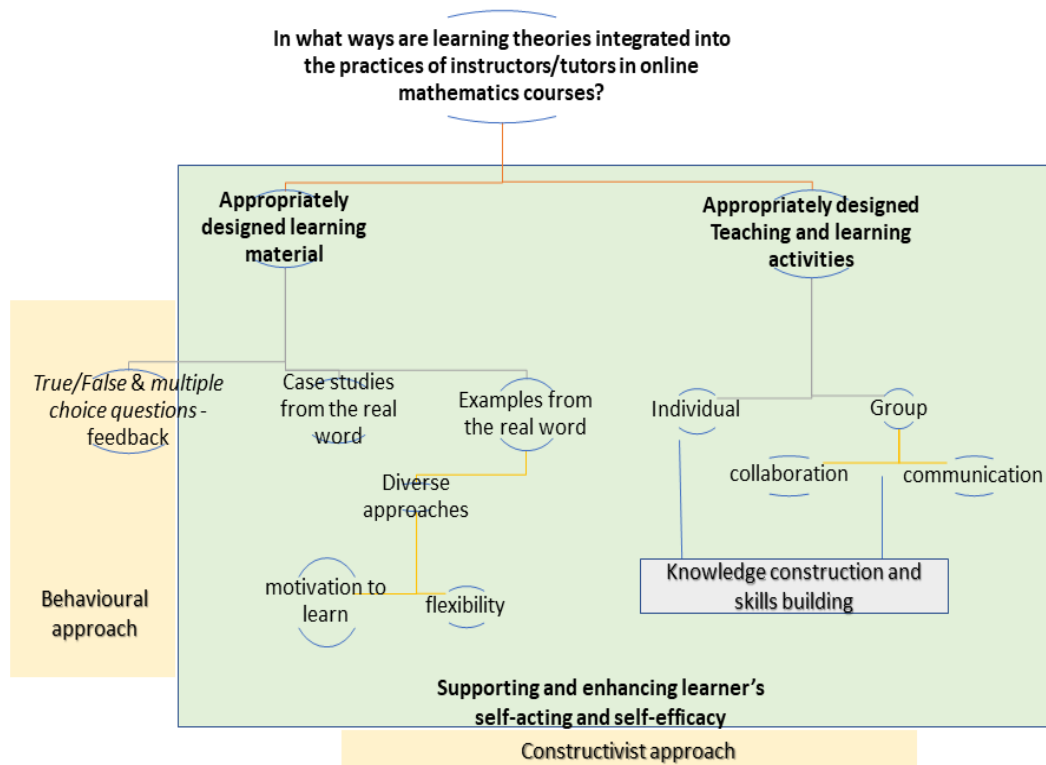


Figure 2. Thematic map of the analysis of the interview data concerning the 2nd research question

Participants also, emphasized the significance of self-efficacy in acquiring new knowledge and the cultivation of skills like cooperation and communication. Enhancing learners' self-efficacy was identified as a fundamental expected outcome of the utilization of learning theories in distance teaching and learning. *“The personal active involvement of the student, along with their autonomy and the acquisition of knowledge, leads to a sense of satisfaction derived from the process of learning.”* (M2.W.)

It is important to notice that, while there may be variations in the level of understanding and utilizing principles of learning theories among the participants, there is a consensus on the significance of incorporating principles of learning theories into the design of educational materials as well as into the design of educational activities, educational techniques and

practices. This alignment in thinking could indicate a recognition of the importance of considering students' developmental stages and needs when creating and delivering instructional resources and activities for students. Additionally, this shared perspective highlights the potential for collaboration and exchange of best practices among the participants to enhance the overall effectiveness of their educational approaches.

Discussion and Conclusion

Given the intricate nature of the scientific field of mathematics, the interactions between pedagogical theories and educational requirements, were highlighted by the findings of the study. The purpose of the study was to investigate *whether* and *in what ways* learning theories are utilized in the e-learning in the field of mathematics in the HOU according to instructors/tutors responses. Through the study of pedagogical methodologies and the utilization of learning theories within the first Greek distance education institution, an effort was made to point out effective approaches while identifying any shortcomings or limitations in the instructional framework of mathematics.

Regarding the first research question *“Are learning theories utilized in the design and delivery of online mathematic courses according to the instructors/tutors?”* it was found that there is not a common behavior regarding the utilization of principles of learning theories in HOU. This fact supported by the different opinions expressed by the instructors and the instructional designers participated in the study.

Six out of ten participants, comprising two instructional designers, three mathematicians, and one computer science instructor, seem to employ learning theories such as behaviorism and constructivism, or a combination of them. All the six participants who supported that they utilize principles of learning theories seem to be based on constructivist theories implementing constructivist techniques and approaches. Four of them supported the utilization of principles of the learning theory of behaviorism in combination with principles of constructivist theories. A combination of different approaches based on different learning theories is emerging. In order for the participants to choose a particular learning theory are based on the profile of the learners (*age, educational level, learning background*), the specific subject to be taught, the aimed degree of involvement of the learners in the educational process, the time available for designing learning activities and planning the lesson, the time available for implementing the learning activities. Furthermore, the complex nature of mathematics, the way each instructor/tutor would like to teach/work with the student, the attitude that the learner can understand several concepts through an experiential way are important choosing learning theories to adopt.

Four out of ten participants do not consciously adopt any specific theory in mathematics instructional design supporting that they have not received any relative training. Three of them were mathematicians and one computer scientist. The three seem to utilize principles of learning theories without realizing it. They use many examples to support students' learning, try to adapt the learning material according to the specific needs and characteristics of distance learning, update often the learning material based on the experience gained each time. They try to take into consideration the needs of the students expressed, to adapt the learning material according to the feedback from the students, to offer to their students an intuition of what is happening in practice based on the theory and explain why it is happening. One of them does not care about learning theories and just follow guidelines and use the material developed by the HOU without designing anything more or different.

The aforementioned observation emphasizes a notable deficiency in training regarding the design of distance education materials and teaching/learning activities, particularly in the realm of learning theories. The literature review underscores the necessity for e-learning in mathematics to be founded upon theories that foster both the construction of new knowledge and the active engagement of learners with their educational materials. Science instructors/tutors must not only possess extensive scientific knowledge within their

respective subjects but also possess the ability to comprehend and implement suitable pedagogical approaches (Van Driel et al., 1998).

Regarding to the second research question “*In what ways are learning theories integrated into the practices of instructors/tutors in online mathematics courses?*” a common ground is established. The utilization of learning theories into distance learning courses is achieved through appropriately designed learning material and teaching and learning activities or tasks, either group or individual, depending on the educational goals that have been set. For example, *True or False* questions that provide immediate feedback are supported by behavioristic approaches while tasks based on learner experience, whether involving case studies or group activities can be supported by theories of knowledge construction. Diverse approaches provide flexibility, motivation for learning to learners leading them to acquire new knowledge and build skills such as cooperation and communication.

In particular, instructor/tutors try to support the learning material through appropriately designed activities with specific learning objectives, guidance by the tutor, evaluation and feedback on the acquired knowledge. Many examples and case studies from the real world, group learning activities for students calling them to interact and share knowledge and experiences are important elements of a learning procedure that is supported by constructivist learning theories.

At the same time, the importance of fostering cooperation and communication skills for students, that can be accomplished through the effective utilization of suitable principles and approaches of learning theories is highlighted. Participants considered that it is very important to support the learners to self-acting based on their own previous experience to build the new knowledge, recognizing the importance, the effectiveness and the added value of the utilization of the constructivist learning theories in teaching and learning by distance. Participants also, emphasized the significance of enhancing learners' self-efficacy in acquiring new knowledge and the cultivation of skills like cooperation and communication.

The utilization of learning theories in e-learning courses could provide opportunities for learners to be engaged with the educational material in a more meaningful way, enhancing their motivation and interest in the subject matter. Additionally, the utilization of learning theories can help to create a more interactive and engaging learning environment, leading to better understanding of the learning content and increased satisfaction with the learning experience (Bates, 2015; Alzaghoul, 2012). Also, the study highlights the importance of utilizing learning theories in e-learning courses, emphasizing the potential benefits for learners and the added value that such theories bring to the educational design process.

In conclusion, the educational material and activities designed utilizing principles of the appropriate learning theory according to the expected learning outcomes provides flexibility and promote pedagogical practices for the mastery of the cognitive object. However, the non-existence of a common teaching trend and the impossibility of taking initiatives related to the upgrading and continuous training of instructors are obstacles for the orderly and competitive operation of the HOU's study programs. The necessity of training and supporting instructors in issues related to learning theories that will promote the educational process is demonstrated.

In order to properly support students to acquire mathematical knowledge, it is not enough having a deep knowledge of the scientific subject, but instructors should be knowledgeable about appropriate pedagogical theories and practices as well as ways of integrating them into the educational process. Wandering the paths of mathematics requires one to have as a fellow traveler the support and appropriate guidance. The instructor, setting his need for continuous training as of vital importance, marches towards his goal of evolving.

References

- Ally, M. (2004). Foundations of educational theory for online learning. *Theory and practice of online learning*, 2, 15-44. Retrieved from: https://ustpaul.ca/upload-files/DistanceEducation/FOUNDATIONS_OF_EDUCATIONAL.pdf
- Alzaghoul, A. F. (2012). The Implication of the Learning Theories on Implementing elearning Courses. *The Research Bulletin of Jordan ACM*, 11(11), 27–30. Retrieved from <http://ijj.acm.org/volumes/volume2/issue2/ijjvol2no5.pdf>
- Apostolopoulou, D., Panagiotakopoulos, C., & Karatrantou, A. (2014). Teachers' Perceptions for the Embedded Theories of Learning in Math and Science Educational Software. In C. Karagiannidis, P. Politis, I. Karasavvidis (ed's), *Research on e-Learning and ICT in Education. Technological, Pedagogical and Instructional Perspectives* (pp. 25-36). DOI 10.1007/978-1-4614-6501-0, Springer Science+Business Media, LLC 2014.
- Bates, A.W. (2019). *Teaching in a Digital Age – Second Edition*. Vancouver, B.C.: Tony Bates Associates Ltd. Retrieved from <https://pressbooks.bccampus.ca/teachinginadigitalagev2/>
- Bates, T. (2015). Thinking about theory and practice in online learning. Retrieved from <https://www.tonybates.ca/2015/07/29/thinking-about-theory-and-practice-in-online-learning>
- Bozkurt, G. (2017). Social Constructivism: Does It Succeed in Reconciling Individual Cognition with Social Teaching and Learning Practices in Mathematics?. *Journal of Education and Practice*, 8(3), 210-218. Retrieved from <https://eric.ed.gov/?id=EJ1131532>
- Cassibba, R., Ferrarello, D., Mammana, MF, Musso, P., Pennisi, M., & Taranto, E. (2021). Teaching Mathematics at Distance: A Challenge for Universities. *Education Sciences*, 11(1). <https://doi.org/10.3390/educsci11010001>
- Creswell, J. (2016). *Research in education: Designing, conducting, and evaluating quantitative and qualitative research* (2nd ed.). Athens: Ion.
- DePruiter, T. (2013). An Investigation of Teaching Strategies in the Distance Learning Mathematics Classroom. *Journal of Educators Online*, 10. doi:10.9743/JEO.2013.2.4
- Dimitriadis, S. (2015). *Learning theories and educational software* [Undergraduate textbook]. Kallipos, Open Academic Publications. Retrieved from <http://hdl.handle.net/11419/3397>
- Elrais, Y. (2020). The Reality of Using E-learning Strategies to Improve the Learning of Mathematics for Undergraduate Students. *International Journal of Higher Education*, 10, 75. doi:10.5430/ijhe.v10n3p75
- Gay, LR, Mills, GE, & Airasian, P. (2017). *Educational research, Quantitative and qualitative methods: Analysis and applications*. Athens: Propompos.
- Giossos, Y., Koutsouba, M., Lionarakis, A., & Skavantzios, K. (2009). Reconsidering Moore's Transactional Distance Theory. *European Journal of Open, Distance and E-Learning*, 12(2). Retrieved from <https://files.eric.ed.gov/fulltext/EJ911768.pdf>
- Harasim, L. (2012). *Learning Theory and Online Technologies*. New York/London: Routledge.
- Hatzinikolaou, M. (2012). *Mathematics and distance education at the Hellenic Open University*, Open Education: the journal for Open and Distance Education and Educational Technology, 8-21. doi: doi.org/10.12681/jode.9781
- Isari, F., & Pourkos, M. (2015). *Qualitative research methodology: Applications in psychology and education*. Athens: Greek Academic Electronic Textbooks and Aids. Retrieved from <https://www.kallipos.gr/el/>
- Krippendorff, K. (2004). *Content Analysis. An introduction to its methodology* (Second Edition). London: SAGE Publications.
- Kumar, V., & Sharma, D. (2021). E-Learning Theories, Components, and Cloud Computing-Based Learning Platforms. *International Journal of Web-Based Learning and Teaching Technologies (IJWLTT)*, 16 (3), 1-16. <http://doi.org/10.4018/IJWLTT.20210501.0a1>

Laurillard, D. (2001). *Rethinking University Teaching: A Conversational Framework for the Effective Use of Learning Technologies*. New York/London: Routledge.

Lessani, A., Yunus, A. S., Bakar, K. A., & Khameneh, Z. (2016). Comparison of learning theories in mathematics teaching methods. In *Fourth 21st CAF Conference in Harvard, Boston, Massachusetts, USA*, 9(1), https://www.21caf.org/uploads/1/3/5/2/13527682/14hrd-4111_lessani.pdf

Lionarakis, A. (2008). The theory of distance education and its complexity. *European Journal of Open, Distance and E-Learning, EURODL*, 2008(1), Retrieved from <https://old.eurodl.org/?p=archives&year=2008&halfyear=2&article=310>

Lionarakis, A., Manousou, E., Hartofylaka, A.-M., Papadimitriou, S., & Ioakeimidou, B. (2020). Editorial. *Open Education: the magazine for Open and Distance Education and Educational Technology*, 16(1), 4-8. <https://doi.org/10.12681/jode.23741>

Niari, M., Manousou, E., & Lionarakis, A. (2016). The Pygmalion effect in distance learning: A case study at the Hellenic Open University. *European Journal of Open, Distance and E-learning*, 19(1), 36-53. Retrieved from <https://www.cceol.com/search/article-detail?id=849088>

Panagiotakopoulos, X. & Sarris, M. (2017). *The Preparation of a Scientific Paper using ICT: an integrated approach*. Athens: Ion Publishing Group.

Rovinelli, R.J., & Hambleton, R.K. (1977). On the use of content specialists in the assessment of criterion-referenced test item validity. *Dutch Journal of Educational Research*, 2, 49-60. Retrieved from <https://eric.ed.gov/?id=ED121845>

Saba, F. (2016). Theories of Distance Education: Why They Matter. *New Directions for Higher Education*, 2016(173), 21–30. <https://doi.org/10.1002/he.20176>.

Stoilescu, D. (2016). Aspects of theories, frameworks and paradigms in mathematics education research. *European Journal of Science and Mathematics Education*, 4, 140–154. doi:10.30935/scimath/9460

Van Driel, J.H., Verloop, N., and De Vos, W., 1998. Developing science teachers' pedagogical content knowledge. *Journal of Research in Science Teaching*, 35(6), 673–695. doi:10.1002/(ISSN)1098-2736

Velentzas, I., & Doukakis, S. (2020). Using Learning Theories for the Creation of a Distance Digital Course in Mathematics for Higher Education. *European Journal of Engineering Research and Science*. doi:10.24018/ejers.2020.0.CIE.2311