THE EFFECT OF TEACHER TRAININGS ON THE ACCEPTANCE AND PERCEPTION OF THE ASYMPTOTE SYSTEM

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Abstract. This paper aims to present the first studies on an innovative technological system, ASYMPTOTE, designed after the Covid-19 pandemic to enable the teaching and learning of mathematics online. A training course (Long-Term Curriculum) on ASYMPTOTE was offered by three European institutions. The results regarding the reception of the training by the course participants are presented and their willingness to use ASYMPTOTE is investigated. The results show that the participants, both future teachers and in-service teachers, positively perceived the system and plan to integrate it into their teaching practices.

Key words: ASYMPTOTE, course experience questionnaire, technology acceptance model.

INTRODUCTION

According to the Technology Acceptance Model (TAM) (Davis, 1989), the success of integrating any innovation into education, be it related to pedagogical or technological issues, depends on teachers' attitudes and perceptions about it. Appropriate teacher training and support are crucial factors in shaping teachers' attitudes towards innovations, especially technological ones, and their intention to use them (Daher et al., 2018). Problems raised by the Covid-19 pandemic have 'forced' both teachers and students to make new use of technology, engaging them in a challenge that has seen a shift in teaching-learning from presence to online. These rapid changes inspired the Erasmus+ Strategic Partnership ASYMPTOTE. The project is being carried out by seven institutions from five European countries (Germany, Greece, Italy, Portugal, and Spain) and aims to develop an adaptive synchronous mobile system for teaching mathematics online.

This paper concerns the evaluation of the effects of a training programme designed to introduce the ASYMPTOTE system. This course, called Long-Term Curriculum (LTC, from here on), was delivered in Greece, by the University of the Aegean (UoAegean), which targeted in-service mathematics teachers. It was also addressed to future mathematics teachers in Italy, by the University of Catania (UoCatania), and in Germany, by the Goethe University of Frankfurt (UoFrankfurt). Our research aims to investigate the impact of the LTC on participants' attitudes toward the ASYMPTOTE system (about ease of learning, usefulness, attractiveness and enjoyment) and their intention to use it in the future.

In the following sections, we begin by explaining the theoretical foundations that frame the ASYMPTOTE project and the description of the technological system of the same name. We will then proceed by presenting the research methodology and data analysis after having explained our research questions. The conclusions will outline the results achieved.

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CONCEPTUAL FRAMEWORK

Educational processes were massively changed by the Covid-19 pandemic in the Spring of 2020: Instead of taking place at a common location, namely the classroom, teaching and learning took place in student's rooms. This unforeseen phase is described by the term *emergency remote teaching (ERT)* (Hodges et al., 2020). It describes the rapid establishment of alternative forms of instruction due to the distance learning situation.

In order to design effective online courses in line with the Community of Inquiry model (Garrison et al., 2000), Salmon (2013) proposes a five-stage model that divides online instruction into phases with different requirements for technical support and moderation. It not only focuses on a) interactive and collaborative course design but also emphasizes b) the need to familiarize students with the tools used and provide technical support.

During Covid-19 distance learning, both requirements could not be fully met. Among others, Barlovits et al. (2022) identified the following five main problems in a cross-national study of ERT online instruction:

- Loss of personal interaction caused by the spatial separation of teachers and learners and the shift of instruction;
- Lack of adequate formative assessment, i.e., teachers reported issues in monitoring students' learning progress, while students perceived a lack of feedback;
- Deficit of curricular resources regarding the availability of ready-to-use materials;
- Lack of technical equipment for student's participation in online courses;
- Lack of digital competencies among teachers and learners.

THE ASYMPTOTE SYSTEM

To address these two principles of online course design, the *ASYMPTOTE system* has been developed since March 2021. It aims to provide a free, adaptive, and technically low-threshold tool for delivering online mathematics education from secondary school to university (Barlovits et al., 2022).

In ASYMPTOTE, a collection of tasks is organized in a so-called learning graph. It consists of a linear sequence of mandatory tasks (main tasks) supplemented by tasks on an easier (support tasks) or higher level (challenge tasks). As the next task is proposed based on performance in the previous task, ASYMPTOTE takes a micro-adaptive approach (cf. Plass & Pawar, 2020). At the same time, students must take responsibility for their learning process, as the support and challenge tasks remain optional. In other words, ASYMPTOTE promotes students' autonomous and self-regulated learning (cf. Greene et al., 2011) in a micro-adaptive learning environment. For a detailed account of the learning graph concept and the ASYMPTOTE system itself, we refer to Barlovits et al. (2022).

Technically, ASYMPTOTE is developed as a two-component system consisting of a web portal and a mobile app. The web portal is the teachers' workspace. Here, teachers can select available tasks or learning graphics from an open database or create their own content. In addition, teachers can follow the students' working process in real time within the Digital

Classroom feature. In addition, the Digital Classroom offers a chat (images, text or audio messages), so that teachers and learners can directly get in contact.

In the mobile app, students can work on the learning graph. It is available for iOS and Android devices. The app offers up to three hints per task and an immediate answer validation after entering a calculated solution. Further, a sample solution can be displayed.

Returning to the issues of the ERT phase mentioned above, the ASYMPTOTE system aims to address these in the following ways:

- Personal interaction: providing a chat tool for synchronous communication between instructors and learners as part of the Digital Classroom feature;
- Adequate formative assessment: providing hints, answer validation and sample solution in the ASYMPTOTE app as well as offering a real-time monitoring function for teachers within the Digital Classroom feature;
- Curricular resources: providing an open database of exemplary tasks and learning graphs and offering the possibility for teachers to create their own contents
- Technical equipment: following a mobile learning approach, as only a smartphone is required on student's side;
- Digital competencies: providing an easy-to-use mobile app for students as well as a handbook and video tutorials for teachers on how to use the web portal.

Since ASYMPTOTE has taken an adaptive and mobile approach to learn, it mostly satisfies the identified issues for online mathematics education (cf. Barlovits et al., 2022).

MOTIVATION AND RESEARCH QUESTION

This study pursues the empirical objective of analysing the effect training in ASYMPTOTE has on a group of in-service and future mathematics teachers. Specifically, we are interested, on the one hand, in analysing the participants' evaluation of their reception of the *Long-Term Curriculum (LTC)*. On the other hand, we are interested in investigating the impact of the training on the participants' attitudes towards the ASYMPTOTE system and their intention to use it. The following research questions should be answered as a result of the study:

(1) What was the reception of the LTC by its participants?

(2) What willingness did LTC participants express for using ASYMPTOTE in the future in relation to their attitude to the system?

METHODOLOGY AND DATA SOURCES

The LTC is designed to be a balanced introduction to the theoretical background of online mathematics education as well as familiarity with the use and affordances of ASYMPTOTE. It is composed of four modules, as illustrated in Table 1. Each module has assigned a specific amount of ECTS adding to 3 in total. Moreover, the last column has the in-person session in hours for each module.

#	Module	ECTS	Est. Hours
1	Theoretical background	0.5	3.5
2	Teacher's perspective with creation of own tasks	1	7
3	Student's perspective	0.5	3.5
4	Testing of a learning graph and peer reviewing of tasks	1	7
	Total	3	21

Table 1: The structure of the LTC training content.

Participants and data collection

Two groups of LTC participants are under examination in this research. The first group concerns 17 participants that attended the LTC in UoAegean while the second group includes 19 participants who attended the LTC at the UoCatania (9) and UoFrankfurt (10). The main differences among the two groups are that a) the LTC of group 1 was conducted using the blended learning model with weekly asynchronous training modules via Moodle and synchronous teleconference sessions via Zoom. The LTC for group 2 was implemented using in-person sessions. Further, b) Group 1 includes mainly in-service teachers experienced in ERT while group 2 consists of students – future math teachers without experience of ERT of mathematics. At the end of the LTC, participants were given a questionnaire. It consisted of 4 parts: i) general information; ii) specific questions on the LTC modules; iii) Course experience; and iv) Willingness to use ASYMPTOTE. The LTC questionnaire can be accessed on the ASYMPTOTE website: urly.it/3r7fv.

The items of the two included standardised questionnaires, namely the Course Experience Questionnaire (CEQ; part iii) and the Technology Acceptance Model (TAM; part iiii), were given on a 5-Point-Likert Scales.

Course Experience Questionnaire

The *Course Experience Questionnaire (CEQ)* is an instrument used as a performance indicator of teaching quality and it studies the degree of quality and satisfaction of the participants of an academic program (Ramsden, 1991; Byrne & Flood, 2003). In this research, CEQ was used to assess the quality of teaching and dimensions of the learning quality, including 21 items divided into 5 constructs: a) "Good Teaching" (GTS), b) "Clear Goals and Standard" (CGSS), c) "Appropriate Workload" (AWS), d) "Appropriate Assessment" (AAS) and e) "Generic Skills" (GSS) focussing on the skill development along the course.

Technology Acceptance Model

To model users' acceptance of digital systems, Davis (1986) proposed the *Technology Acceptance Model (TAM)*. It aims to explore the influence that external factors, such as training, can have on an individual's internal attitudes and intentions, and provides a theoretical model for predicting user acceptance of technology. The TAM Model is grounded on the assumption that the use of a digital system is determined by a) "Intention of Use" (IoU). To determine this intention, the b) "Attitude" (AT) of a person toward the specific behaviour and c) the "Perceived Usefulness" (PU) of the system by the individual are

cumulatively taken into account. Moreover, a user's attitude is also related to d) the "Perceived Ease of Use" (PEU). External factors like e) "Perceived Attractiveness" (PA) of the ASYMPTOTE system, and f) "Perceived Enjoyment" (PE) of the LTC are further investigated. Detailed description of the CEQ and TAM items used per construction is available in the online version of the LTC Questionnaire.

RESULTS

The results for the CEQ and TAM questionnaires of group 1 and group 2 are presented to infer hypotheses about the impact of the LTC training on the in-service teachers (group 1) and the future teachers (group 2). The future teachers from UoCatania and UoFrankfurt can be considered as one group, since their answers to CEQ and TAM are homogenous according to the χ^2 test carried out.

Course Experience Questionnaire

Table 2 shows the descriptive statistics for CEQ including mean value μ, SD and Cronbach's α. It is notable that the construct's mean values are close to the maximum possible value. So, in general, the teachers receive the course very well in all its aspects.

CEQ			**UoAegean** GRE; N=17			**UoCatania & UoFrankfurt** ITA & GER; N=19		
Construct	*items*	*max*	*μ*	*SD (n-1)*	*Cron-bach's α*	*μ*	*SD (n-1)*	*Cron-bach's α*
GTS	6	30	25.24	3.65	0.77	24.89	3.41	0.74
CGSS	3/4*	15	12.71	1.45	0.60	12.47	1.50	0.65
AWS	4	20	15.00	2.29	0.59	15.21	2.66	0.69
ASS	3	15	11.12	2.76	0.66	12.11	1.85	0.66
GSS-TPK	4	20	17.00	2.09	0.77	17.21	2.18	0.74

* Item 3 for UoA CEQ and item 1 for UoC &UoF were excluded to increase Cronbach's α

Table 2: Descriptive statistics of CEQ.

However, medium reliability or agreement among the participants is shown by Cronbach's α for "Clear Goals and Standards Scale" (CGSS), "Appropriate Workload Scale" (SWS), and "Appropriate Assessment Scale" (AWS). That is considered expected because ASYMPTOTE is a new tool for the in-service and future teachers. Thus, it was not easy for participants to predict what would be their workload and their required performance. Further, the amount of workload subjective and thus varies significantly for each participant.

Technology Acceptance Model

In Table 3, the summary of the descriptive statistics for TAM is presented. All the constructs and the items have high mean values and narrow standard deviation. It seems that the teachers have a good attitude against ASYMPTOTE: they believe it is easy to learn, useful, attractive, and enjoyable so they declare the intention to use it in their classes.

TAM			**UoAegean** GRE; N=17			**UoCatania & UoFrankfurt** ITA & GER; N=19		
Construct	*items*	*max*	*μ*	*SD (n-1)*	*Cronbach's α*	*μ*	*SD (n-1)*	*Cronbach's α*
PEU	3	15	13.24	1.48	0.69	12.89	1.88	0.83
PU	3	15	11.71	1.83	0.77	12.26	2.23	0.85
PA	3	15	12.29	1.53	0.82	12.47	2.29	0.87
PE	3	15	12.71	1.53	0.83	12.68	2.14	0.92
AT	3	15	12.12	1.90	0.83	12.16	2.29	0.78
IoU	3	15	12.47	1.81	0.83	12.79	2.39	0.94

Table 3: Descriptive statistics of TAM.

For the LTC at UoAegean, we see that Cronbach's α is quite high for most of the constructs except "Perceived Ease of Use" (PEU). The latter one shows that the teachers do not have agreement on whether ASYMPTOTE is easy to use to the extent that they are with the other constructs of the TAM. On the other hand, and despite their varied opinions, it is notable that PEU shows the highest mean value of 13.24 of all six constructs. Similar is the situation to "Perceived Usefulness" (PU) where the teachers do not agree so much on questions: *PU2. I think ASYMPTOTE makes me more effective in teaching mathematics* (μ=3.82, SD=0.81), and *PU3. If I use ASYMPTOTE to teach mathematics the students will learn more easily* (μ=3.59, SD=0.80). It seems that some teachers have some doubts regarding the system's effectiveness in making teaching and learning substantially easier.

For the LTC at UoCatania and UoFrankfurt, Cronbach's α is quite high for all the constructs. The lower value of 0.78 concerns the construct "Attitude" (AT). Even if most the participants express a highly positive attitude towards ASYMPTOTE (μ=12.16, SD=2.29), they seem to disagree on item *AT3. Using ASYMPTOTE is the best way to teach mathematics in Emergency Remote Teaching* (μ=3.63, SD=0.9). Similar is the situation to PU where the future teachers do not agree so much on the question *PU3. If I use ASYMPTOTE to teach mathematics the students will learn more easily* (μ=3.79, SD=0.79). These data show that some future teachers express the same skepticism, as in-service teachers, regarding the system's effectiveness in making learning substantially easier.

Figure 1 shows the TAM model. Since all constructs are significantly correlated in pairs (Spearman's rank order correlation r, α=.05), in accordance with the TAM model, the theoretical claims of TAM are valid in the specific case of LTC participants' answers. The TAM analysis support the hypothesis that the LTC participants are possible to use ASYMPTOTE in the future and systems quality along with training had a significant impact on this result. Comparing TAM, using the data of Table 3 and Figure 1, among the two groups, mostly similar results can be observed. However, in the case of group 2 (LTC at UoCatania and UoFrankfurt) the relations between PEU and AT are not so powerful (p=0,043). So, it seems that either there was a difference in the training of the 2 groups that resulted in the future teachers having a lower PEU, or/and the difference is due to the experience that the in-service teachers had in ERT which lead to them finding the system easier to use than the students. Since ASYMPTOTE is not as complex to use the hypothesis that experience in ERT

makes familiarization in ASYMPTOTE easier and results in better PEU values seems more possible.

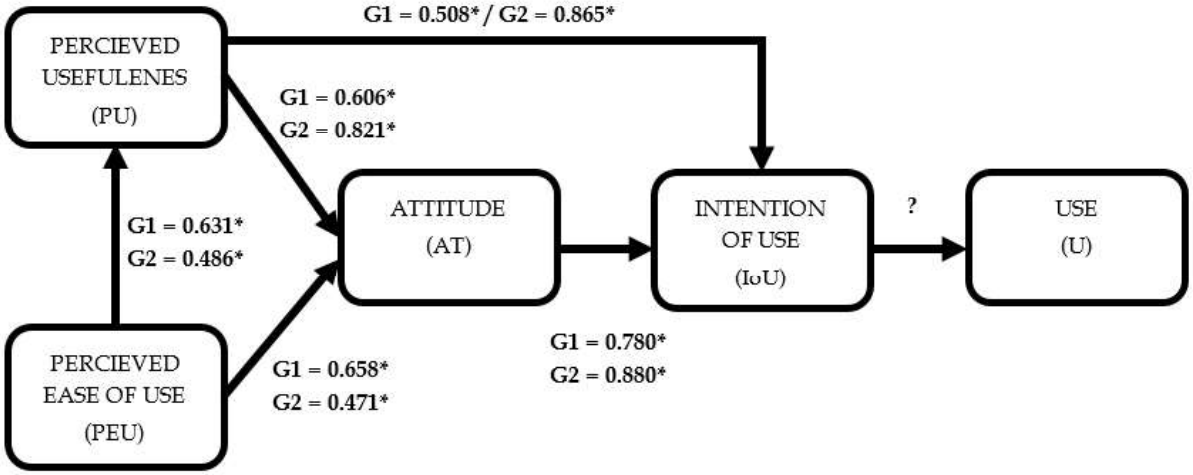

Figure 1: The TAM model verification by the LTC data for G1 (in-service teachers; UoAegean) and G2 (future teachers; UoCatania & UoFrankfurt).

Two external factors, i.e., "Perceived Attractiveness" (PA) and "Perceived Enjoyment" (PE) were included in the questionnaire. The results show that both must be considered as important factors for the acceptance of ASYMPTOTE, as they are strongly related to all theoretical constructs of the TAM (PU, PEU, AT, IoU). Overall, the LTC supported the participants to recognize the ASYMPTOTE's system advantages and formulate a positive attitude toward its integration into their educational practice. It is reasonable to support the hypotheses that ASYMPTOTE was received well by the participants as an attractive and engaging digital teaching/learning tool.

CONCLUSION

In the present study, the ASYMPTOTE system for teaching and learning mathematics online was presented during a training programme (LTC). Both, in-service teachers from Greece and future teachers from Italy and Germany participated in the course, which was evaluated by a questionnaire. In view of the *course experience* of the participants, both groups perceived the course very well in all its aspects (see CEQ). Regarding their *willingness to use the system* in the future (see TAM), we can observe that both groups showed a positive attitude. One difference between the two groups can be found in their perception of how easy to use is the system. It is plausible to assume that this difference in attitude is to be found in their prior teaching experience. In fact, while in-service teachers have also worked during the ERT, future teachers have not yet been able to gain any concrete teaching experience. Another possible explanation for this finding might be grounded in the different availability of ready-to-use resources between the three countries. It can be assumed that there is a larger number of available learning platforms and materials in Italian or German than in Greece. Regarding the intellectual merit of the project, we would like to emphasise how the ASYMTPTOTE system and in particular these first training courses for (future) teachers have impacted on the mathematical knowledge of the participants in terms of how

they can integrate a new technology into their teaching practices in order to facilitate online mathematics learning. In addition, this work contributes in general to the design of the evaluation of teachers' education and training for using digital technology in education. A limitation of this study is certainly the small and heterogeneous sample to which the LTC was proposed. Furthermore, both groups constitute small numbers to be able to consider the statistics obtained as general. However, these results are the first obtained in terms of knowledge and readiness to use ASYMPTOTE. Since the system is still being developed, further studies need to be conducted on how in-service and future teachers experience the system after its further developments.

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References

Barlovits, S., Caldeira, A., Fesakis, G., Jablonski, S., Koutsomanoli Filippaki, D., Lázaro, C., Ludwig, M., Mammana, M. F., Moura, A., Oehler, D.-X. K., Recio, T., Taranto, E. & Volika, S. (2022). Adaptive, Synchronous, and Mobile Online Education: Developing the ASYMPTOTE Learning Environment. *Mathematics, 10*(10), 1628.

Byrne, M., & Flood, B. (2003). Assessing the Teaching Quality of Accounting Programmes: An evaluation of the Course Experience Questionnaire. *Assessment & Evaluation in Higher Education, 28*(2), 135–145.

Daher, W., Baya'a, N., & Anabousy, R. (2018). In-Service Mathematics Teachers' Integration of ICT as Innovative Practice. *International Journal of Research in Education and Science, 4*(2), 534–543.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use and user acceptance of information technology. *MIS Quarterly, 13*(3), 319–340.

Garrison, D. R., Anderson, T., & Archer, W. (1999). Critical inquiry in a text-based environment: Computer conferencing in higher education. *The internet and higher education, 2*(2-3), 87–105.

Greene, J., Moos, D., & Azevedo, R. (2011). Self-regulation of learning with computer-based learning environments. *New directions for teaching and learning,* 449, 107–115.

Hodges, C., Moore, S., Lockee, B., Trust, T., & Bond, A. (2020). The difference between emergency remote teaching and online learning. *Educause Review, 27*, 1–12.

Plass, J. L., & Pawar, S. (2020). Toward a taxonomy of adaptivity for learning. *Journal of Research on Technology in Education, 52*(3), 275–300.

Ramsden, P. (1991). A performance indicator of teaching quality in higher education: The Course Experience Questionnaire. *Studies in higher education, 16*(2), 129–150.

Salmon, G. (2013). *E-tivities: the key to active online learning* (2nd ed.). Routledge.