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# Professional development online: The impact of the ASYMPTOTE MOOC on (future) teachers' meta-didactical praxeologies

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*This paper focuses on a professional development programme delivered via MOOC in order to introduce future and in-service mathematics teachers to the ASYMPTOTE system. It is a two-component system (web portal and app) designed to enable teachers to provide synchronous and adaptive mathematics lessons online. Since (future) teachers are involved in activities in which they work and learn in contact with researchers, the MOOC instructors, it is significant to focus on how participation in the MOOC influenced the meta-didactical praxeologies of its participants by considering the Meta-Didactical Transposition (MDT) model. The data we consider is derived from participants' answers to questionnaires and their creations using the ASYMPTOTE system. The findings showed that the MOOC enabled teachers to get familiar with the ASYMPTOTE system and be able to use its affordances to an extent.*

*Keywords: ASYMPTOTE, MOOC, online mathematics, meta-didactical transposition.*

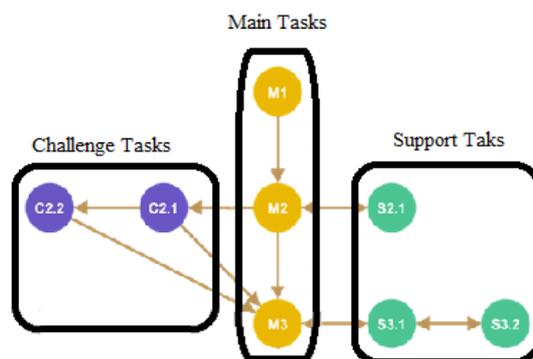
## Introduction

MOOCs are online courses, usually structured on a weekly basis, that include: (1) specific learning activities that participants are expected to get involved in; (2) specific course material that they need to use; (3) and an evaluation process for their outcomes (Taranto & Arzarello, 2020). In addition, MOOCs are free courses, open to anyone through the web, and massive in terms of the great number of participants from different demographic areas. MOOCs have gained interest as a new form of e-learning in higher education and professional development programs, also in mathematics (Taranto & Arzarello, 2020). It has been observed that teachers and future teachers often enter such online spaces to find professional learning opportunities (Anderson, 2020). In this paper, we focus on an international MOOC as part of the Erasmus+ project ASYMPTOTE. The MOOC was aimed at future and in-service mathematics teachers. It was designed to be a balanced introduction to the theoretical background of online mathematics education as well as familiarity with the use and affordances of the ASYMPTOTE system (more on this in the next section). The aim of the study is to investigate what impact did the content covered in the MOOC have on the professional practices of the participants. In fact, 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).

## The ASYMPTOTE project and the homonymous system

ASYMPTOTE [Adaptive Synchronous Mathematics Learning Paths for Online Teaching in Europe] is a project that aims to develop an effective, powerful, and easy-to-use digital tool for online mathematics teaching. The ASYMPTOTE project enables teachers to provide synchronous and

adaptive mathematics lessons online with a low barrier for students, who only need a smartphone and an active internet connection. The project has been started due to the challenges both students and teachers faced during the Covid-19 pandemic (Lemay et al., 2021). The new situation “shocked teachers at all levels and at the same time inspired them to find solutions to problems they have not encountered before” (Flores & Swennen, 2020; p. 456). Much emphasis was placed on the importance of personal support and teachers’ feedback for students’ distance learning (Lemay et al., 2021). A promising approach to reduce the self-organisation of individual student learning was the synchronisation of the teaching process through the use of digital tools (cf. Barlovits et al., 2021): As in the classroom, students should be able to ask questions that the teacher can answer immediately and get direct feedback on their solution. Therefore, the use of digital media should enable teachers to monitor students’ learning progress and provide them with real-time support (cf. Barlovits et al., 2021). Following this idea, the ASYMPTOTE project consists of a web portal and an app. The web portal has been created to provide a database of tasks (including task formulation, hints and solution examples) on different primary, secondary and university level learning topics. On the web portal, teachers can select ready-made tasks or create their own. Using these tasks, the teachers can create an individualised, adaptive and self-regulated learning trajectory presented in the form of a graph - the so-called learning graph (LG) (Barlovits et al., 2022). On the smartphone, students are able to access the LG appointed to them and receive systemic and synchronous feedback on their entered solution. The core of a LG is made up of a sequence of mandatory main tasks, which are complemented by support and challenge tasks (Figure 1).



**Figure 1: Example of a LG in ASYMPTOTE**

The optional support tasks aim to help students to deal with the main tasks, e.g., by offering an easier version of the task or giving a rehearsal of already known topics. The challenge tasks can be unlocked after solving the related main task and they offer a more difficult version of the task in order to deepen student’s understanding of the given topic. A more detailed description of the LG concept and its inherent micro-adaptivity can be found in Barlovits et al. (2022). To allow the creation of various tasks, the system provides 9 different answer formats: exact value, interval, multiple choice, fill in the blanks, vector (exact value), vector (interval), set, fractions, information station. Besides the ability to create training tasks, special attention is drawn to the creation of reasoning and modelling tasks, since a fall back on basic computation task types was observed during the Covid-19 distance education (Barlovits et al., 2021). The students work on the LG in the free ASYMPTOTE app which is available for Android and iOS. Within the “ASYMPTOTE Tutorial Graph” (available in the app by entering the code G47109), we introduce the student’s perspective and workflow in the app, as well as examples of the 9 answer formats.

## **The MOOC “ASYMPTOTE: teaching and learning mathematics online”**

The MOOC “ASYMPTOTE: teaching and learning mathematics online” was created as an open and freely accessible MOOC which aimed mathematics teachers and future teachers to build up their awareness of the potentials of using the ASYMPTOTE system in mathematics education. It lasted 10 weeks, between October and December 2022. Moreover, it included 30 hours of training which was divided to a commitment of about 3 hours workload per week. 129 participants enrolled in the MOOC and 47 completed it successfully. The MOOC was delivered via DI.MA. Moodle platform (<https://dimamooc.unict.it/>) in English language. Among the resources offered to support online learning were videos created in English with the possibility of selecting subtitles in the project partnership languages (German, Greek, Italian, Portuguese and Spanish). The presence of qualified instructors from all countries involved in the ASYMPTOTE project guaranteed successful monitoring of the participants’ learning pace and appropriate support if needed. The ten weeks of the MOOC were divided into 7 modules which were organized as follows: The introduction (first week) was to get to know the ASYMPTOTE project and the MOOC instructors. Module one (two weeks) was to learn more about ASYMPTOTE and its theoretical background. In the modules from two to five (one week each), the participants were to design 9 math tasks which then had to be structured in a LG during the subsequent final module (two weeks). Afterward, the LGs were peer reviewed. The 9 maths tasks that the participants were asked to design, had to be divided as follows: 2 training, 2 reasoning, 2 modelling, 1 challenge, 1 supportive and 1 challenge or supportive. Each submission was reviewed by the MOOC instructors, directly on the ASYMPTOTE system. Each module of the MOOC was associated with a badge that was automatically awarded by the platform when the module’s homework (e.g., the design of math tasks) was completed. To successfully complete the MOOC, it was necessary to obtain all badges during the course.

### **Theoretical framework**

The theoretical framework of Meta-Didactical Transposition (MDT) is a model for dynamically interpreting teachers’ activities as they work and learn in communities within institutions, in contact with researchers (Arzarello et al., 2014). This is relevant to the ASYMPTOTE MOOC as its participants were (future) teachers who attended a MOOC designed by university researchers belonging to the homonymous European project partnership. MDT makes use of the notion of didactical praxeology<sup>1</sup> (Chevallard, 1999) within the context of the didactical transposition, as it concerns teachers instructing/tutoring in class. Referring to teachers as learners engaged in professional development activities, MDT considers their praxeologies in a learning situation: for this reason, these praxeologies are called ‘meta-didactical’. The meta-level means that teachers are simultaneously considered as learners and as teachers that reflect on their didactical praxeologies (Robutti, 2018). At both levels (didactical and meta-didactical) a praxeology is made up of 4 components, according to Chevallard (1999): task, technique, justification and theory.

As outlined in Taranto et al. (2020), an example of the components of a didactical praxeology (of a teacher in a classroom) could be itemized as follows: introducing students to the type of task; how to

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<sup>1</sup> Chevallard, in his *Anthropological Theory of the Didactic*, provides a frame for investigating mathematical and didactic activities in terms of praxeologies, focusing on their components, dynamics, and the conditions that enable their existence and development in a given institutional setting. The main idea of the concept of didactical praxeologies is that all human activities comprise and link two parts, a practice and a theory one.

organise such an approach; why one has to organise it like that; why one knows that one has to organize it like that. An example of components of a meta-didactical praxeology (of a teacher in professional learning) could be as follows: solving an assigned didactical task; how to solve it; why one has to solve in such a way (justifying discourses); why one knows that one has to organise it like that (theoretical references). The given task and the technique used to solve the task are the pragmatic components of the praxeology, while the justification and the theory are the theoretical components that validate the use of that technique. The components can be considered as internal or external to a community (or to an individual): they are internal if used by members of a community (or by an individual) and external if not used. Thus, for example, the ASYMPTOTE system is an internal component for the instructors of the previously mentioned MOOC, but it is external for the teachers who enrol in the MOOC. The goal of a teacher professional development program is to transform praxeological components that are initially external to the teachers' community into internal ones (e.g., tasks and techniques around the use of technology for learning, theoretical results from research on teaching, ...). If one or more components of a praxeology shift from external to internal (i.e. internalization process), then the community of teachers can evolve towards a sharing of this component amongst the community members, along with the researchers (considered in the role of teacher educators).

## **Research question & methods**

In this study, we are interested in answering the following research question: *How does participation in the ASYMPTOTE MOOC influence (future) teachers' meta-didactical praxeologies in designing tasks using ASYMPTOTE system?* Therefore, we focused on the following praxeological components (1) the task, i.e., design of digital math tasks, (2) technique, i.e., using ASYMPTOTE for task design, (3) justification as an appropriate teacher design of the LG (e.g., arrangement of tasks and their identification as main, challenge or support) and (4) theory, i.e., how to teach and learn mathematics online.

The data collected for this study were retrieved from a Pre-course Questionnaire (PQ) that the participants were asked to fill in in the introductory module of the ASYMPTOTE MOOC, a Final Questionnaire (FQ) that was administered to the participants after the completion of the MOOC and the participant's LGs which were produced during the final module of the MOOC. Both the PQ and the FQ (you can find them here: <https://www.asymptote-project.eu/en/research/>), consist of three types of questions: multiple choice, Linkert scale and open questions. More specifically, the PQ was divided into six general categories: 1. General information (demographics), 2. Studies, 3. Teaching experience, 4. Use of ICT tools, 5. MOOC past experiences and expectation 6. Previous experiences and knowledge in task design. Similarly, FQ was classified into three general categories: 1. General information (demographics), 2. Opinions and suggestions about the MOOC and 3. The use and attitudes towards the ASYMPTOTE system. Both the PQ and FQ were administered via google forms and the quantitative analysis was done with Microsoft Excel. The method of analysis that was used is the mixed approach with both quantitative and qualitative data accumulation. In particular, the qualitative analysis is in regard to the open questions of the FQ. The answers of the participants were documented and general response categories were identified. The individual responses were also identified and in the end, the final categories were organised and quantitatively analysed.

## **Sample & pre-conditions**

The sample of the analysis of this study is the 47 participants (32 female, 14 male, 1 prefer not to say) who successfully completed the ASYMPTOTE MOOC. The participants were mostly university students that are planning to become teachers (future teachers, 60%) and in-service teachers (28%). The other participants were also related to mathematics education, e.g., teacher trainers. The fact that most of the participants were future teachers explains the high number of participants that did not have any teaching experience (32%) or had teaching experience only a few months (23%). One of the factors that are important going into this analysis, is the previous experience of the participants in the use of ICT tools when teaching mathematics. More specifically, the data shows that the majority of the participants did not use ICT tools in teaching mathematics (45%) which is in line with the fact that the majority of the participants are future teachers with no or small teaching experience. While around 40% of the participants defined their ability to design mathematical tasks as “Fair”, the 30% stated to have “Poor” or “Absolutely poor” pre-knowledge. Interest arises also from the participants’ answers on what tools or resources they use to design tasks for their students. As expected, a high quota of the participants (26%) declared that they had never designed tasks in the past. The others, instead, explained how they used to design them: e.g., “my creative vein” (17%), “Dynamic Geometry Systems” (16%), “resources found on the Internet” (16%) and “textbooks” (14%).

## **Findings**

In order to determine the impact of the MOOC on participants’ meta-didactical praxeologies, it is important to analyse the way the participants used and viewed the ASYMPTOTE’s affordances. Especially we documented changes in (1) their task design skills, (2) their technique and ability to use ASYMPTOTE for their designs, (3) the justification of their designs in the ASYMPTOTE online environment and (4) their theoretical foundation in teaching and learning mathematics online.

### **Meta-didactical component: Task and technique**

Although 20 participants characterised their design skills as only “Fair” and had never used ICT tools in teaching mathematics, all 47 managed to successfully design LGs and to utilise a plethora of the possibilities that the ASYMPTOTE system provides. The participants created a variety of tasks from “Geometry” (148 tasks), “Calculus & functions” (146), “Algebra, numbers & operations” (103) and “Probability & statistics” (36) for primary and lower or upper secondary education. A total of 433 mathematical tasks were created during the MOOC. Note that the majority of the participants (89%) created LGs with 9 tasks as they were encouraged to by the MOOC instructions, while some (11%) created LGs with more tasks than required. All the participants complied with the instruction to incorporate 2 tasks of each task type (training, reasoning, modelling) into their designs. Regarding the tasks for which they were free to choose the type of task (i.e. when they had to choose to work on challenge and support tasks), the majority (63%) chose to design training tasks. However, a notable quota of participants created more complex task types like reasoning (20%) and modelling (17%).

Participants were also free in structuring their LGs with respect to the relation of challenge and support tasks. An equal distribution was observed despite the fact that support tasks were graded as “very easy” to create by more participants (70%) than challenge tasks (45%) and challenge tasks were graded “not at all easy” by a higher percentage (11% vs 6%).

A very important factor for task creation when using technologies is the answer formats that the system supports. It is one of the main elements that sets the limitations and the prospects for the creators. From the 9 answer formats that the system provides, the participants used mainly 3. The “multiple choice” format was used in 51% of the tasks, followed by the “fill in the blanks” with 24% use and the “exact value” with 17%. The other 6 answer types were altogether used in less than 9% of the total tasks. Moreover, from analysing the produced LGs it was observed that participants persisted on specific task types: 15 participants used at maximum two answer formats, 23 used three and only 9 participants used four or more answer formats. These observations can be explained either by the inexperience of the participants with the system or the general tendency to stick to the familiar.

### **Meta-didactical component: Justification**

Despite the fact that the MOOC participants limited themselves to an almost repetitive use of answer formats, they do not identify this as one of the main difficulties they faced when using ASYMPTOTE to create their LGs. Only 3 out of 47 participants faced problems with the available answer formats, while 4 mentioned the optional use of LaTeX as an obstacle. 6 participants identified the need for mathematical creativity and the general difficulty of task design as a challenge, while 5 named the structuring and the LG creation process. Other problems that the participants identified were regarding: the task types (2), the hints (2), image insertion boundaries (2) and learning the system (3). On the contrary, a big number of participants (20) mentioned no difficulties whatsoever.

### **Meta-didactical component: Theory**

Concluding with the analysis in order to determine the impact of the system on participants’ meta-didactical praxeologies, it is important to take a look at their views and attitude towards the system after using it. The majority of the participants (66%) feel that ASYMPTOTE made them more effective in teaching mathematics (40% agree, 26% strongly agree). Concurrently, 87% of the participants are interested in using ASYMPTOTE (47% agree, 40% strongly agree) and 79% predict that they will use the system in the future (45% agree, 34% strongly agree). In a 5-point Likert scale question, an impressive 81% of the participants replied that they feel that the MOOC developed their ability to utilise digital technology in teaching mathematics (60% agree, 21% strongly agree) and a 64% feels that the MOOC developed their ability to teach online (43% agree, 21% strongly agree).

## **Discussion and conclusion**

The Covid-19 pandemic was experienced as a major challenge for teachers and students (Lemay et al., 2021). While dealing with distance learning led to the development of new forms of teaching (Flores & Swennen, 2020), it also brought along several issues, such as a high demand on students’ self-organisation, a lack of direct feedback and increased use of simple computational tasks (Barlovits et al., 2021). Within the ASYMPTOTE system, an approach to address these issues of distance and online teaching is presented in this paper. In addition, a MOOC for (future) teachers on how to use the ASYMPTOTE system is described. The MOOC was conducted in autumn 2022 with a total number of 129 participants. Of these, 47 successfully completed the course, resulting in a completion rate of 32% which is considerably higher than other MOOCs for professional development purposes (e.g., 11% in Panero et al., 2017). On the other hand, this positive result is limited by (i) the relatively low number of participants compared to other MOOCs, and (ii) the high number of future teachers, who partially participated in the MOOC as part of their academic studies.

The paper aims to analyse the impact of the MOOC on participants' meta-didactical praxeologies. Hereby, we focussed on (1) the task level, (2) technique, (3) justification, and (4) theory. The results of the study can be summarised as follows: (1 & 2) When designing the tasks, most participants only used a maximum of 3 out of 9 available task types to create the tasks. In particular, the "Multiple Choice" format was used in half of the tasks created, followed by "Fill in the Blanks" in about a quarter of the tasks. Both results can be seen as an indicator that more examples of the use of the different task types should be given in the ASYMPTOTE web portal. (3) All participants were able to successfully design tasks and LGs and a large number of them considered it an easy process even though the majority had no or small experience in using ICT tools and task design. Therefore, we assume that the creation of learning content in the ASYMPTOTE web portal is well manageable after participating in the MOOC. This impression is supported by the finding that the vast majority of participants indicated that their way of teaching mathematics was improved by using ASYMPTOTE and that they are willing to continue using it in the future. (4) Related to the theoretical module of the MOOC, a large majority agreed that they have developed their ability to use digital technologies in mathematics teaching and to teach mathematics online. The participants thus seem to feel confident in transferring the input from the theoretical module of the MOOC into teaching practice. However, this satisfying result in terms of personal development must be seen as limited due to the participants' limited experience in teaching and using digital tools.

Nevertheless, we conclude that the MOOC enabled teachers to get familiar with the ASYMPTOTE system in self-study and to take advantage of ASYMPTOTE's micro-adaptivity. Moreover, in view of the created support and challenge tasks, the MOOC encouraged participants to anticipate potential difficulties or interesting bonus material by making predictions about their students' possible learning processes (cf. Mammana et al., 2023).

## **Outlook**

The study showed the need for more detailed documentation of the task development process in the ASYMPTOTE web portal (see (1 & 2)). Therefore, a manual was developed at the beginning of 2023. In view of further research on the ASYMPTOTE MOOC, more answers will be analysed in a next step to deepen our impression of the participants' learning process. Moreover, case studies on the quality of the LGs created during the MOOC are planned. On the process dimension, we will be investigating how the tasks were improved after the first review by an expert and the subsequent review by a peer. On the product dimension, the quality of the tasks created during the MOOC will be compared between teachers and future teachers.

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