ICME-13 Monographs

Jason Silverman
Veronica Hoyos *Editors*

Distance Learning, E-Learning and Blended Learning in Mathematics Education

International Trends in Research and Development

ICME13
Hamburg 2016

Springer

ICME-13 Monographs

Series editor

Each volume in the series presents state-of-the art research on a particular topic in mathematics education and reflects the international debate as broadly as possible, while also incorporating insights into lesser-known areas of the discussion. Each volume is based on the discussions and presentations during the ICME-13 Congress and includes the best papers from one of the ICME-13 Topical Study Groups or Discussion Groups.

More information about this series at http://www.springer.com/series/15585

Jason Silverman · Veronica Hoyos
Editors

Distance Learning, E-Learning and Blended Learning in Mathematics Education

International Trends in Research and Development

Springer

Editors
Jason Silverman
School of Education
Drexel University
Philadelphia, PA
USA

Veronica Hoyos
National Pedagogical University
Mexico City, Distrito Federal
Mexico

ISSN 2520-8322 ISSN 2520-8330 (electronic)
ICME-13 Monographs
ISBN 978-3-319-90789-5 ISBN 978-3-319-90790-1 (eBook)
https://doi.org/10.1007/978-3-319-90790-1

Library of Congress Control Number: 2018939465

Printed on acid-free paper

This Springer imprint is published by the registered company Springer International Publishing AG part of Springer Nature
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Contents

Chapter 1
Research on Technologically Mediated Mathematics Learning at a Distance: An Overview and Introduction

Jason Silverman and Veronica Hoyos

Abstract In this chapter, we provide an overview and introduction to this monograph, which reports on the work of an international group of scholars that joined together at the 13th International Congress on Mathematics Education to share and build on current and emerging research in distance learning, e-learning and blended learning in mathematics. We share work that emerged from *Topic Study Group 44: Distance learning, e-learning, blended learning*, including research and development in the use of digital teaching and learning platforms, usage of this technology to scaffold mathematics instruction and tutoring, novel interfaces for communicating and analyzing student thinking, and specialized mathematics teacher education platforms.

Keywords Research on electronic and distance learning · Teaching and learning platforms · Scaffolding mathematics instruction

This book emerged from the Topic Study Group 44 at the 13th International Congress on Mathematics Education, ICME13, held in Hamburg, Germany on 2016, from July 24th to 31th, where an international group of scholars joined together to share and build on current and emerging research in distance learning, e-learning and blended learning. Specifically, in TSG44 we sought to push on the boundaries of what was known on distance education, e-learning and blended learning and teaching of mathematics through an examination and discussion of recent research and development through these modalities and the common factors that cut across them.

J. Silverman (✉)
Drexel University, Philadelphia, USA
e-mail: silverman@drexel.edu

V. Hoyos
National Pedagogical University, Mexico City, Mexico
e-mail: vhoyosa@upn.mx

J. Silverman and V. Hoyos (eds.), *Distance Learning, E-Learning and Blended Learning in Mathematics Education*, ICME-13 Monographs,
https://doi.org/10.1007/978-3-319-90790-1_1

The papers published in this monograph are revisions and extensions of the original papers presented during the TSG 44 sessions and reflect additional work carried out by all participant authors after the conference ended. The monograph is organized in four parts: The first part presents two chapters that focus on the incorporation of new technologies into mathematics classrooms through the construction or use of digital teaching and learning platforms (see chapters by Mundt & Hartman, and Hoyos et al., in this book). The second part presents a wide range of perspectives on the study and implementation of different tutoring systems and/or computer assisted math instruction (see Chaps. 4–6 in this book, correspondingly authored by Chekour; Liang et al.; and Landenfeld et al.). The third part presents four new innovations in mathematics learning and/or mathematics teacher education that involve the development of novel interfaces' for communicating mathematical ideas and analysing student thinking and student work (see Chaps. 7–10, authored by Albano & Dello-Iacono; Nakamura et al.; Matranga, Silverman, Klein & Shumar; and Crisan). Finally, the fourth part presents latest work on the construction and implementation of new MOOCs and rich media platforms accomplished to carry out specialized mathematics teacher education (see chapters authored by Avineri et al.; and Chazan et al., in this book).

1.1 Overview of Parts and Chapters

1.1.1 Part I: E-Learning and Blended Learning of Mathematics

Chapter 2 introduces the reader in the construction of the *e:t:p:M*® platform, developed by Mundt and Hartman from 2012 to 2016, at the University of Education Karlsruhe (Germany). The authors worked to improve the quality of higher education instruction through a platform that integrates digital and internet-based technologies into regular (brick-and-mortar) classes. Specifically, the authors looked at the articulation of online material and other technology to enable a variety of options to be implemented in a blended-course format through the *e:t:p:M*® approach. Additionally, teachers can modify the content and also student activities can be tracked and reported for a continuous evaluation and improvement.

The potential benefits of this platform are clear as students can find materials for specific content as well as document occasions of interactions with the materials, colleagues, a mentor and/or the teacher; and teachers can create his/her materials specific to their individual needs. In addition to sharing the *e:t:p:M*® development and model, Mundt and Hartman's chapter provides additional data and analysis regarding the usage of the platform, for example measuring student accesses to the platform as well as understanding relationships between interactions with the content and the archived online lessons.

Chapter 3, by Hoyos et al., from the National Pedagogical University in Mexico City, addresses opportunities and challenges posed by the teaching and learning of mathematics through digital platforms. Specifically, the chapter focuses on the design and implementation of several different mathematics learning environments that provided new teaching and learning opportunities for students in hybrid environments. In this work, the authors establish a relationship between student mathematical attainments and digital tools functionalities, by means of the elaboration of teaching cycles that have influenced the design of the activity and students' learning improvement.

In the chapter by Hoyos et al., the authors documented usage of digital platform tools for the administration, storage and deployment of resources and for facilitating interactions within the resources stored in the platform. One important consideration in this chapter is the teaching challenges of attending to the promotion of reflection processes during the resolution of math problems in an online environment. This paper documents the challenges when teaching and learning of mathematics were completely online and mediated by technology.

1.1.2 Part II: Online Environments and Tutoring Systems for Leveling College Students' Mathematics

In Chap. 4, A. Chekour, from the University of Cincinnati-Blue Ash College in USA, describes an effort to utilize technology to support more effective developmental mathematics learning and teaching. The chapter compares the academic performance of students enrolled in developmental mathematics sections that utilize computer-assisted instruction with those using traditional instruction. Results show the potential of the computer-assisted instruction, both in aggregate and for both males and females separately. The chapter also discusses the challenges and opportunities for incorporating computer assisted instruction into university mathematics classes.

Chapter 5 by Liang et al., from the University of Hong Kong in Hong Kong, presents an evaluation of the different user behaviours on an e-learning platform for students with different levels of calculus knowledge. Having collected data from a sample of 225 students who have used the platform, which includes both video lessons and assessments, the authors focus on student interaction with a supplemental (i.e. not required) e-learning system. Results highlight relationships between activity in the system and student performance on standard examinations. For example, they document that while students with the necessity and urgency to catch up (i.e. with less prior knowledge on calculus) tend to be more active on the e-learning platform in general, many of them tend to ignore the importance the quizzes, which are designed to provide practice and support the development of fluency with the contents at hand.

In Chap. 6, Landenfeld and her colleagues from the Hamburg University of Applied Sciences in Germany discuss the online learning environment via MINT, which was designed to provide differentiated mathematics support to undergraduate science and engineering students. Assessment results allow for the system to recommend differentiated "paths," that can include selections of video tutorials, learning activities and exercises and the "Personal Online Desk" provide a view for the student and others to view progress. In addition to sharing details of the system, this chapter also shares results of analysis of student engagement with the environment.

1.1.3 Part III: Innovations on E-Math Learning and Teaching

Chapter 7, by Albano & Dello-Iacono, from the University of Salerno in Italy, presents an innovative approach to competence-based mathematics learning, through the use of a digital platform named DIST-M (Digital Interactive Storytelling in Mathematics). DIST-M allows learners to define a model where the roles of participants and the sequence of activities promote cognitive, socio-cognitive and metacognitive processes. In this platform, students are engaged in activities within a storytelling experience. The authors used both experiential and discursive approaches to mathematics learning, integrating individual and social tasks, defined by external scripts. The development DIST-M was based on the assumption that such environment can be arranged in a way that a good exploitation of platform tools and a well-structured collaboration among peers can act as an expert support to students in achieving their learning goal. The environment also supports the exploration of specific mathematics content—representation and management of graphics and descriptive statistics, in the case of this paper—in spatial activities that the authors have designed around thematic contexts, such as the discovery of a new planet.

In Chap. 8, Nakamura et al., working in three different universities from Japan (the Nagoya University, the Mukogawa Women's University and the Nihon University) and including the participation of the Sangensha LLC., and the Cybernet Systems Co., Ltd., address two challenges that instructors encounter when implementing the e-learning systems that are prominent in Japan: entry of mathematical symbols and equations and the development of content for specific courses and content. The authors share details of two input interfaces that integrate with commonly used e-learning systems and allow students to input mathematical symbols and equations using both computer and mobile devices, importantly, to address the unique challenges of mathematics e-learning using mobile devices (tablets and mobile phones). These input interfaces are one component of the *MeLQS* e-learning, question specification allows for questions to be cross-platform, and users from many different e-learning systems collaborate and share questions and tasks, thereby making the use of e-learning systems more generative.

Matranga et al. (Chap. 9), from the California State University San Marcos and the Drexel University in USA, describe an online environment designed to support the emergence of a set of professional practices within a group of mathematics teachers. In the chapter, the authors share the design and features of the environment, highlighting the design process through which it was thought to meet specific use cases identified by teachers. The chapter addresses the challenge of scaling teacher professional development through using technology to emulate a boundary encounter between a group of teachers and an existing community of educators with productive pedagogical practices. Their findings show the promise of this approach, specifically noting the emergence of productive pedagogical practices normative in the target community.

Finally in this part, Crisan (Chap. 10), from the UCL Institute of Education, University College London in UK, discusses her work supporting teachers as they explore how digital technology supports students' understanding and learning of mathematics. Video cases that depict actual student engagement with specific mathematics tasks, including audio and video of students synchronized with recordings of their actual work, were specifically developed for this project and participants engagement with these cases—and the student thinking that are depicted in the cases—was analysed. Crisan reports that persistent engagement with these video cases and the other supports provided in the online context show promise for scaffolding teachers as they analyze student work and develop pedagogical solutions based on this analysis. Using a modified version of the Technological Pedagogical Content Knowledge (TPACK) framework, *Research-informed TPACK* (RiTPACK), Crisan presents additional evidence of teacher development resulting from their engagement with the video cases and online course.

1.1.4 Part IV: MOOC and Rich Media Platform for Mathematics Teacher Education

Chapter 11 by Avineri et al., from three universities in USA (the North Carolina School of Science and Mathematics, the North Carolina State University, and the Middle Tennessee State University) and including the Victoria University in Melbourne (Australia), specify design principles for the implementation of MOOCs for professional development of mathematics teachers, based on recent research on this topic. The chapter documents the design efficiency and discusses specific impacts that participants report on changes into their teaching practices. Specifically, some participants addressed changes to their approach to teaching (e.g., increased focus on concepts as opposed to algorithms), others described how their participation supported their refined attention to and understanding of their students' thinking and their own personal improvement in knowledge of mathematics. According to Avineri and colleagues, the research-based design principles that guided the creation of the *MOOC-ED* courses have afforded educators' choice in professional learning, complemented with relevant, job-embedded activities, access to the perspectives of experts, teachers, and students, and a network of educators learning together around a common content area.

Chapter 12, by Chazan et al., from three institutions in USA (the University of Maryland, the University of Michigan, and the Rowland Hall School at Salt Lake City in Utah), describes how the *LessonSketch* platform has been used to implement a larger project between math teacher educators. In particular, these authors use Grossman's pedagogies of practice to explore how teacher educators are representing practice, decomposing it, and providing opportunities for their students to approximate practice through the curricular artefacts that they are creating. Chazan et al., describe a practice-based approach to helping teachers explore the content of mathematics teacher education, and report the novel ways in which a certain online environment (*LessonSketch* in this case) supports new opportunities for teacher candidates to practice the work of teaching. These authors note that professional development experiences created with these platforms not only have pedagogical characteristics and support learning about teaching, but also have curricular characteristics that help shape what it is that teacher candidates should learn.

1.1.5 Purpose of This Monograph

This book addresses issues of collaboration, equity, access and curriculum in the context of learning and teaching mathematics. For example, Mundt and Hartman focus on the population of students entering Universities (Chap. 2) and propose an online platform such as *e:t:p:M*® to address the challenges brought forth through significant increases in undergraduate populations and associated challenges in instruction and supervision. This is a consistent role posited by authors in this text utilizing existing course management systems and tools, such as *Moodle* and *Blackboard Learn,* as well as other custom designed platforms. While the vast majority of online platforms offer similar features, such as organization of the content, and integration of external software including e-mail, and discussions, the authors noted that *e:t:p:M*® approach innovates because it could establish or monitor a relationship between the usage of different mobile technology resources with the blended courses it promoted. These results and others presented throughout this volume confirm the existence of new teaching and learning opportunities when working with students in hybrid environments.

With regards to wholly online mathematics learning and teaching, authors in this volume reported the existence of challenges related with the promotion of reflection processes when teachers or students solve mathematics complex tasks while participating in a course at a distance (see Hoyos et al., and Matranga et al., chapters). Using different contexts and approaches, the authors suggest that effective digital collaboration requires attention to individual's (teacher or student) activity and specific supports to accomplish an epistemological change required in order to engage productively and solve such mentioned tasks. These supports can be included in the computational device, learning environment or otherwise be provided by tutorial intervention.

A second broad theme in this volume is the construction and evaluation of mathematics tutoring systems for supporting college students' persistence and success. Such tutoring systems are essential, both given the growth in undergraduate students and continued issues regarding entering freshman's preparation for college level mathematics. While there are various commercial tutoring environments available, the authors in this volume (Chekour; Liang, et al.; and Landenfeld et al.) notice the benefit of custom designed environments to address specific local constraints and share information about their systems as well as suggestions to improve students' use of an e-learning platform.

The third part of this volume addresses a third theme: innovation in e-learning. In this part, the authors discuss new approaches to mathematics learning and mathematics teacher collaboration through the use of Web platforms and communication tools. Albano & Dello-Iacono introduce a general methodology to support an e-learning-based approach to competence-based mathematics learning. These authors designed and implemented certain computer-supported collaboration scripts aimed to foster students' shift from investigating, reasoning and communicating what they have found. Nakamura et al.'s chapter described and displayed a series of interfaces designed to minimize the challenges of mathematical symbols and syntax in e-learning environments. In Matranga et al. chapter, the authors documented that a specifically designed online collaborative environment had the potential to scaffold teachers' legitimate participation in reform-type conversations and activities that were not common for these individuals without the online supports. Finally, Crisan's chapter provides another example on the use of varied multimedia for teacher development resulting from their engagement with video cases and specific online course.

The fourth part of the book addresses a final theme: the use of online rich media platform for teacher education, including the development and implementation of both visualizations of teaching and specially constructed MOOCs for mathematics teacher education. Two of these applications are discussed in Chaps. 11 and 12, and share theoretical and empirical evidence regarding both the effectiveness of the specific design and medium as well as emerging advancements in this area. As an example, Chazan et al. (Chap. 11) use the mathematics education literature on curriculum to suggest that the curriculum creation process that is underway in teacher education, when it happens online, is influenced by the digital nature of technological artifacts.

This book is a scholarly collaboration on the part of professors, developers and researchers in the broad fields of technologically-enhanced mathematics education and serves as an effort to disseminate significant contributions and share international perspectives on this important and timely area. The book provides an overview of the current state-of-the-art research and shares and discusses emerging work, including trends, ideas, methodologies, and results and represents a special call to continue research and development and to grow a canon of research foundations for distance learning, e-learning and blended learning in mathematics education.

Part I
E-Learning and Blended Learning of Mathematics

Chapter 2
The Blended Learning Concept e:t:p:M@Math: Practical Insights and Research Findings

Fabian Mundt and Mutfried Hartmann

Abstract The chapter outlines the key ideas of the blended learning concept e:t:p:M® and its further development in the field of Higher Mathematical Education. e:t:p:M@Math aims to integrate digital technologies and face-to-face interactions to simultaneously allow personalized and high-quality learning. Both practical teaching experiences as well as research findings will be discussed. One focus is on the description of the self-developed and designed e-Learning environment, its possibilities and further development. Another focus is on the reflection of the practical implementation into everyday teaching, especially the integration with face-to-face seminars. In addition, first research insights will be presented and explained.

Keywords Blended learning · E-learning · Distance learning · Learning analytics

2.1 Introduction: Challenging Trends in Higher Education

In the winter term 2014/2015, the Federal Bureau for Statistics of Germany counted 2.7 million university students—a milestone in the history of the Federal Republic of Germany (SB, 2015). Given that only ten years ago there were far less than 2 million students (Bildungsbericht, 2014), the magnitude of this increase becomes even more significant. Many universities have adopted "bulk-instruction" with heterogeneous student groups and an unfavorable student-to-instructor ratio (Himpsl, 2014). In particular, high-demand introductory courses suffer under these problematic circumstances. Therefore, the quality of education is lacking and the need for reforms is apparent (Asdonk, Kuhnen, & Bornkessel, 2013).

F. Mundt (✉) · M. Hartmann
University of Education Karlsruhe, Bismarckstraße 10, 76133 Karlsruhe, Germany
e-mail: fabian.mundt@ph-karlsruhe.de

M. Hartmann
e-mail: mutfried.hartmann@ph-kalrsruhe.de

J. Silverman and V. Hoyos (eds.), *Distance Learning, E-Learning and Blended Learning in Mathematics Education*, ICME-13 Monographs,
https://doi.org/10.1007/978-3-319-90790-1_2

Since this situation is unlikely to change in the foreseeable future—neither nationally nor internationally (Dräger, Friedrich, & Müller-Eiselt, 2014; Maslen, 2012)—innovative teaching and learning concepts are necessary. In contrast to widely-discussed MOOCs, one very promising approach involves integrating regular class sessions with the opportunities of digital (Internet-) technologies (see Carr, 2012). One specific model that specifically aims at the integration of both class sessions and digital content is e:t:p:M®.

2.2 The Blended Learning Concept e:t:p:M®

e:t:p:M®[1] was developed as an introductory course in education in the winter term 2012 at the University of Education in Karlsruhe by Timo Hoyer and Fabian Mundt. Detailed information about the project and its theoretical framework can be found in Hoyer and Mundt (2014, 2016). The acronym, which indicates the individual parts of the project, are described in depth below.

2.2.1 "e" for E-Learning

The core of the e-learning content consists of 11 studio recorded *online lessons* that have been post-produced according to a creative framework. The lessons are all between 20 and 30 min long and are comprised of a speaker as well as info boards, images, animations and quotations. Additionally, the lessons are structured through so called "Fähnchen" (thematic headlines). The students can access the content via an especially for the e:t:p:M® project developed *responsive web-app* (Fig. 2.1).[2]

Personal annotations can be added to every "Fähnchen" and then downloaded as a PDF-file (Fig. 2.2). Furthermore, the web-app grants access to additional materials (texts, exercises etc.) and does not only contain general information about the class but also an extensive FAQ-area and the possibility to get in touch with the lecturers directly. The web-app also provides the user with a differentiated module for analysis that enables the teacher to track the students' interactions.[3]

[1]Project website: http://etpm.ph-karlsruhe.de/demo/ [13.12.2016].

[2]The web-app was developed with the open-source frameworks Laravel, Vue.js, Semantic UI and Video.js.

[3]As a tool for analyzing the interaction, an adjusted version of the open analytics platform "Piwik" is used. All collected data is anonymized. The tracking function can be deactivated from inside the web-app, which is highlighted for the users.

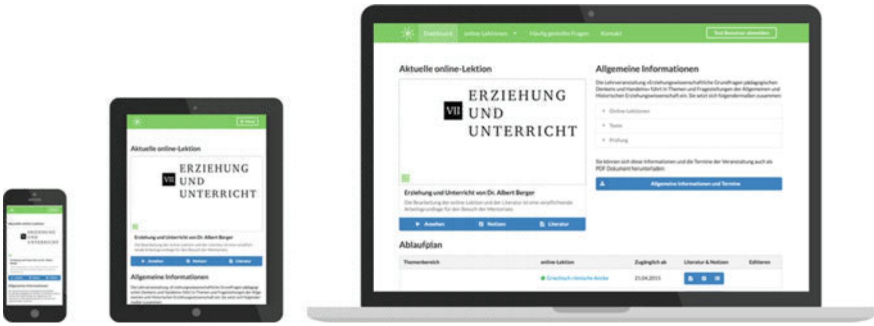

Fig. 2.1 The responsive web-app (original version)

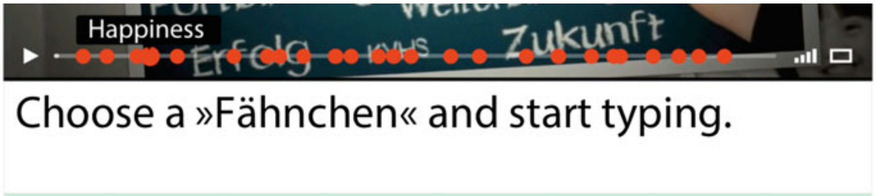

Fig. 2.2 The annotation function of the web-app

2.2.2 *"t" for Text and Theory Based*

Alongside every online lesson, the students are provided with a text that deepens the content (primary as well as secondary literature). In addition to suggested approaches to the text, the file contains questions that will be dealt with during the attended seminar. All texts are formatted uniformly and have been edited for the use in a seminar.

2.2.3 *"p" for Practice-Oriented (and Attendance-Oriented)*

The e-learning content of e:t:p:M® aims at a high personalization of the learning content as well as its integration into the seminars. The latter are comprised of information sessions (lecturers), FAQ-sessions (lecturers) and weekly mentoring sessions (student mentors) (Fig. 2.3).

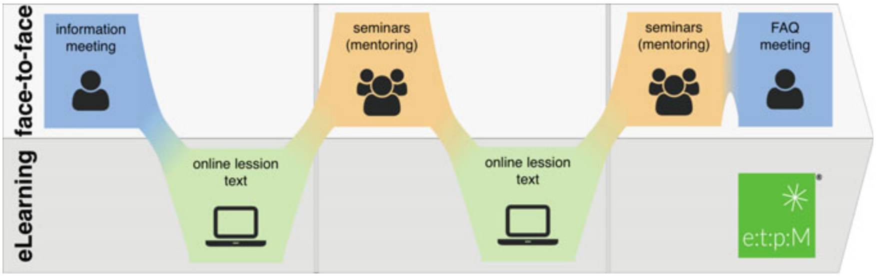

Fig. 2.3 The e:t:p:M® concept

2.2.4 *"M" for Mentoring*

Especially in the beginning of studies at university, the support and care for beginners is of high importance. In addition to subject-specific competences, the students need to acquire a sense to navigate the foreign academic world. In e:t:p:M® the class is separated into smaller groups who will be mentored by a tandem of older students during the semester. The mentors are trained in a specifically designed workshop and receive a certificate after completion.

The program received an award for extraordinary teaching methods in 2013 and was evaluated positively several times.[4]

2.3 Using e:t:p:M® in an Introductory Course in Mathematics

Based on the previously explained challenges for teaching at university and the very positive feedback towards the project e:t:p:M®, the concept is being adapted for other subjects outside the realm of pedagogy. At the moment, the authors work on applying the program to an "Introduction in Mathematics" course, which started in the winter term 2015 (Mundt & Hartmann, 2015). The current evolution of the concept is presented below. Since the contents are more historical and theory oriented, the application of e:t:p:M@Math requires adjustments. The online lessons and web-app, in particular, are being revised extensively to meet the requirements of mathematical learning.

The adaptation is informed and guided by "design-based research methodology" (Wang & Hannafin, 2005). Specifically, it is situated in a real educational context (mathematics introduction) and is focusing on the design and testing of significant interventions (e:t:p:M@Math concept) (see Anderson & Shattuck, 2012). As part of the design process, we refer to contemporary findings in the field of Higher

[4]http://etpm-dev.ph-karlsruhe.de/etpm-evaluation/ [13.10.2015].

Education eDidactics (Ertl, 2010; Kerres, 2013) with a special focus on mathematical learning in digitally supported environments (Aldon, Hitt, & Bazzini, 2017; Juan, 2011) and "User Experience Design" (Meyer & Wachter-Boettcher, 2016; Walter, 2011). In this text, we are concerned with the extensions of the web-app.[5] For this reason, we also include a review of existing blended-learning specific tools.

2.3.1 Existing Tools and e:t:p:M@Math Web-App

A review of the current literature and software shows that there are many blended learning concepts in the field of Higher Education, but only few explicit tools. Besides well-established Learning Management Systems like *Moodle*, *OpenOLAT* or *ILIAS* there are some more recent MOOC related platforms like *edX*. A more detailed overview of these and similar resources can be found in Spring et al. (2016) and Ma'arop and Embi (2016). All these solutions offer functionality for blended learning scenarios. Often, these tools require special plugins or add-ons (Kumari, 2016). They also often lack both a good user experience design and context-specific needs (e.g. for mathematics teaching), which goes hand in hand with the overwhelming functionality of the software (Persike & Friedrich, 2016). Hence, it is no surprise that there are also a variety of special and often well-designed tools in addition to the all-embracing systems. These range for example from applications which enable the creation of interactive videos (H5P[6]), deliver the opportunity to brainstorm online (MindMeister[7]) or create entire learning lessons easily (TES Teach[8]).

In contrast to this situation, the e:t:p:M@Math web-app is a blended learning-specific software. This means it integrates modern technologies and ideas, e.g. creating rich interactive video content, with the pedagogical aspects of the e:t:p:M® concept and context specific needs in mind. One example might be personalized annotations optimized for seminar use (see Fig. 2.2) or instant exercise feedback for teachers as outlined below. The web-app can be seen as a continuously developing framework in the sense of the design-based research, where interventions are repeatedly added, evaluated and improved. The web-app itself can also be seen as a research tool.

[5]The web-app is developed in the sense of "Agile Software Development" (Dingsøyr, Dybå, & Moe, 2010), which fits perfectly with the design-based research methodology.

[6]https://www.h5p.org [10.7.2017].

[7]https://www.mindmeister.com [10.7.2017].

[8]https://www.tes.com/lessons [10.7.2017].

2.3.2 Research Questions

The review of the current literature and software showed that there is a lack of a well-designed blended learning specific software that integrates modern technologies in a tight didactical way and is also open for further research-based development. Out of this, our focus is on the following overarching question: *How can modern technology enabled options be implemented in the mathematical adaptation of e:t:p:M®?* The following sub-foci organize our discussion of our broad research focus:

(a) How can *interactive content* be integrated in the web-app?
(b) How can *discussions*—a key element of teaching and learning mathematics—be integrated in the web-app?
(c) How can *exercises and tests* be implemented?
(d) How can the teachers *modify and generate content*?
(e) How can student activities be tracked and reported for *continuous evaluation and improvement*?

2.3.3 Series of Interactive Content (Sub-focus a)

An online lesson is not only comprised of just a single video, but contains a series of shorter videos and interactive learning applications. This series of interactive content enables a more differentiated structure of the more abstract, mathematical learning contents. The interactions make it possible for the user to comprehend complex correlations on their own. Current versions of the video environment are shown in Figs. 2.4 and 2.5.

At present, we are considering about at least three different content types:

- Interactive videos
- Exploration exercises
- Test exercises

As you can see in Fig. 2.4 the video environment integrates these new ideas in the existing application. In addition, the concept of “Fähnchen” can be used in both the shorter videos and in exercises. In case of the exercises, the concept has to be adjusted, particularly through structuring each interactive exercise around several tasks. Each of these tasks can be visually and functionally highlighted by one “Fähnchen”. Thereby individual notes can be taken while solving the tasks.

To implement interactive exploration and test exercises the open-source software CindyJS[9] is used. CindyJS is a JavaScript implementation of the well-known interactive geometry software Cinderella (Richter-Gebert & Kortenkamp, 2012).

[9]http://cindyjs.org [13.12.2016].