User Interface Design of Interactive Mathematics Software

Suggestions for an improved mathematical online learning platform

Stefanie Bogner

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Abstract

This paper contains research findings from literatur review and system comparisons concerning learning platforms and learning management systems and suggestions how to improve these systems by enabling social learning. The results are packed into first ideas and drafts for a new learning platform, which will be implemented within GeoGebraTube, the material sharing platform of the mathematics software GeoGebra.

Acknowledgement

Contents

1 Introduction

During my research studies abroad, at Florida Atlantic University in Boca Raton, Florida, I did research on learning platforms and learning management systems, I reviewed existing systems as well as literature, and worked on suggestions for creating a "better" learning platform. While I was looking for features, which can make learning platforms "better", I focused mainly on features that enable social learning, because it can have a great positive impact on students' learning progress and besides it allows students to gain and improve additional social skills, which will be explained in detail in 2.4 on page 6.

My goal was to

- get ideas, how such a system could be designed and implemented, such that it can lead to greatest possible learning success for students and make it fun to use,

- create first drafts based on these ideas and

- start with the implementation of a learning platform within GeoGebraTube, the GeoGebra materials sharing platform.

In the following pages I will first of all explain some general terms, and later write about my findings and present some drafts for the learning platform, which will be integrated in GeoGebraTube. Detailed information will be available in my diploma thesis, which will be finished by the end of 2015.

2 Definitions

2.1 GeoGebra

GeoGebra[1] is freely available software for learning, teaching and exploring mathematics. It is suitable for all levels of education and "brings together geometry, algebra, spreadsheets, graphing, statistics and calculus in one easy-to-use package". [GeoGebra, About] You can install GeoGebra on your computer, or you can use the web application or

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[1] Visit the GeoGebra website: www.geogebra.org

chrome app, if you don't want to install it[2]. Since summer 2013 there are also tablet apps for the three main operating systems Windows 8, iOS and Android available, and versions for smart phones are coming soon.

The open source software project GeoGebra was started by Prof. Markus Hohenwarter, who I am currently working with at Johannes Kepler University in Linz, Austria.

2.2 GeoGebraTube

GeoGebraTube is an online platform with about 180.000 public, interactive GeoGebra materials, shared by almost 100.000 GeoGebra autors and used by millions of GeoGebra users worldwide[3].
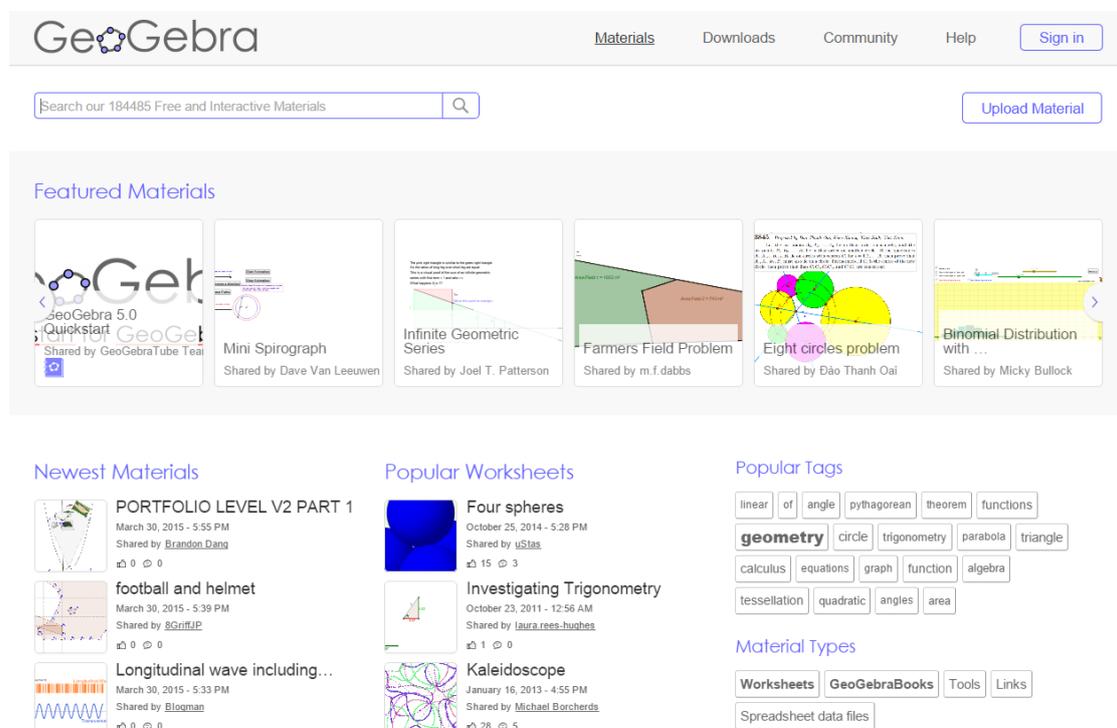

Figure 2.1: Current startpage of GeoGebraTube [GeoGebra, Materials]

By integrating a learning platform to GeoGebraTube, we want to help teachers organizing their materials for school classes and sharing them with their students easily, create

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[2]Downloads available at: `http://www.geogebra.org/download`
[3]Statistics retrieved on March 30th, 2015

exercises and tests online, push out information to all of their students at a time and keep track of their students progress, as well as giving feedback on their progress.

Students will have it easier to access materials, shared by their teacher, they will be able to find help quickly, when problems are arising, due to good communication tools, they will get involved and feel like an active part in the course, due to equal rights in sharing content, thoughts and feedback and they will be able to keep a good overview over their due dates and learning results.

By mentioning all the desired functionalities, I've already anticipated the functions of learning management systems and learning platforms, which I would like to explain in detail in the following subsection 2.3.

2.3 Learning management systems and learning platforms

Philip D. Long [in Distefano et al., 2007, Learning Management Systems (LMS)] describes a learning management system as it follows:

> "A learning management system (LMS) is a set of integrated software services that organizes and supports online learning, education, and training. These systems usually provide content uploading and distribution, class administration, and discussion facilities [...]. Some offer additional functionality such as assessment tools for online quizzing and testing; homework submission tools for managing the collection, grading, and redistribution of homework assignments to students in an online class; and student profiling to track the progress and performance of individual students using the system."

So according to Long learning management systems have four main purposes, namely administration, content distribution, communication and student assessment.

> "A *learning platform*, then, is a Web application service that is intended to facilitate the achievement of learning goals by the user. [Bruce Landon in Distefano et al., 2007, Learning platforms]

And also learning platforms offer prexisting content and content distribution, they usually allow collaborative learning and typically provide some kind of learner evaluation. [Bruce Landon in Distefano et al., 2007, Learning platforms]

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So one can think learning management systems and learning platforms are almost the same. But there are a few differences, which make the LMS market go away from LMS towards learning platforms [Hill, 2012] and why also we are designing and implementing a learning platform and not a learning management system, although we take some desired features of learning management systems for our platform.

Learning platforms are shared platforms provided for multiple users and institutions, in contrast to learning managment systems, which are customized instances set up for each institution. [Hill, 2012]

We like the idea of having one shared platform for multiple users and institutions, because we would like users to be able to communicate and work with other users beyond class room and even institutional borders.

According to Hill [2012] in learning platforms, social applications are not just on demand extensions, but built into the core design and they are built around the learner and make them central actors in the system. They want to support connections between learners and besides of viewing instructional content they want to allow users to view other user-generated content.

Considering social learning, this is very important for us, because social learning is all about interacting with other users as well as sharing content and thoughts with each other.

2.4 Social learning

Van Dam [2012] defined social learning as

> "the interaction between two or more people utilizing social media and/or other collaborative technologies to facilitate exchanges in knowledge acquisition." And furthermore "Social learning is characterized by interactive collaboration and iterative knowledge creation stimulated by cycles of sharing and feedback."

As already mentioned in section §1 Introduction, social learning might help us to improve our learing platform. But what is it about, what is it good for and why should it help us to increase learning success of students?

Learning mathematics is not only solving of calculations, it is a good deal more. Students should learn to use their mathematical skills in new, flexible situations, which means they have to understand what they are doing. They should learn what role mathematics plays in our world, be able to read and understand mathematical texts, argument and present, they should work together and help each other, learn to handle oneself's and others' problems considerately, organize one's learning and even more. [Barzel et al., 2010, p. 9]

Social learning can help us reach these goals and even more, because according to Kerres et al. [2011, p. 5] these reasons speak in favor for social learning:

1. Social learning can help to teach students social behavior like negotiation and the ability to work in a team.

2. It enables different learning experiences for students like cooperative learning, which is according to Roger and Johnson [1994, p. 1] that students work together and they are interested in their partners success as well as in their own.

3. Social learning supports relationships between students, which helps upvalue learning and makes learning more interesting. Also it helps reducing the dropout rate of students.

4. Other students have different knowledge, skills and views, which they can share with their group and thus lead to a better understanding and learning progress.

5. Social learning helps creating a social community, which gives users access to cultural knowledge and societal communication.

Also, Naismith et al. [2004, p. 15] say that learning can be much more effective, if learners can talk to each other and can share their point of views.

3 Suggestions for GeoGebraTube

Now that we know what features learning management systems and learning platforms offer and what we want to achieve in our new learning platform, namely enhancing social learning, we can go further, think about which features of learning manangment systems and learning platforms we want to adopt for GeoGebraTube and put down our ideas on paper.

3.1 Administration, class management

First of all I will focus on administrational functions of learning management systems and learning platforms, which are necessary to create, manage and organize an online course. Later I will introduce content distribution and communication features, which support social learning and drafts how social learning can be enhanced in our learning platform.

3.1.1 Login requirements

Most learning management systems and learning platforms require users to create an account and login into the system with their credentials.

I also found an example for a learning platform[4], where students can study resources without login, but as soon as users want to save their results and the platform is used to keep track of students progress, it is obvious that a login becomes necessary.

For GeoGebraTube we want users to create an account and sign in to be able to create and enrol to courses. This can be done very easily by entering an email address, username and a password, or even simpler by choosing to sign in with an existing Google, Office 360, Microsoft, Facebook or Twitter account (see figure 3.1).

Figure 3.1: Login screen of GeoGebraTube

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[4]Gooru: http://www.goorulearning.org/

3.1.2 Creating a group in GeoGebraTube

After signing in, every GeoGebraTube user has the same rights to create GeoGebra materials and courses, which will be called groups in GeoGebraTube.
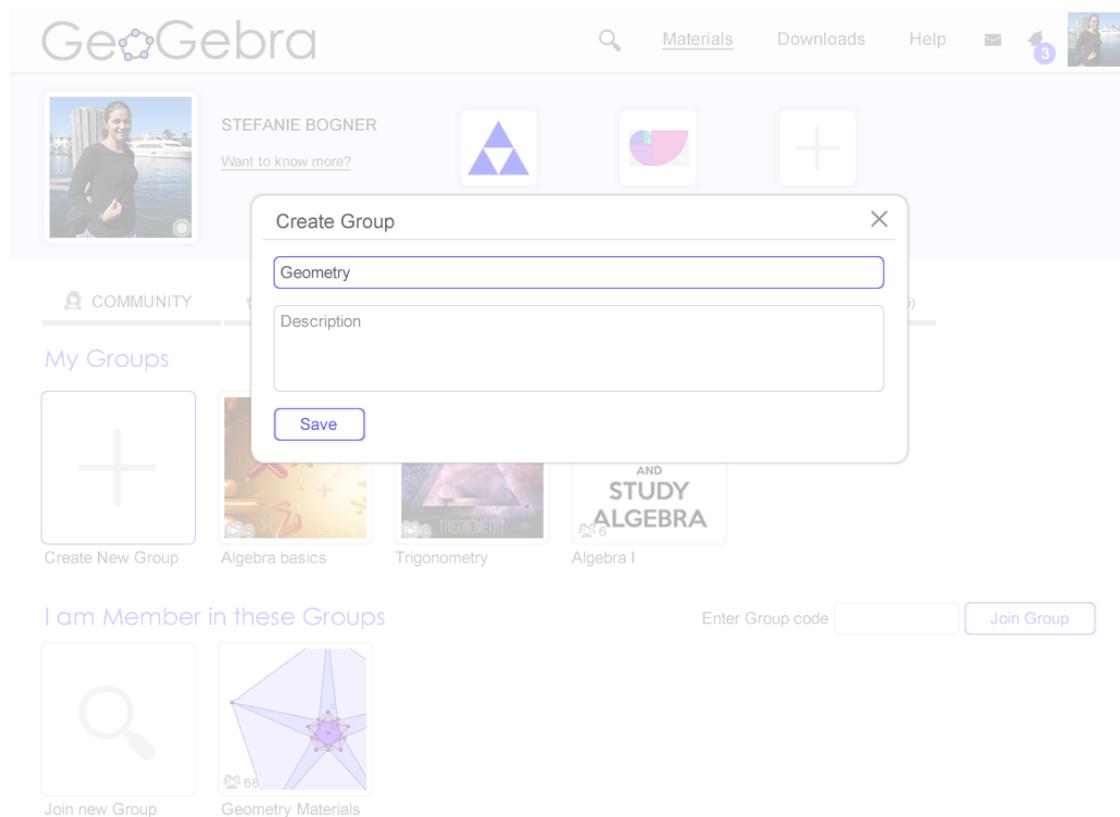
Figure 3.2: Creating the group "Geometry"

Creating a group should be very easy in GeoGebraTube, one simply needs to enter a group name and optionally a description of the group, which can be added or changed later on in the group settings, see figure 3.3.

Group settings are only available for the creator or administrator of a group, not for members of a group, which leads us to our next section, where I will introduce different roles within a learning management system or learning platform.

Figure 3.3: Group settings for "Geometry"

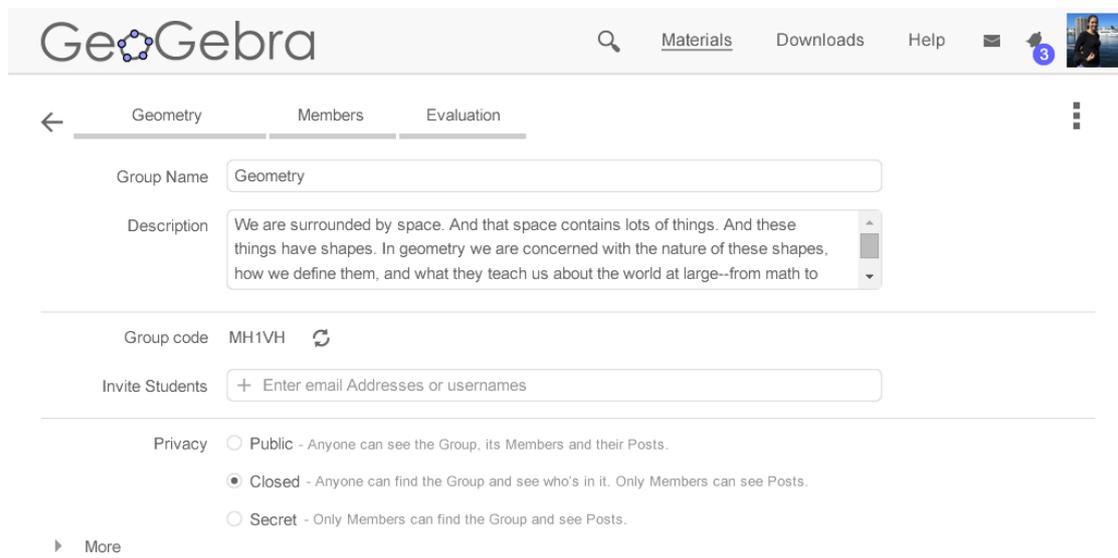### 3.1.3 Roles and rights

Many different learning management systems and learning platform offer different user roles, which means that there are groups of users with different rights. There is always a **teacher role**, which can be also called trainer or instructor and sometimes the administrator of a course. The teacher usually adds and manages the students of the course, as well as adds and modifies the content of the course. For students there is of course a **student role**, which are members of one or more courses and have limited rights than a teacher.

On our platform the creator of a course is automatically the administrator of the course, called teacher. All members added to the course are students with limited rights for managing the course, which can be changed by the teacher such that they can be administrators (teachers) as well. But in comparison to other learning management systems and learning platforms students should have equal rights to share content and thoughts

with other course members and present themselves not only within their courses, but within the entire GeoGebraTube platform, which is an imporant feature for our new social learning enhancing learning platform (see section 3.2).

In GeoGebraTube there will be two different enrolment methods for adding students to a course, manual and self enrolment, which will be explained in the following paragraph.

3.1.4 Add students to a course

Once a course is created, the creator of the course can add students either by **manual enrolment** or **self enrolment**. With manual enrolment the teacher adds students to the course manually, by entering email addresses, or by entering their user names, if students are already registered in the system. With the second possibility, self enrolment of students, a unique class code is generated and students have to know and enter that class code to get access to the course.
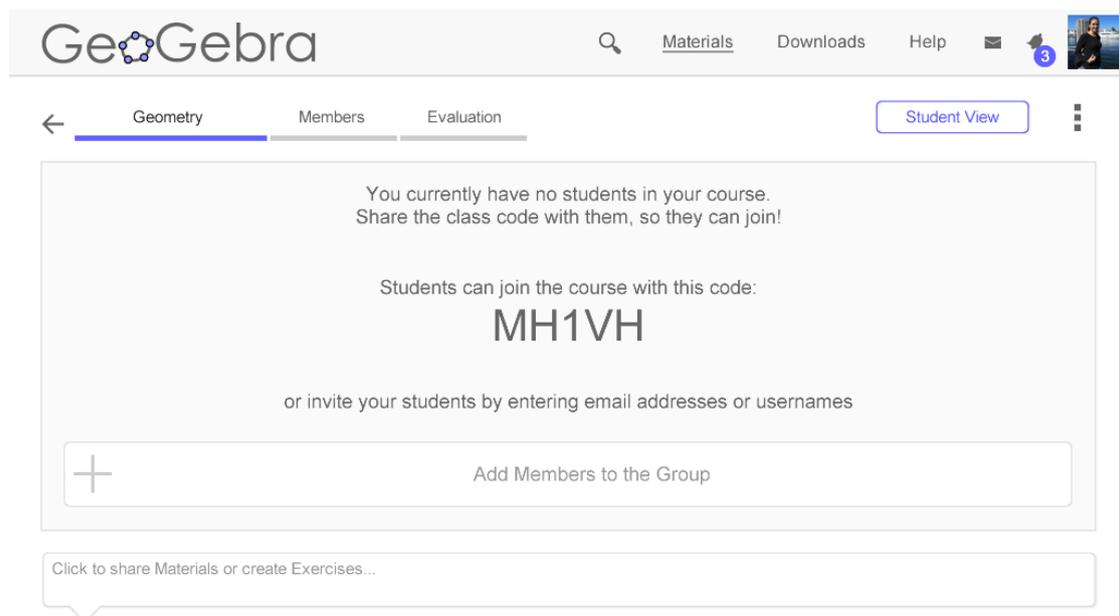

Figure 3.4: Enrolment methods in new course "Geometry"

New course members will be automatically listed on the members screen (see figure 3.5). If students are invited by manual enrolment, they will be pending until they accept the invitation.
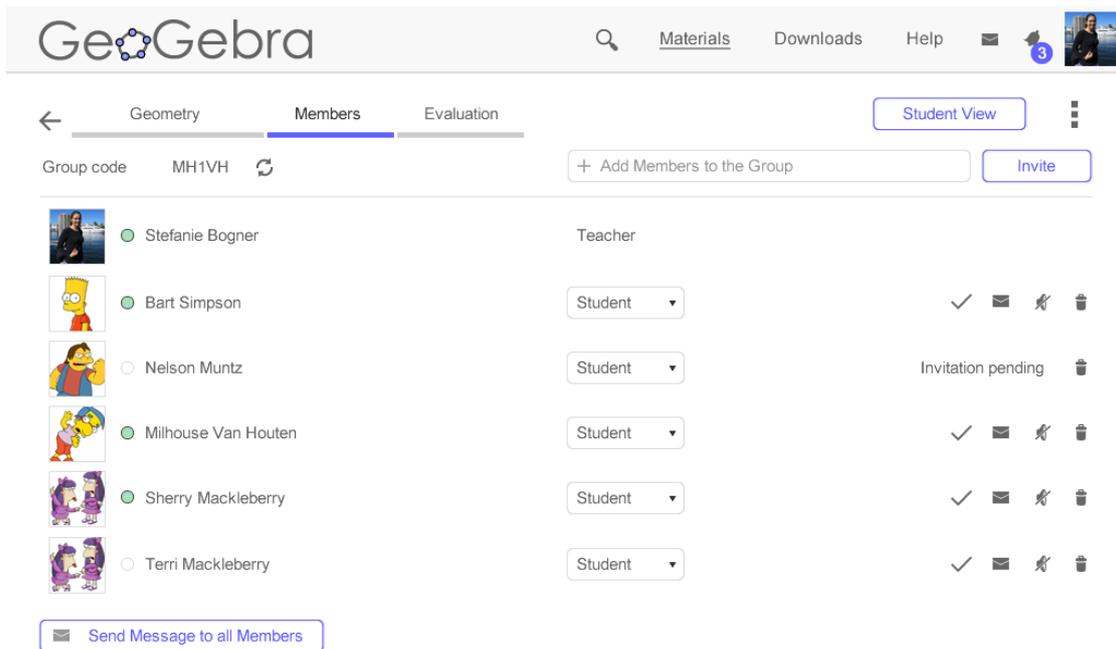
Figure 3.5: Members screen in course "Geometry"

On the members screen the teacher has again the possibility to add further students and update the group code, if desired. As soon as students are members of the course, several options will be available for the teacher, like look at the students learning progress, by clicking on the tick in line of the student's name, sending a message to one student or all of them, setting a student mute, when the student should no longer be able to contribute content to the course and of course, the teacher is always able to remove a student from the course by clicking the recycle bin.

We also see the dropdown box, which says "Student" for every student and can be changed to "Teacher", when the student should have rights for managing the course.

Another important element visible in that view, is the green or grey circle next to the name of every member of the course. This is an important feature for a social learning enhancing platform and is called online status indicator, which will be described in detailed in section 3.3.1, when I will write about communication in learning platforms.

Once a course is created and all members have been added successfully, the next step is to create or share content with other course members.

3.2 Content creation and distribution

Depending on the learning management system, it allows the creation of different kinds of content, like simple text elements with links to webpages and files, collections of learning materials, as well as assignments and quizzes, but they all let teachers share such content with their students. According to Dahlstrom et al. [2014, p. 10] this is the mainly used functionality in learning management systems in higher education.

> "The most successful learning comes when the learner is in control of the activity, able to test ideas by performing experiments, ask questions, collaborate with other people, seek out new knowledge, and plan new actions."
> Naismith et al. [2004, p. 15]

So what we want for our improved learning platfrom is, that not only teachers share content with their students, also students should be an active part in the course, contribute content and thoughts, collaborate and take over control of his or her learning progress. First step is to allow students to create their own profile, to introduce themselves to other users.

3.2.1 Userprofiles

We want students to communicate with each other and work together, so it is very important that they get to know each other, their interests and goals. [Baldauf et al., 2014, p. 95]

Everybody knows profile pages from social media like facebook, where a user can enter his/her information and provide that information to other users, so they get to know each other. Usually it contains a profile picture and some personal information like age or birthday, location, occupation.

In learning platforms the profile pages of students should focus more on course-related content like their interests in the appropriate subject, their mastery and goals in the course, if they are willing to help other students, if they prefer to work in groups and so on. [Baldauf et al., 2014, p. 96]

With that information students can find classmates or users with similar interests for e.g. learning circles, students with problems can search for users with knowledge and get

Figure 3.6: Facebook profile image with user information

assistance, and also teachers can get information about their students. [Baldauf et al., 2014, p. 96]

In GeoGebraTube we are planning to give a lot of information about a user via badges, which are rewards for the user's contributions and skills and will be presented on a user's profile page (see figure 3.7). This information will go beyond the borders of a class or course and will represent characteristics of the user in the GeoGebra user community. Please see section 3.2.3 for more details on badges.
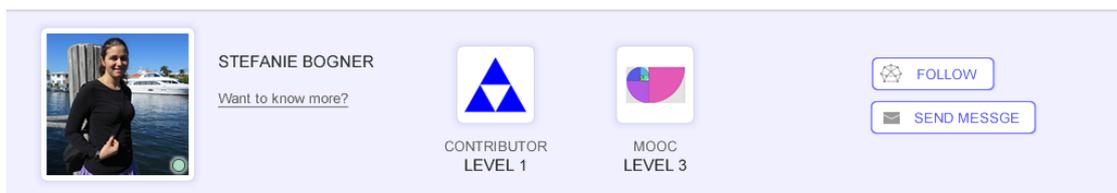

Figure 3.7: A part of a user's profile in GeoGebraTube

In figure 3.7 we again have the online status indicator (in the profile picture), was well as a "Follow" button, which allows any other user to subscribe to the user's channel, that means he or she can see newest activities like new materials and posts[5] and a "Send message" button, which allows users to get in contact very easily and which is an important feature for a social learning enhancing learning platform.

3.2.2 Class discussion board

Baldauf, Jiang, Marshall, and Dennen [2014, p. 97] suggest to provide a news feed for a course or class, which acts like a discussion board, where everybody is encouraged to contribute anything class-related.

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[5]Details to the "Follow" functionality will not be explained in this work

This discussion board can contain administrative announcements from the teacher and notifications for the entire class, as well as assignments and upcoming events. But besides teacher announcements, students can come up with questions, ask for help or share other course related issues. [Baldauf et al., 2014, p. 100]

> "The ongoing messages of a news feed encourage casual interaction between students and allow students to build relationships with each other." [Baldauf et al., 2014, p. 97]

Baldauf et al. [2014, p. 100] say, a very good example would be a group for a school class in facebook, where every student is a member. Teachers and students would have the same right to share content and thoughts on the group stream, and all users can comment and give feedback on these posts easily.

A main feature of learning management systems and learning platforms is to provide students with course content, so teachers can upload files and share contents with their students. Since we want to encourage students to interact and participate, also students should be able to upload and share content and files within the course. Baldauf, Jiang, Marshall, and Dennen [2014, p. 98] think that it is important that students can also add content from other web sources like "YouTube videos, Prezi presentations, Flickr photos, Google Calendars or Twitter feeds".

Again I would like to refer to the group functionality in facebook, where all members of the group have the same right to upload files and share a variety of different media types with their colleagues, which can again, be liked and commented by the teacher and students. [Baldauf et al., 2014, p. 100]

When we have a look at section 2.4 Social learning on page 6, we will see that this is exactly how social learning is defined and when we look at different learning platforms like Google Classroom, Edmodo and schoolOGY, we will see that all of them have the class discussion board as a main part of an online course.

In figure 3.8 you can see a new post on the discussion board being created. It may have a due date, when the teacher wants the students to finish the assignment within a certain time. When a due date it set, the assignement will also appear in the students "todo"-list, and they will be able to have a good overview over their outstanding assignments.

Worksheets can be attached to posts, which are webpages containing text, pictures, videos, GeoGebra applets, links to other webpages, and for evaluation purposes they can
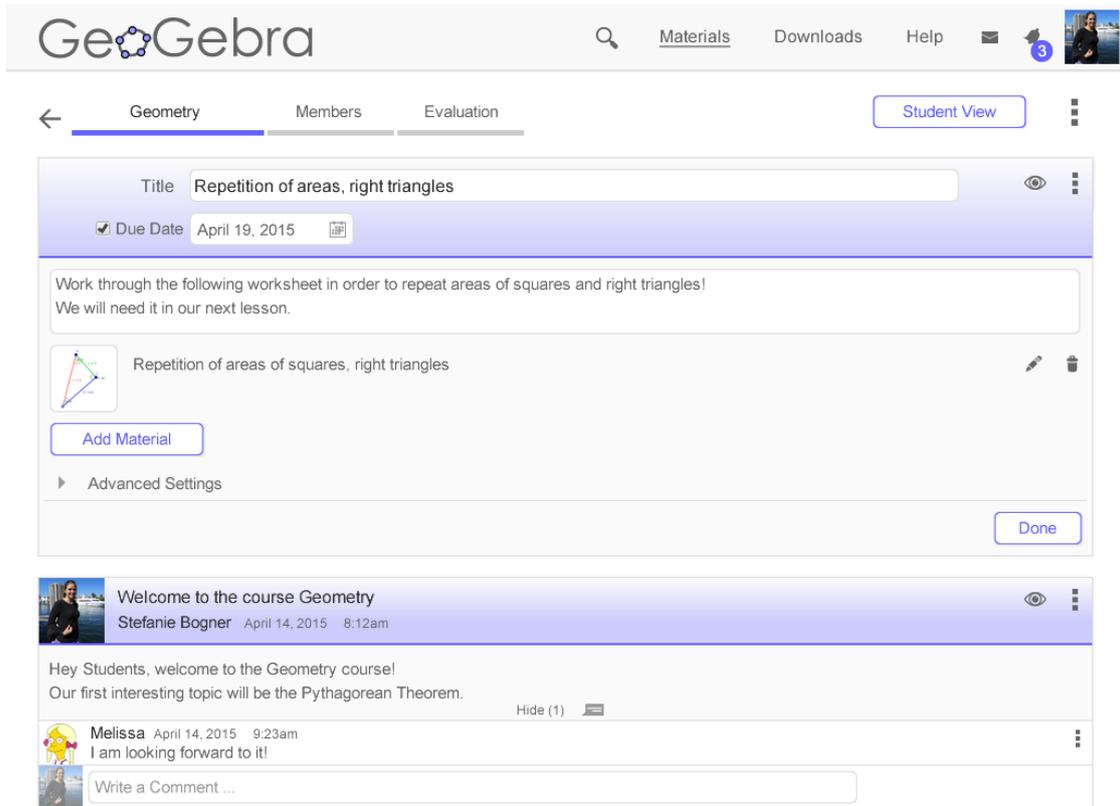
Figure 3.8: Teacher creates new post in course "Geometry"

also contain questions and exercises (see figure 3.9). Figure 3.10 shows a worksheet being created in GeoGebraTube, which contains questions and an exercise.

Students can create own posts with own worksheets and comment on posts unless it is defined otherwise in the group settings (figure 3.3).

3.2.3 Badges

Baldauf, Jiang, Marshall, and Dennen [2014, p. 97] describe badges as a "form of feedback" as a "virtual form of recognition", which is typically given from a teacher to a student as a reward.

Abramovich et al. [2013, p. 3] distinguish between Merit-badges and video game achievements.
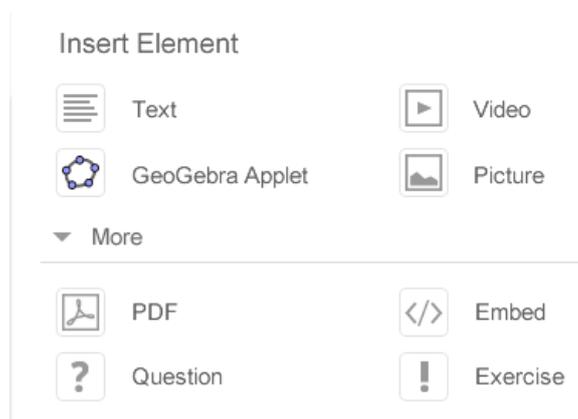
Figure 3.9: Available elements in a GeoGebra worksheet

Merit-badges are knowledge or skill badges, which can be achieved by participants. It's a feature of the United States' Boy and Girl scouts, where the Children select the badge they want to earn, and the "goal of earning a badge will trigger an increase in motivation". [Abramovich et al., 2013, p. 3]

Video game badges "allow players to earn recognition of their in-game achievements outside of the game itself". Xbox for example allows players to create their virtual profile, which displays the different game rewards, earned through playing video games, for other users. This should simply encourage users to play more. [Abramovich et al., 2013, p. 3]

Educational badges are a mix of the two different models of badges. They can be earned through "incidental activity in addition to mastery of skills or demonstration of knowledge" and are usually displayed on users profiles outside the traditional educational institutions, for example on the profile page of the learning management system or learning platform. [Abramovich et al., 2013, p. 3]

In GeoGebraTube badges will be given automatically by the GeoGebraTube system, and the badges are valid beyond the borders of groups, within the entire GeoGebra ecosystem. There will be badges for contributors, which reward users who create and share materials, networker badges reward the amount of time spent within the GeoGebraTube ecosystem, guru badges will reward popular users, whose materials are shared, copied and/or discussed, community badges stand for contributions to the GeoGebra regional and global community and MOOC badges recognize user competencies in GeoGebra.
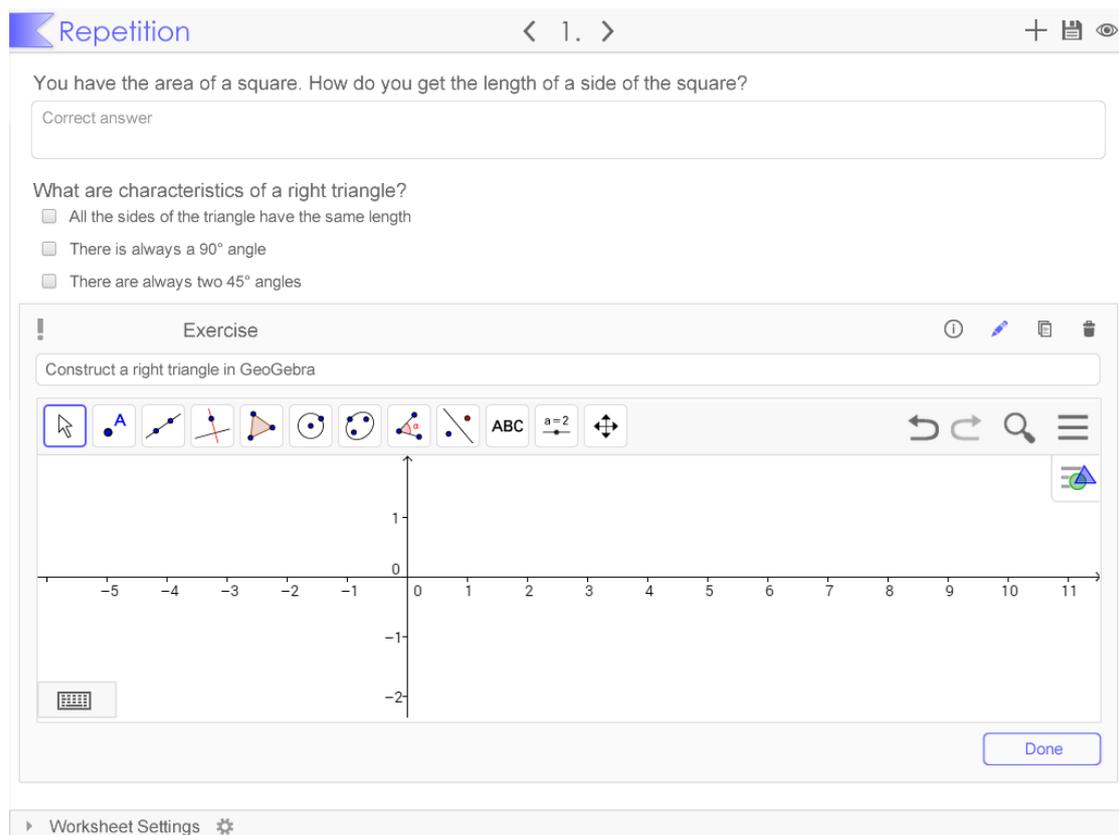
Figure 3.10: Worksheet created in GeoGebraTube

3.3 Communication

In online courses we distinguish between synchronous and asynchronous communication.

Asynchronous communication "takes place outside of real time". For example communication via email. If you receive an email, read it and usually respond to the message later. Even if the time lag between receiving and responding to a message can be very short, you could take as much time as you want. [University of Wisconsin-Madison, 2014]

That is a big advantage for asynchronous communication and activities, it is very flexible. The user receives information whenever it is best for him. But it is also a disadvantage, especially if we think about collaboration. It might take hours, days or even weeks until a response comes back. [University of Wisconsin-Madison, 2014]

Contrariwise **synchronous communication** takes place in real time, "like a conversation". An example therefore is a chat session, where "everyone gets online in the same
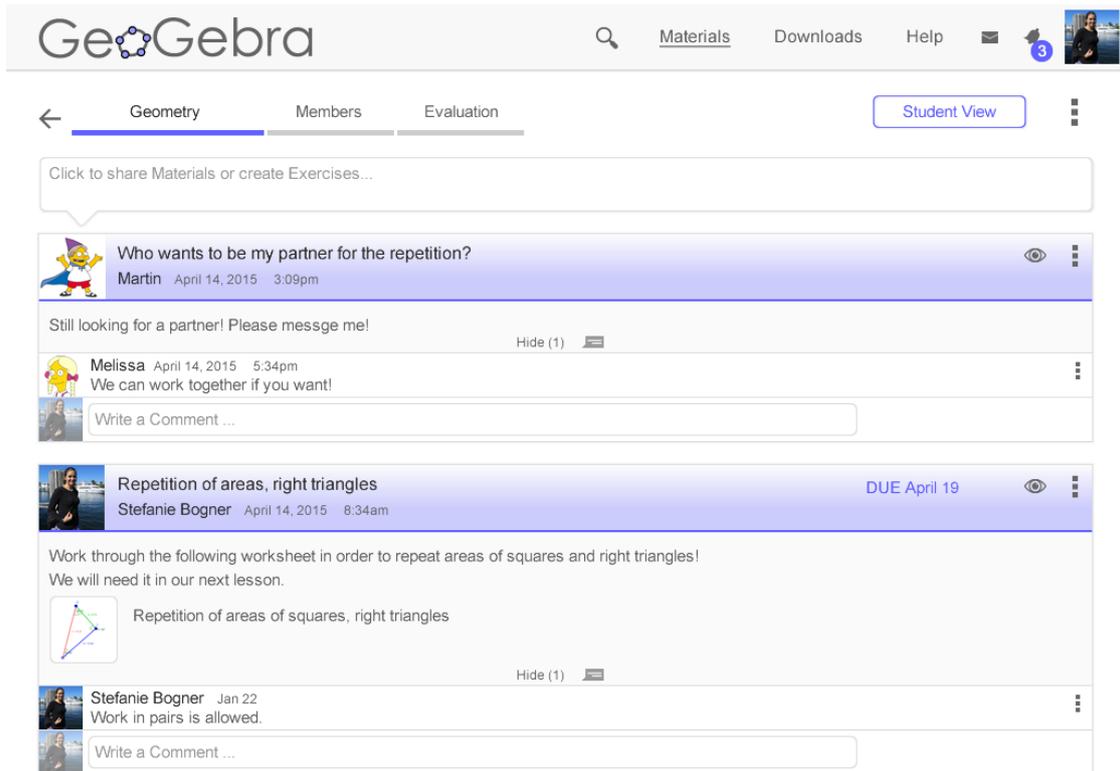
Figure 3.11: Students and teacher posts on "Geometry" discussion board

virtual chat room and types questions, comments and responses in real time." [University of Wisconsin-Madison, 2014]

One advantage is immediacy, which makes collaboration more interactively. But in synchronous activities the users, who want to work together, have to be online and willing to work at the same time. [University of Wisconsin-Madison, 2014]

Chickering and Gamson [1987, p. 3] say in their "Seven Principles For Good Practice in Undergraduate Education":

> "Frequent student-faculty contact in and out of classes is the most important factor in student motivation and involvement."

To increase communication and interaction Misanchuk and Anderson (cited by Liu et al. [2007], 2001) introduced some strategies, such as, let users interact quick and easy which each other, encourage students to post personal profiles and participate in discussions,

allow students to give feedback and have group-projects, that require students to work together and discuss.

Students in higher education wish to have better interaction and communication features in their learning management systems. When they were asked, how they would redesign LMS from scratch, 46% of them cited amongst others, various communication features should be improved, like chats, online tutoring, social group discussions, forums and access to other student's contact information. [Dahlstrom et al., 2014, p. 19]

3.3.1 Online status indicator

Corbeil and Corbeil [2014, p. 79 ff.] think that online status indicators for users are an important feature for learning management systems, because it allows users to see whether another user is currently online or not. This feature in combination with a chat can help users to communicate synchronously with each other.

While students are working on their assignments in the LMS they can easily communicate with their instructor, if he's present, or ask other students, that are currently online. This helps avoiding user isolation and desperation, because it allows students to get an immediate response to their question, beyond the instructors office hours. A smartphone app would expand this functionality even more. [Corbeil and Corbeil, 2014, p. 79 ff.]

Also the extent to other communication media like, audio and video would be a good feature to consider. [Baldauf et al., 2014, p. 97]

3.3.2 Work and learn collaborative

The second principle of Chickering and Gamson [1987, p. 3] "Develops Reciprocity and Cooperation Among Students":

> "Learning is enhanced when it is more like a team effort than a solo race. Good learning, like good work, is collaborative and social, not competitive and isolated."

When sudents work together, involvement is increased and when they share their different views and ideas it leads to a better and deeper understanding of the learning materials and topics. [Chickering and Gamson, 1987, p. 3]

So it is good to provide a learning environment where students can learn and work together in a team, and thereby learn from each other.

Some examples where students are working collaborative on mathematical problems are made by desmos, where I would like to refer to the weblinks for a detailed information. "Penny Circle" [Penny Circle, Desmos, 2015a] is an example for students collecting data together to make an estimation on a future problem. Another example "Polygraph Parabolas" [Polygraph Parabolas, Desmos, 2015b] is a game, where students have to play together and ask questions to find the picked parabola of the other student.

3.3.3 Feedback

Feedback is very important for learning. Students need appropriate feedback on their performance in the course, so it should be possible for teachers to give feedback quick and easy. [Chickering and Gamson, 1987, p. 4]

Most traditional learning management systems provide private feedback for students by teachers, which has of course it's advantages. Baldauf, Jiang, Marshall, and Dennen [2014, p. 97] say that users would benefit from visible feedback and peer feedback, which means that not only teachers, also students should be able to give feedback on other students' contributions and comments. They cite Ertmer et al. [in Baldauf et al., 2014, p. 97], whose say that "Peer feedback can influence the quality of student work and has benefits for both the recipient and the evaluator."

It is obvious that peer feedback, although it can add a great value, can also be challenging. Ertmer et al. [2007, p. 415] mention two mainly problems:

- It can be hard, especially for shy students, to overcome the anxiety about giving and recieving feedback, in particular when it is negative feedback.

- It is hard to ensure reliability.

An option for a peer feedback tool would be a simple "like" button, used for example in facebook, which doesn't allow negative feedback at all and students can mark content, which feels valuable for them. [Baldauf et al., 2014, p. 97]

In GeoGebraTube feedback is planned via comments, which can be made by teachers and students. Also special feedback from teachers to students within a worksheet where

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questions and exercises are created is planned. For this I would like to refer to the Assessment functionality described in section 3.4.

3.4 Assessment

As already mentioned in section 3.3.3, feedback is very important for students. Learning management systems and learning platforms offer usually a point system, where only teachers can evaluate their students' work with points.

In GeoGebraTube we would like to go away from a point evaluation system towards an evaluation with symbols and comments (see figure 3.12). We also think that the evaluation will be very popular as immediate self evaluation. By that we mean, that the teacher provides answers for questions and solutions for exercises when he or she creates the worksheet, but invisible for students. When students work through the exercises they can check their answers themselves by showing the correct answer provided by the teacher. This will minimize the teachers assessment effort and will also encourange the students' self-assessment and self-organization.

4 Conclusion

According to a PBS survey [2013], the number of teachers in schools using new technology and platforms to support instructions for their students is growing, so it's definitly worth, spending time in designing and implementing a new learning platform.

We want to help teachers and students by providing a very easy to use and clearly designed learning platform, where no extra training for the use of the system is necessary. We want to achieve better learning results of students by enhancing social learning.

We are looking forward to seeing the results of our research and design work, and to see how teachers and students like to work with and on the platform.

Figure 3.12: Teacher evaluation within a GeoGebra worksheet

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