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Discussion forums in education

A feature and usage oriented approach for choosing the right software

Masteroppgave

NTNU
Kunnskap for en bedre verden

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Abstract

Discussion forums have become widely used for student-to-instructor interaction. They are a great tool for this and are a positive addition to the classroom. However, there is not much research on designing them or picking features for them from a software development perspective. This thesis looks at the literature regarding discussion forums and their challenges to better understand the theoretical viewpoint. It also reviews some of the state of the art systems used for discussion and question answering today. Finally, how the literature intersects with the state of the art systems is discussed in light of the challenges related to the educational context. The result is a model that instructors or software designers can use to identify or target a certain type of activity, using software features and usage characteristics.

Sammendrag

Diskusjonsforum blir mye brukt i utdanning for kommunikasjon mellom student og lærer. De er et godt verktøy for dette, og er et positivt tilskudd til klasserommet, men det er lite forskning på hvordan man skal designe dem eller velge programvare-features. Denne oppgaven ser på litteraturen rundt diskusjonsforum, samt deres utfordringer, for å bedre forstå det teoretiske synspunktet. Den ser også på noen toppmoderne systemer som brukes til diskusjon og spørsmål-og-svar-tjenester i dag. Til slutt diskuteres krysningen mellom teorien og de toppmoderne systemene, i lys av utfordringene til utdanningskonteksten. Resultatet er en modell som kan brukes av programvareutviklere eller lærere, for å identifisere eller sikte på en gitt hovedaktivitet ved bruk av features og brukskarakteristikk.

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Chapter 1

Introduction

This chapter introduces the challenge of designing or picking the correct discussion forum for a given context. It also mentions what research methodology is used and what the contribution of this thesis is.

1.1 Motivation

Discussion forums and similar services have been around since long before the World Wide Web. Forums reflect one of the biggest advantages of the Internet: letting anyone communicate with everyone at any time. The forum format is a very intuitive way of communicating in a networked environment. You broadcast your message to anyone who wants to listen, and anyone who sees the message can respond and tell you what they think. It's a perfect tool for mass communication and information sharing.

Beginning with bulletin boards and pure text-based communication, today's forums pack many features that can fit different user demands. Evolving from the classical *thread*, *post* and *reply*, forums today have reputation systems, badge systems, gamification, great search functions, post rating systems and much more. Whether or not we are aware of it, we use forum-like solutions and features a lot. We comment on each other's posts on Facebook, we join online communities with specified interests on Reddit and post bits of text that other people can respond to on Twitter. Each service with a different set of features.

Commercially, the good solutions seem to emerge naturally due to competition and correctly meeting a demand. Websites like Reddit, Quora and Stack Overflow each serve a specific purpose. They combine a set of features that work well together and use that to build their platform. Reddit lets users create *subreddits*, which act as their own forums within the Reddit platform. Quora is a Community Question Answering (CQA) site for asking and answering questions and crowdsourcing knowledge with other people within certain topics or categories. Stack

Overflow (or any Stack Exchange site) also focuses on CQA, letting users ask questions tagged with specific technologies, giving points to the user that manages to find the correct answer.

Since forums are pretty much used everywhere on the Internet, they also happen to be used in education. They are a great tool in this context, as it is often the case that one person, the instructor or a student, has to convey messages or information to many people at the same time, especially in Massive Open Online Courses (MOOCs), where thousands of students can be enrolled simultaneously. Since the world of discussion forums has evolved a lot, educational forums have evolved too. We see different solutions today, all from the classical pure text-based system to the more modern post rating system that orders posts. These forums vary from being integrated into an e-learning or LMS platform, being self-hosted, or hosted externally by a service provider. Although they have evolved with the times, the most beneficial features for forums in educational use might not be obvious, and there is little research regarding what makes a good discussion forum when used in an educational context. There is a lot of research on the general effect of discussion forums in education, and it's mainly positive regarding their use, but how do we design them? And how do we choose what type of discussion forum to use, given a certain intent or context?

1.2   Method

This thesis follows the *Design and Creation* strategy explained in [1]. The thesis presents a *model* for designing an educational discussion forum or picking out what type of discussion forum to use based on a given intent. This will be the main contribution of the thesis. Further, this thesis provides examples of how to use this model to design and analyse these systems.

Based on the former, I have formulated the following research questions.

RQ1 What would be a generic model of a universal discussion forum?
RQ2 What features are commonly used in discussion forums, and how can they be categorised?
RQ3 How should discussion forums be used to support education?

To answer these questions, I will present literature about how we use discussion forums, how they are used in education, how forum communication looks, how we can build communities by using forums and how we can motivate students to participate. I will also look at some state of the art systems, both for educational use and wider public use. Here I will look for prominent features used and attempt to analyse how these features would work in an educational setting. Specifically, I

will look at how community building and communication are related in the educational context and how the formality of the situation might impact the way we use discussion forums in an educational context.

1.3 Note

Before writing this master's thesis, I researched discussion forums and their features. Specifically how we could increase student-on-student communication when discussion forums are used in education. The project report is not published, but I will reuse some of its contents in this thesis. If a chapter is reusing material I will state it in the chapter's introduction and cite it with [2].

Chapter 2

Background

In this chapter, I present relevant literature for answering the research questions presented in the previous chapter. For **RQ1**, we look at the history of discussion forums and their core features to provide a general model. To research **RQ2**, we look at the challenges of discussion forums and how they are currently solved. These challenges revolve around participation, motivation, and community building, which are important in an educational context. For **RQ3**, we look at the literature on how discussion forums are used in education currently, their effect on education, and the potential differences between public use and educational use. Elements from this chapter have been reused from [2].

2.1 History of discussion forums

Discussion forums and similar services have been around since before the World Wide Web. Precursors include Bulletin Board System networks like FidoNet and distributed discussion services like Usenet back in the 1980s. The main usage seemed to be spreading information to many people simultaneously and for those people to be able to respond or comment on the information. News, bulletins, messages and software was shared within a network, sometimes with the ability to subscribe to certain news feeds or message feeds. One of the first discussion forums released on the World Wide Web was W3 Interactive Talk (WIT), made in 1994. Its purpose was to "allow discussions on W3 technical matters to be stored in a more structured fashion" (quote from `https://www.w3.org/WIT/User/Overview.html`). In the following years, similar systems appeared, becoming more and more sophisticated.

The core features and user models of a forum have stayed the same over time. Usually, the discussions are focused around *threads*, sometimes called *topics*, which are collections of *posts*. A thread is started when a user posts something and other users respond to it. The thread then forms from the original post. All responses to a post will fall into this thread, creating a relation between them. Many forums also have a user hierarchy with certain permissions or possible actions for each
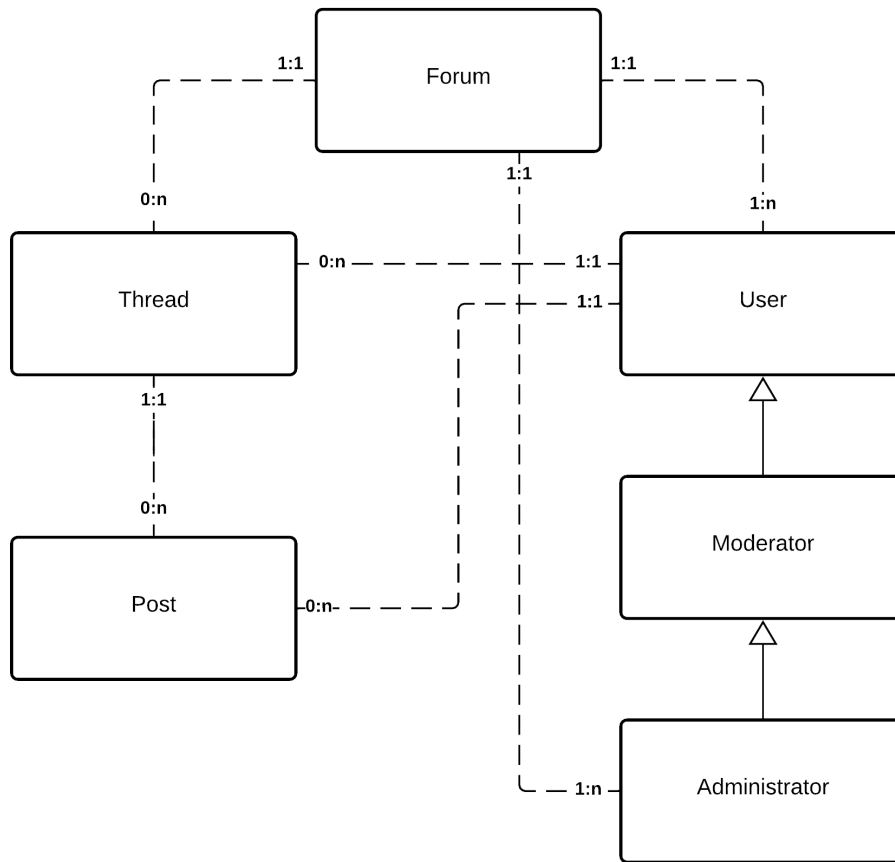
Figure 2.1: Generic model of a discussion forum.

hierarchy level. The most common model is having Administrators, Moderators and regular Users. Administrators have full access to everything. Moderators can modify or delete user posts or remove users from the forum. Regular Users can read threads and create posts in areas of the forum where they have been given access. These core features and user models have stayed mostly the same in newer times, but with certain additions used to meet different demands. A simple model of this can be seen in Figure 2.1.

Some forums are based on a single forum provider enabling smaller communities to form within that forum; others provide a forum template, letting people self-host their own forums or host via a given provider. It seems like this has been the case historically as well. A user in an online community called Forum Software Reviews posted a timeline from 1994–2012, categorising and displaying the different discussion forums in that time period. They used the categories "Free software" (labelled in green), "Commercial software" (labelled in blue), and "Hosting

service" (labelled in orange). See Figure 2.2. A current example of free software is Discourse, an open-source discussion forum that anyone can host. Discourse is also available as a hosting service, with the option of tailoring the forum to the customer's needs. Commercial software is sold commercially, sometimes with a free tier, like Stack Overflow Teams.

Today, classic discussion forums are still in use. Additionally, new and modern solutions have emerged, like Reddit, Quora, Yahoo Answers, and Stack Overflow. These platforms offer new functionality like gamification and post rating systems. Moreover, some of them, like Reddit and Quora, take an approach to communication that is closer to social media. Most of them look different than the classic discussion forum, but their communication structure still follows the generic model for discussion forums in Figure 2.1. While many would not call these new sites "discussion forums" they are still used similarly, for community building, crowd sourcing knowledge on particular topics, and social connection.

2.2   Educational use and learning

Discussion forums have been used in education for a long time, and, understandably, their features are appealing for this purpose. A forum gives the ability for one person to talk to or pass information to a lot of people at the same time. Instead of asking the instructor directly, they can post the question to a forum where everyone can read the response. This lightens the workload for the instructor, having to answer fewer messages or requests for information. It also lets the instructor broadcast information to all students at any time. They are also essential for Massive Online Open Courses (MOOCs), as these courses sometimes aim to have several thousand students taking the course simultaneously. Letting the students discuss and getting important information out to all students can easily be done using a discussion forum.

To further understand why it is desirable to use a discussion forum in this context, we might look at some social learning theory. Social learning theory says that we learn when we are participating in activities with other people, when we get feedback from other people, and when we interact with other people in public or other social contexts [3]. We can facilitate this learning process by using digital tools, such as a discussion forum. Hill et al. [4] believe that web-based learning environments have a lot to offer when it comes to social learning. The paper ties in a lot of the theory and discusses how it might be used in a digital context and what to look out for when designing such an environment.

There has been done a lot of research on discussion forums used in an educational context. Generally, the research seems to focus on their effect on learning and student perception of community. Discussion forums connecting the students and the instructors have a positive effect on learning [5]. The cited study fea-
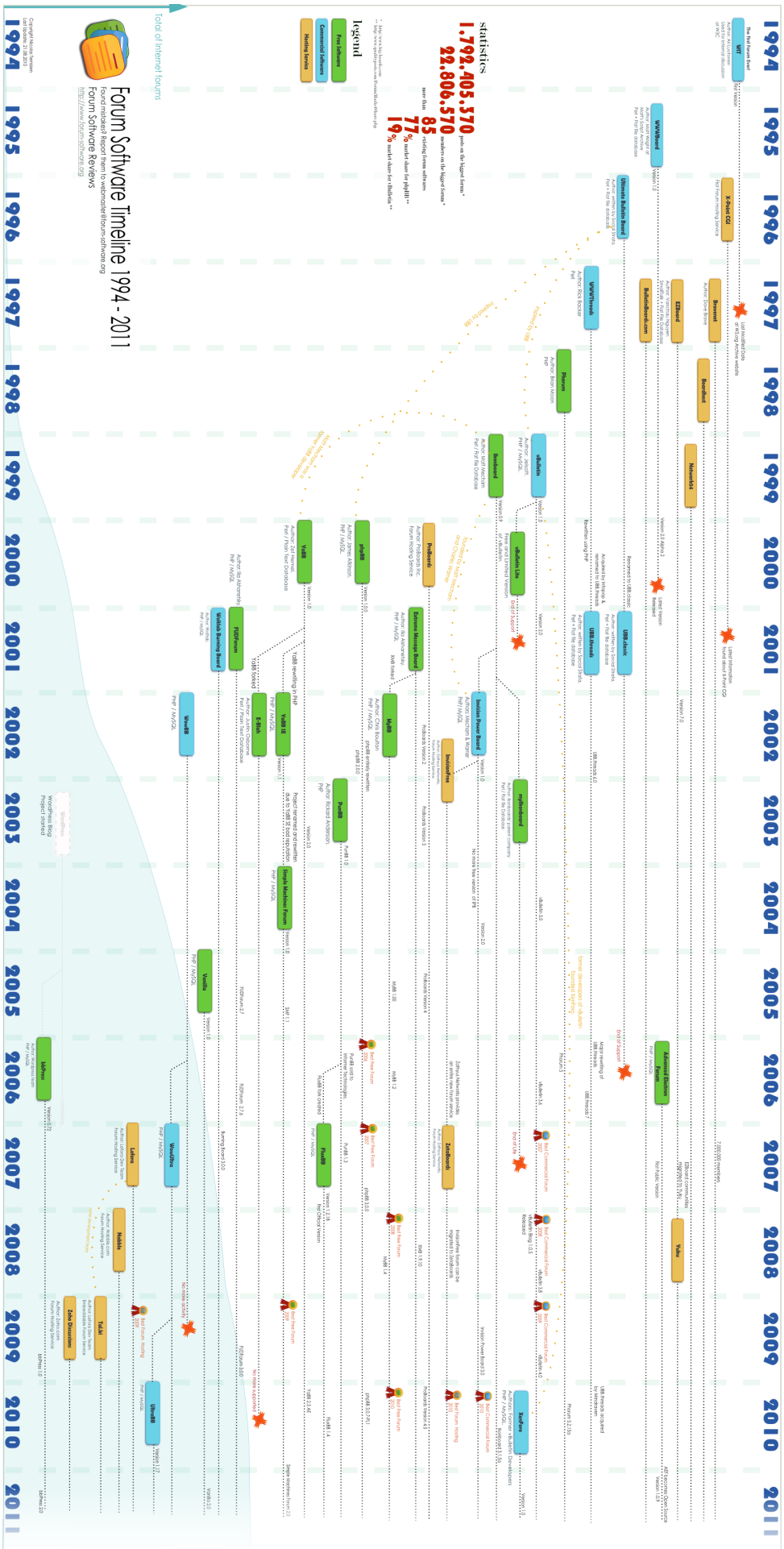
Figure 2.2: Timeline of forum software released from 1994 to 2012.

turing two on-campus courses at the Rochester Institute of Technology found a positive correlation between a student's grade in a course and their participation rate in the course's online discussion forum. They also conducted a student survey for the same courses. A majority of students (55 %) stated that they felt the online discussion positively impacted their learning. The qualitative part of the survey indicated that the students felt the discussion forum helped their student-to-student and student-to-instructor communication during homework and assignments. They also stated that it helped with student-to-student interaction and instruction. That participation in discussion forums is positively correlated with a student's grade was also found by Cheng et al. [6]. They looked at two different psychology courses in higher education, experiment one having 1284 participants and experiment two having 1334 participants. In addition to looking at the effect of posting on the forum, they looked at the effect of reading other students' posts and how that contributes to learning. They found that reading posts from other students also had a positive effect.

A paper by Mark Northover from 2002 discusses what features should be used for online discussion boards used in education [7]. The paper brings up how to make discussion boards work, the tutor's role, and how to create discussion. For making discussion boards work, six aspects are brought forward:

1. Value in the discussion
2. Challenge in the discussion
3. A non-threatening environment
4. Feedback from tutors
5. Encouragement by tutors
6. The authenticity of the discussion points

Facilitation by the tutor is presented as very important for online discussion. As in face-to-face discussion, the tutor should keep the discussion going and offer their knowledge when appropriate. It is mentioned that students who are mostly familiar with instructivist environments might find it challenging and unfamiliar to collaborate with other students and that it might keep them from participating. Anonymity is also viewed as a factor. The author suggests that one might allow students to post anonymously in the beginning. It does not seem like the size of the course is taken into account in this paper, so it is unclear whether these features work the same way when there is a large number of students. The paper is also discussion-heavy, meaning it does not cite too many sources but builds on the author's own experience.

Instructor involvement in discussion forums seems context-dependent. One study found that instructor involvement boosted participation numbers on a Q&A platform [8]. Another found that instructor participation made student participation numbers stay the same and that discussions shortened in length [9]. Several authors have concluded that instructor involvement can be good for creating learn-

Formal communication	Informal communication
• Scheduled in advance	• Unscheduled
• Arranged participants	• Random participants
• Preset agenda	• No arranged agenda
• One-way	• Interactive
• Impoverished content	• Rich content
• Formal language	• Informal language
• Used for predicted situations	• Used for unpredicted situations
• Not useful for social maintenance of a group	• Used for social maintenance of a group

Table 2.1: Communication traits for formal and informal communication [14].

ing communities. Shea et al. found "a significant link between students' sense of learning community and their recognition of effective instructional design and directed facilitation on the part of their course instructors" [10]. G. Salmon lists several ways in which a teacher, acting as an e-moderator, can increase participation among students in online learning [11].

In the context of learning in discussion forums, it can be useful to consider the difference between intentional learning and incidental learning. This is to better understand how students might use it and be able to make good design decisions. Intentional learning can be defined as "learning that is motivated by intentions and is goal-directed" [12]. In contrast, incidental learning happens as an incidental outcome of some action or event, where learning was not necessarily the primary objective. In one example, it is compared to learning a second language [13]. You can choose to study the language's grammar rules and words by seeking information about it, which would be intentional learning. You can also move to another country, be exposed to the language repeatedly, and pick it up as you go, which would be incidental learning. Asking a question or seeking out answers on a Q&A forum would be intentional learning. Learning something from a random discussion on a discussion forum would be incidental learning.

2.3   Communication

A discussion forum can be used as a medium for communicating asynchronously. One of the ways we can categorise communication is by viewing it as formal or informal. Some differences between formal and informal communication are presented by Kraut et al. [14] as shown in Figure 2.1.

The differences between these two categories are based on both situation and
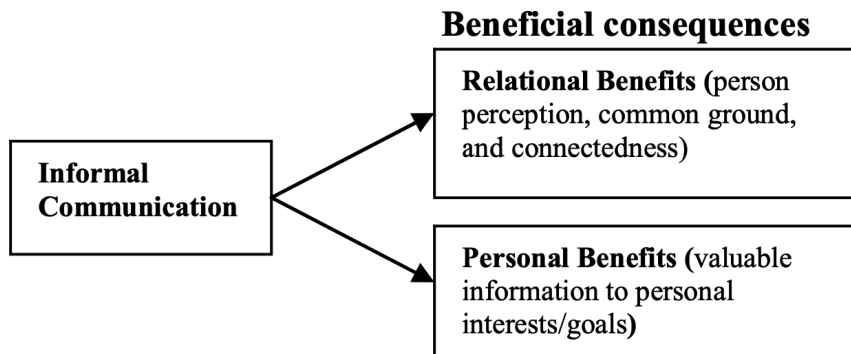
Figure 2.3: Figure presented by [15] on the benefits of informal communication.

content. Keeping these differences in mind can be useful when determining what type of communication a forum can support through its communications channels and features for communicating. It is also useful for analysing the communication between student and instructor and what that might mean for the forum's design. What is particularly interesting is the difference in social maintenance of a group, as it can have implications for community building.

In a paper from 2009, Dejin Zhao and Mary Beth Rosson summarised some literature on the benefits of informal communication [15]. The benefits were split into two categories: relational benefits and personal benefits. See Figure 2.3. Informal communication is a good way for people in organisations and work environments to connect personally. Among the personal benefits, they bring up the potential effect that weak social ties can have on exchanging novel information. They point out that informal communication might help develop these weak ties, increasing the amount of novel information that flows from person to person. Although the examples in the paper are related to organisations and work environments, they might be relevant for an educational context and learning communities.

2.4 Community

There are several definitions of what an online community is, but according to [16], the most cited seems to be this: "an online community consists of people interacting socially and sharing a purpose, of policies to guide these interactions, and of computer systems to facilitate the sense of togetherness" [17]. Social interaction between members of the community and a feeling of togetherness are key differences between a community and a crowd. A crowd can be defined as "a group of individuals who have different perspectives" [18]. It can be important to differentiate between these two, as they may require different features from software built to support them. Crowdsourcing knowledge and building knowledge

in a community are two different things.

An article by DeSanctis et al. names three types of online communities and what characterises them [19]. Type 1 communities are called *information kiosks*, characterised by "notably fewer unique contributors per month than other communities, a lower retention rate, and a small degree of overlap with other communities". Type 1 communities also lack deep discussion, and interactions focus more on "seeking and providing information". Type 2 communities are called *associations* and are often affiliated with a professional society. Discussions are deeper than in Type 1, and user retention is higher. There is more information exchange as well, and users tend to participate in multiple communities. Type 3 communities are called *communities of practice*, named after the term established by E. Wenger [20]. More on communities of practice later. These communities have deeper, denser discussion, more social interaction and more user retention. They also do well regarding information generation and exchange.

The authors of [19] also provide guidelines for using and developing learning networks. Some key points they suggest to work towards are:

1. Frequent interaction
2. Making the technology a media space for interaction
3. Deep discussion
4. Positive and respectful tone
5. Recognising the importance of facilitators
6. Build a large core group of participants
7. Recognising routines for interaction
8. Experimenting with the technology

These key points can be helpful when recommending features for discussion forums where community building is prioritised.

Etienne and Beverly Wenger-Trayner define communities of practice as the following in an introductory article about the term: "Groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly" [21]. The article cited introduces what they call communities of practice, how they work, what they require and where they are used. Communication between participants in a community of practice is important in the form of discussion, sharing ideas, sharing information and creating new knowledge. The members of the community are practitioners within the domain that the community is built on. They gain their own knowledge and experience, which they use to contribute to the community by sharing it with others. Sharing experiences will then contribute to the learning of everyone within that community.

2.4.1 Community Question Answering

Community Question Answering (CQA) sites like Stack Overflow and Quora are prevalent sites for building community knowledge and problem-solving. This type of site is increasingly used in education. A popular example is Piazza, which is a course-by-course forum used for Q&A. Using this type of site in education can be useful, as it makes it easy to ask questions for the course staff and for building a community around the Q&A format. In a survey posted in 2016, Srba et al. provide a framework describing the QA process [22]. One part of this framework describes what they call the *Question Lifecycle* and its components. The lifecycle consists of four steps: (1) question creation, (2) question answering, (3) question closing, and (4) question search.

Srba et al. developed a CQA application for use in education called Askalot [23] in 2015 and provided some reflections on CQA applications and their use. They divide CQA applications into two dimensions: context and environment. The contexts they use are educational and non-educational, and the environments they use are open environment, organisation-wide environment, and organisation department. As examples, they categorise Stack Overflow as "non-educational" and "open environment", and Piazza as "educational" and "organisation department". Their CQA system, Askalot, is aimed at the "educational" and "organisation-wide" categories. To explain this, they point at the students' expertise and that a closed class forum only contains students of the same year of study. By creating an organisation-wide forum, students who have taken a course previously can help students currently taking it. In their design, they also emphasise instructor involvement and motivation. However, their design choices seem to rely on personal experience rather than literature. As an example, their choice to let the teachers rank student answers on a 1 to 5 point Leikert-scale is related to external motivation, which can have some negative effects. This is not discussed in their paper.

Although there is a lot of research on CQA in a general context, there are few broad studies on how they should be used in education [8]. Srba et al. used their application Askalot to research the CQA approach from a student's perspective [8] in 2019. They implemented Askalot as a CQA service for computer science courses at three universities, analysed log data after its use, and had 182 students from different experience levels answer a questionnaire. Students were split into two categories: continual and sporadic students. Continual students had used the service in many courses for several years. Sporadic students were new to the system and had only used the system experimentally in a few courses. Their data was used to derive characteristics of CQA systems in education and how students view them. Some characteristics were marked as positive, and some as challenges that occur in the educational context. Among the positive characteristics, we find the potential for variability in the number of students, creating a long-term repository for data, and allowing for both active and passive participation. Some of the chal-

lenges were achieving continual deployment, instructor participation, and privacy issues. In general, CQA is presented as a good solution for educational use and a good alternative to standard discussion forums.

2.5 Participation

There has been done a lot of research on online community participation. However, most of the research focuses on active participation and concrete contributions [16]. According to [16], measuring the quality of a community is likely more complex than counting the number of contributions by active users, which is often how participation is measured. In online communities, the majority of participants tend to be passive. These users are often called "lurkers", and their influence on the community is unclear. Passive participation is seldom measured as participation, even though those passive members feel part of the community as a whole.

Schultz et al. [24] looked at characteristics of lurkers, why lurkers lurk, and how to make lurkers become active participants, among other topics. From their literary study, it seemed that lurkers are not more common in any age group, sex, education level, or employment status. Additionally, lurkers have more introverted behaviour, wanting to observe and analyse rather than participate. They also make a point that the physical classroom shares the same characteristics, and that it might be natural that online communities or classrooms experience the same phenomenon. Aided by online facilitators, they nominated three main reasons why lurkers do not participate: (1) shy about posting, (2) others respond the way I would, and (3) not enough time to post. They conclude that private contact with individual lurkers is the best way to facilitate them becoming posters. Additionally, a list of several helpful activities and tools is provided.

2.5.1 Anonymity

The ability for a user to remain anonymous while posting is a popular feature in modern educational forums. Intuitively, this will lead to more contributions as you remove some of the social tension that can come from posting. Kilner et al. [25] found this to be the case in their study on the effects of anonymity in an online community of practice. They established four levels of anonymity for people who wanted to contribute to the community: (1) no username needed, (2) username with no connection to the real person's identity (pseudonym), (3) username with connection to the real person's identity (e.g. JohnDoe), and (4) post signed with full identity. Their results showed that while the number of contributions went up when level 1 anonymity was allowed, so did unwanted and negative behaviour. The professionalism and productivity of the content went up when level 1 anonymity was removed, the number of negative comments went down 89%. There was no significant change when level 2 was removed. The authors discuss that this might be because of peer perception for continued membership in the

community. While level 1 anonymity affected active participation, the authors did not observe a change in passive (or peripheral) participation, such as page views and log-ins.

2.5.2 Motivation

There are a lot of possible motivations for participating in online discussion forums. Instructors can give bonus points on a student's grade, make regular participants better candidates for teaching assistant positions, or participation in the forum can be made mandatory. The most popular motivation is probably to receive help with their course activities from the instructor. We also have technological ways of increasing motivation using software features. The most natural modern choice here is *gamification*, which is a way to incorporate game elements into course activities. This section will present some literature on motivation from both an instructor facilitation standpoint and gamification.

A paper from 2006 looked at student motivation in online discussions [26] and found that a student's participation can be linked to their intrinsic motivation to participate. It also found several factors that might influence student motivation when choosing to participate. It looked at two separate class-related forums. One where participation was recommended and valued by the instructor, and one where it was not. They find that if the instructor actively encourages participation, this can significantly increase students' participation. The instructor's role in the discussion is also brought up as one of the themes from the student's interviews. Students stated that they felt more motivated to participate in the online forum when the instructor actively participated, guided and provided feedback. They also believed that interaction between peers was another important factor that could positively influence their motivation.

Gamification can be defined as "the use of game design elements in non-game contexts", [27]. In discussion forums, these gamification elements are usually based on active participation on the forum. Stack Overflow has the reputation system, which works like a user-score. Reddit uses awards and karma. More on these specific systems in chapter 3. Since gamification is applied to active participation, they are used to encourage good behaviour, quality contributions, and participation in general. For example, by granting a *badge,* or any type of achievement confirmation, when a user's post has been "liked" a certain amount of times. These can also be given out for simply posting something, like on Discourse, in order to increase the number of active participants. Or by giving a user a public score that increases with their positive contributions.

Literature studies from 2015 [28] and 2017 [29] indicate that gamification features can have both negative and positive effects on learning and motivation and

that the literature does not provide a generalised approach to it. Dichev et al. [29] mention that while some studies might find positive effects, it usually happens in a special context that can't be generalised. They classified 63 papers in their study. Of those papers, 64% were inconclusive as to how gamification impacts education. And among the 26% of articles that had a positive outcome, meaning they presented valid evidence for their claims, there were mixed findings on gamification's effect. 12 papers found positive effects, 3 found negative effects. This indicates that while gamification in education can be positive in some situations, it's hard to tell which situations benefit or can experience a negative impact.

As mentioned, the instructor can choose to give rewards for participation. However, studies have indicated that extrinsic motivation can have a negative impact on learning [30]. Abramovich et al. used *badges* as rewards for participation or show of skill in their 2013 study on how badge rewards affect learners of different skill levels. Their findings suggest that learners react differently to badges and that they can have different effects on their motivation based on their prior skill level. Results indicate that there might be both positive and negative effects from using badges, and the authors argue that these effects can be mediated with thoughtful badge design. Skill badges seemed more related to intrinsic motivation than participation badges, and it might be beneficial to display how a badge is earned. This study was not large or thorough enough for the results to be generalised. Still, it shows clear indications that extrinsic motivators such as badges can have unknown negative effects on learners.

2.5.3 Question routing

Question routing is about routing questions in a forum to a user that's likely to answer it, using software to determine whether a user is suitable. Research indicates that this can lead to higher participation rates and user retention, and several techniques can be used to classify questions and identify potential users [31] [32]. Macina et al. [33] implemented question routing for an educational context. They routed questions using a model of a student's *willingness to participate*, combined with their *expertise.* Their experiments showed promising results. Question routing led to higher interest in participation, leading to more activity on the forum. It also decreased dropout rates for active contributors.

A challenge with question routing can be that only experts with a previous answer history get question recommendations [34]. Using activity to find experts will rule out the passive users (lurkers) from being recommended as answerers. The article cited by Srba et al. suggests using data from sources like a user profile, user bio, or personal blog to determine if a passive user is a valid candidate. This can lessen the workload on the experts in a community and increase participation among lurkers.

2.6   Summary

Discussion forums have been around for a long time, and have been identified as a valuable tool in the educational context. They are a positive addition to the classroom, as there have been observed positive effects on learning when students are participating or just reading other students' posts. In terms of communication, discussion forums are an asynchronous way of communicating, and can support both formal and informal types of communication. Community building seems to be a focus for many online forums, both in the educational context and public contexts. In the educational context, this is because of the well documented positive effect of social learning. There is much literature on how to create online communities in terms of techniques and strategies, but little on how those techniques and strategies translate into software features. Participation in forums also has much research. Again, many of the recommendations in the literature focus on facilitation techniques and strategies, and not so much what software features can be used to increase participation. However, some techniques like question routing and anonymity seem promising.

Chapter 3

State of the art systems and analysis

In addition to literature, there are many popular software solutions for discussion forums that have emerged and evolved over time. To further attempt to answer the research questions, we will look at some of these systems and pick out their most interesting and prominent features. The literature written about discussion forums often focuses on their general effect on students, such as their learning effect. As far as I can tell, there is little literature on concrete features and their impact on how students use forums. For example, "Feature A has an impact on the behaviour of student B because of its effect C." Looking at popular systems and what features they use can help understand the relationship between their intended use and effect, and the features themselves. Elements from this chapter have been reused from [2].

3.1   State of the art systems

This section will present some of the more popular systems available today and how they work. The systems presented in this section are similar in some ways, as they are all within the definition of a discussion forum. However, they solve very different problems. They also seem very successful at solving them, some being popular systems with much traffic. This analysis will discuss the features in these systems and how they shape the interactions within the platform. Picking out these systems has been done by looking for features around community building, participation, motivation, information distribution, discussion, and question answering. They might shed some light on how we can design forums for an educational context. They have also been selected because of their popularity or certain innovative features they might have.

3.1.1 Discourse

Discourse is an open-source discussion forum available for self-hosting or as a tailored service by the Discourse company. Its open-source community is very active, and there does not seem to be any differences between the free version and the paid version. The look and feel of the forum resemble classic forum services out of the box. It also seems like several online communities regard it as a good piece of software.

Core system functionality

Out of the box, the forum consists of different *topics* and *categories* that are predefined. Structurally, a forum is be divided into hierarchical categories, which are meant to represent a domain or theme of discussion. See Figure 3.1. Each category can consist of several subcategories, which can, in turn, consist of more subcategories. There does not seem to be a limit to how many levels of nested categories you can create. Discourse also has a feature called Groups. Groups can be used as access control, where a user gets access to a specific category if they are part of a specific group.

When a user wants to create a post, this is done by making a new *topic.* Topics seem to be the most important entity within Discourse, and it is here that the user-generated content lies. A topic is always part of a category. They can be created and posted at any time; you do not need to navigate into a category to create one. The category of the topic is picked before posting. Once posted, other users can reply to the topic, bookmark it, share it, etc. It does not seem like a post can belong to several categories at the same time unless the categories are nested. Categories follow a hierarchical structure by nesting categories in other categories. For example, if you have the categories "Help" and "Python", where "Python" is nested within "Help", a new topic in "Python" will also belong to "Help". However, it will not belong to any other categories on the same hierarchical level as "Help" or "Python". A topic can also be made into a *Wiki.* A Wiki is a post that all other users can edit if they have the required permission level. It also stores a history of edits and revisions.

User accounts carry a lot of functionality and customizability in Discourse. Firstly, users can be put into several *trust groups.* Each trust group has certain privileges and permissions. Membership in a trust group can be obtained by meeting certain criteria that the forum administrators choose. For example, if a user is new and has not done anything on the forum, they can be placed in trust level 0. Here, they can only post topics and reply to others. After some activity, they reach trust level 1, where they can contribute to Wikis, for example. How much activity required to reach a trust level and what benefits each trust level has is up to the administrators. The ability to post anonymously is an example of a benefit that can be granted by trust level. Users can also be made administrators or moderators. If a

user is an administrator or a moderator, this will show by their name when posting topics or replying to them. They also gain the usual abilities associated with those roles, like post-editing or silencing other users.

Users can earn badges, which are designed to be awarded if the user has accomplished something special. See Figure 3.2. For example, by visiting the forum 10 days in a row, posting 100 topics or getting 50 likes on your posted topics. Additionally, administrators can create custom badges. This is done by defining a query to be run on the forum's database. If a user satisfies the query, they receive the badge. This can be done to make badges for activity within specific categories or areas of the forum. For example, you could make a badge saying "Answered 10 questions in the Python category".

Plugins are a big part of Discourse. They function as smaller pieces of software that can add to the forum's default functionality. The creation of plugins has much support within the Discourse community and has its own category on Discourse's own developer forums. On those forums, you also find a lot of open-source plugins. An example of a plugin is the "Accepted answer"-plugin. This lets administrators define categories where users might mark a reply on their topic as a "correct answer". Using this plugin lets Discourse mimic a Q&A style forum like Stack Overflow. Another example is a Github plugin that integrates with Github and provides information when a repository has new changes. Plugins are simple to install. Still, they can make big changes to how the forum is used, meaning that you can tailor different parts of a forum for different use cases, as a plugin can be applied on a category basis.

Notable design elements

Discourse's features are notably promoting community building and maintenance. The trust level feature and the badge feature are ways of rewarding users for their participation. Especially the trust level system, where the administrators can give elevated permissions to users who have had a steady contribution over time. Trust levels and social status within the community can also be made visible if the administrators choose to do so. For example, by giving a group of users an icon on their profile picture. These icons can be used to indicate status or contribution, in addition to badges. For example, a Discourse employee will have a Discourse logo in the bottom right of their profile picture when posting on their developer forums. These icons can also have tool-tips explaining what they mean. The admin panel can also be useful when building a community. Discourse's admin panel provides a lot of data on the forum's use. See Figure 3.3. This information can help community leaders focus their attention on specific issues or challenges that the community might have. For example, if there are many log-ins on the platform but fewer contributions than expected from that number of log-ins.

Figure 3.1: Category overview page of a Discourse forum.

Figure 3.2: Display of a user's badges on Discourse.
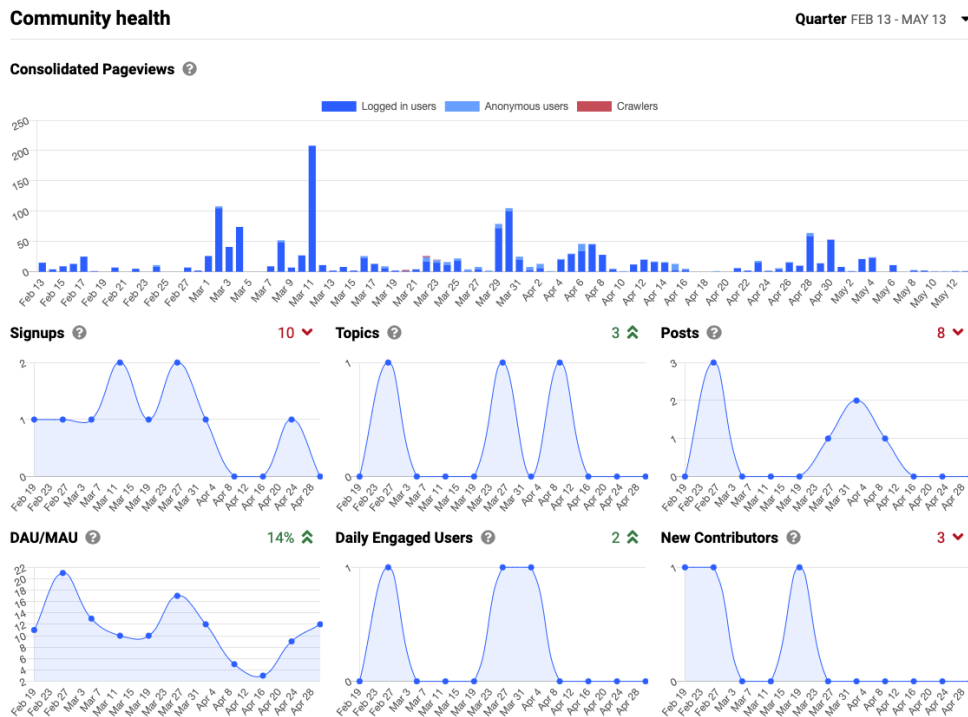
Figure 3.3: The admin panel in Discourse.

Concerning participation, Discourse supports both active and passive participation. Active participation is supported through posting and replying to topics. Passive participation is supported through the ability to like posts, a click counter on links, and badges. Some badges are rewards for just being on the forum, such as visiting it for 10 days consecutively.

Forums on Discourse can be adapted to many scenarios due to different plugins and an extensive admin dashboard. Discourse can be a Q&A forum, a classic discussion forum, and a bulletin board at the same time. This gives communities much room for adapting to a certain context and find their preferred way of communicating. The adaptability even goes as far as having a minimum length on posts and answers, forcing users to write proper responses and topics. This feature can be disabled, but it shows how far Discourse goes to facilitate different types of communities and different ways of participation.

3.1.2 Reddit

Reddit is a very popular website featuring discussion and content sharing. One of its defining qualities is that it is divided into *subreddits*. This allows different communities to organise their forum content in their own way, making their own community inside a much larger one. Reddit is chosen for this chapter because of its popularity and community features.

Core system functionality

As mentioned, Reddit consists of subreddits, which are smaller independent forums. While every subreddit has the same functionality and features, each subreddit is its own forum. User accounts are platform-wide, not specific to a certain subreddit. This means that your display name when posting is the same across subreddits. Subreddits have their own administrators and moderators and can be customised in several ways to make the community unique. An example of this is the *flair* feature. Flairs are labels that appear next to a username when posting, and the community can customise what flairs are available and what form they should have. Flairs can also be restricted, meaning that they can only be obtained through a moderator enabling them for you. For example, in a subreddit about football, you might have a flair that states what team you are cheering for. Alternatively, if you are a popular football player, the moderators can grant you a special flair to showcase that. A subreddit can also change some of the visual design on the page, such as the colour scheme and the appearance of the post voting buttons.

The way content is produced and organised on Reddit is much like a classic discussion forum. You need a user on the Reddit platform to post. When you post something, you post it to a subreddit or the feed on your own user profile. The subreddit and username the post is posted to are visible in the top left corner of the post. See Figure 3.4. Your post can then be commented on, starting a thread and making you the original poster. It is also possible to comment on comments. The original poster has a microphone icon next to their name in the comment section, indicating that they are the original poster. See Figure 3.5. Posts and comments can be up-voted or down-voted, which impacts the poster's *karma*. Karma is a score attached to a user that sums up all the up-votes and down-votes on a user's posts and comments. The total sum is also displayed on every post, showing its net score.

A post or comment can be given an *award* as a symbol of appreciation or emotion. See Figure 3.6. Awards can be purchased using Reddit's internal currency, Coins. It seems that awards are mainly for visual purposes and to "react to stuff on Reddit", as Reddit puts it [35]. However, some awards come with benefits, for example, the Gold Award shown in Figure 3.6. Some general awards can be given across the entire platform and some community-specific awards that the community's moderators can create.

Figure 3.4: A post appearing in a feed on Reddit.

Notable design elements

Reddit focuses on community building. Each subreddit can be adapted to a certain community's needs by having its own moderators, rules, flairs, awards, colour schemes, etc. A community can thereby define the format of their communication by using rules and content moderation. For example, by setting a rule in a game development subreddit saying you cannot directly promote your own game, but you can show interesting aspects relevant to other developers. Moreover, while each subreddit is its own community, platform-wide user-profiles tie subreddits together, making the whole platform a community.

Post rating is important on Reddit and plays a big role in the ecosystem. Firstly, it serves as a tool for selecting good posts and comments. Reddit has many filtration and sorting features for selecting the best posts and comments. Secondly, a post or comment score affects a user's karma, affecting their peer recognition and status within the community. A contribution can both give and take away karma, as down-votes are usually enabled. It should also be noted that karma is platform-wide, meaning that negative behaviour on one subreddit can affect your reputations in other subreddits and the platform as a whole.
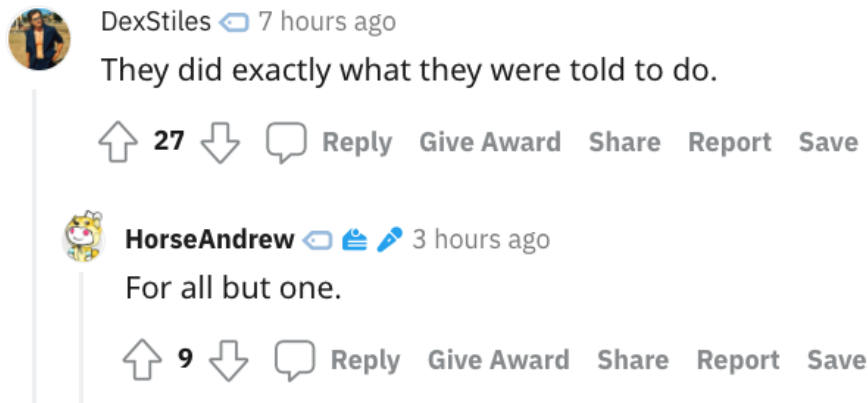
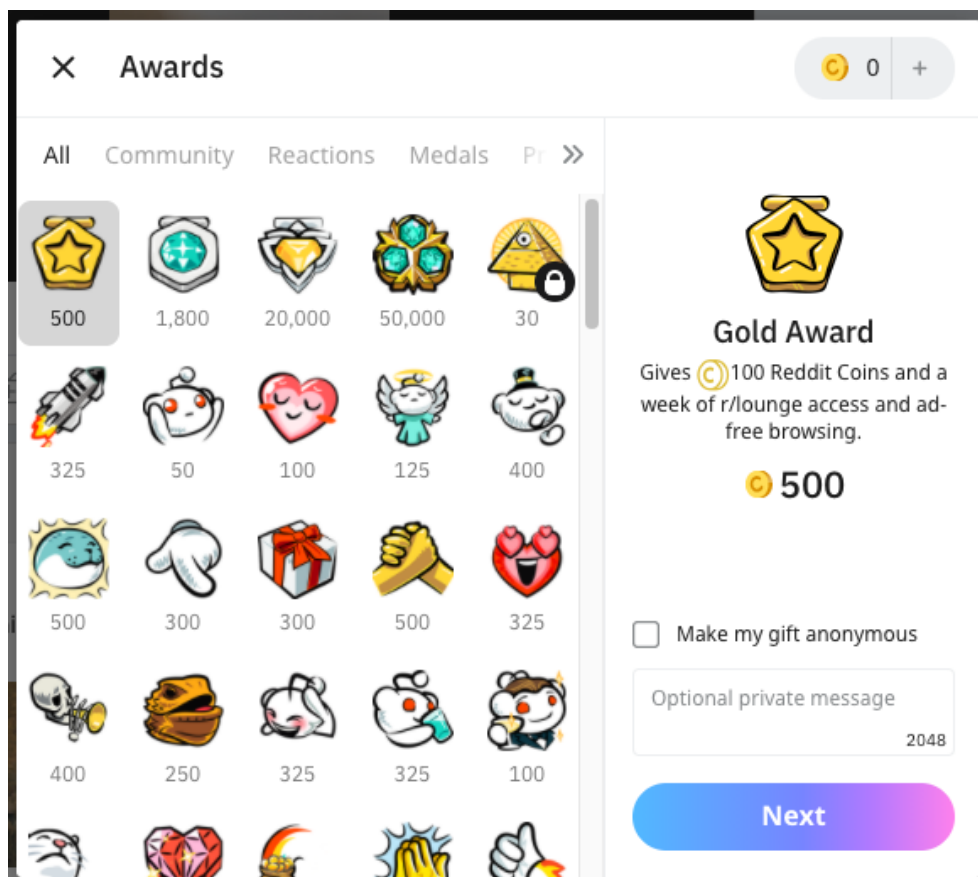**Figure 3.5:** Part of the comment section on a Reddit post.

Figure 3.6: Some of the awards users can buy and award to pieces of content.

3.1.3 Stack Overflow

Stack Overflow is a public CQA website for programming that allows anyone with a user account to post a question. It is very widely used today and is often the first hit you get when using a search engine to find an answer to something you have been struggling with. This overview will focus on the public question version of Stack Overflow, not the private product for teams.

Core system functionality

The design of this service is pretty simple yet very effective. Stack Overflow is made up of questions that are tagged with different technologies or knowledge areas. Other users can answer each question. The original poster can then mark one of the answers as the correct answer if the original poster deems it correct. There are also several *communities* where each question should be within the theme of that community. An example of a community is "TeX - LaTeX" or "Ask Ubuntu".

When searching for questions, you can sort them by "Newest", "Active", "Bountied", "Unanswered", "Frequent", and "Votes". You can also choose to view all posts with a different set of tags. For example, you can choose *Python* as a tag by itself, or you can add *Django* on top of that if you want to view questions with both tags. When sorting by "Bountied", you view questions that the original poster has but a *bounty* on. A bounty is an extra reward for providing the accepted answer to that question. The user asking the question rewards an amount of their own *reputation* to the person who manages to solve it.

Reputation is a mechanic that exists for every user on Stack Overflow. When a user's answers or posts are voted upwards, the user gains reputation. This reputation is displayed whenever the user's username is displayed. See Figure 3.9. It is also visible in more detail on their profile page. See Figure 3.8. For example, when the user answers a question or when they participate in a discussion. Reputation is numeric and can be everything from 100 to 1 000 000. This serves as a way of gaining credibility on the website.

Badges are used as a mechanic for awarding users when they answer questions. Depending on how many votes you get and in what context, your user might be granted a badge. There are also intuitive quality differences between different badges: bronze, silver and gold. The number of badges of each quality a user has gained is displayed next to the username when a user answers a question or participates in the discussion. See Figure 3.7.
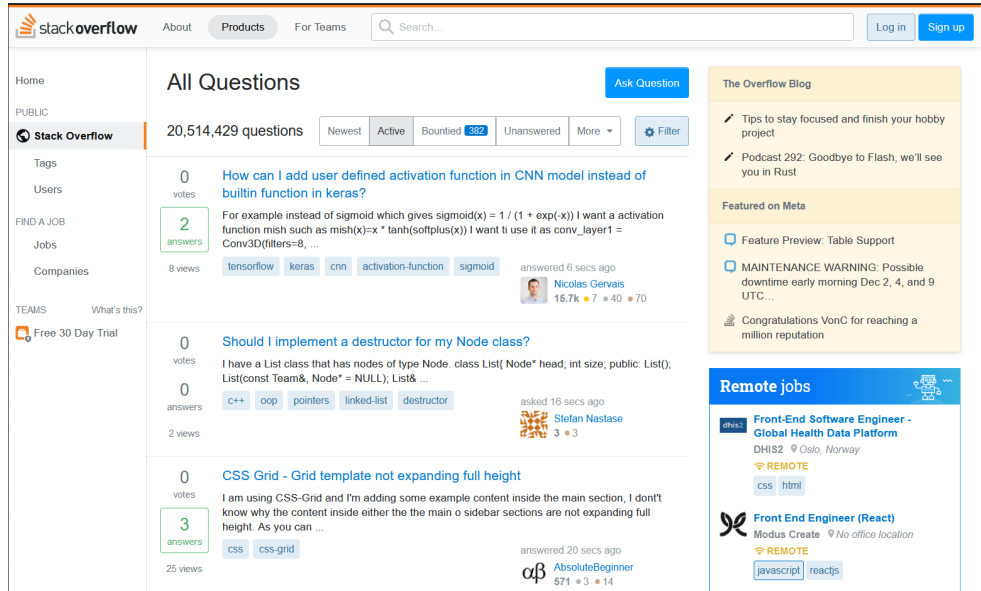
Figure 3.7: Landing page for questions on Stack Overflow.
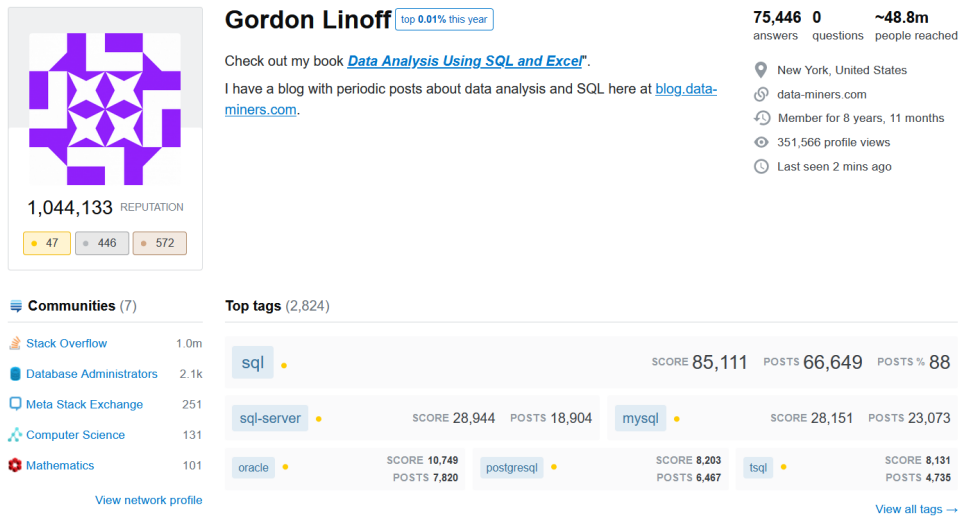
Figure 3.8: User profile of a highly active user on Stack Overflow.

Notable design elements

Stack Overflow's features focus on making relevant information available and visible to the user. When an answer is accepted as the correct one, it gets a big, green checkmark next to it. See Figure 3.9. Also, responses are sorted by votes by default. Note, the post with the most votes is not necessarily marked as the correct answer. The discussion related to an answer or a question is secondary here, as it takes up a lot less room on the site than the questions and answers.

Gamification features are prominent on Stack Overflow. The author's username is displayed on every question and answer, along with their badge totals and their reputation, as mentioned previously. These gamification features work as incentives to answer questions. The bounty system adds an additional competitive element to this. Getting reputation is competitive in itself, but the bounties add an extra layer.

Figure 3.9: Accepted answer on Stack Overflow.

Figure 3.10: Question answered by instructor on Piazza.

3.1.4 Piazza

Piazza is a CQA service that is currently free of charge and widely used by educators worldwide. It is simple in its design and offers just the features needed to function as a good course forum system.

Core system functionality

Piazza is made up of individual courses. Each course has a set of instructors and a set of students. Students function like regular users on a forum, whereas instructors are moderators. Importantly, instructors also verify the quality of the content,

Figure 3.11: Question endorsed by instructor on Piazza.

and are important content producers. The instructors' answer or contribution is an important part of every question. A forum on Piazza will not work the same way without an instructor present. Each course has three main sections: The Q&A section, the Resources section, and the Statistics section.

The Q&A section functions as the landing page for each course and can be seen as the main page. Here students and instructors can make posts for a Q&A feed where all previous posts can be seen. A post can be made as a Question, Note or Poll. You can choose whether the post is available to the whole class or just the instructors. Instructors can also define different folders that act as categories for the posts. A student can choose to remain anonymous when posting. Either to classmates only or everyone, including the instructors, if the instructors have allowed it.

In the Q&A section, the question is usually the most regular type of post (see Figure 3.10). Each question-post in the Q&A section has four parts: The question itself, the students' answer, the instructors' answer, and the follow-up discussions. The question is displayed on the top of the page and can contain images, text or references to previous posts. The author and timestamp of the question are also displayed. All users (instructors and students) can indicate that they think the question is good by clicking a "good question"-button. A counter of how many people have pressed the button is displayed. The students' answer is displayed below the question. This is an answer constructed by all students, not just the first student to reply. Meaning all students have edit rights on other students' answers. All users can indicate a good answer by clicking a "thanks!"-button. This button also has a counter for the number of people that have clicked it. Below the students' answer is the instructors' answer. This answer works the same way, where all instructors collaborate to form a single answer. The follow-up discussion is below the instructors' answer and is based on comments (or talking points) and comments on those comments.

Resources is a section for the distribution of course material and information. Here the instructors can upload files from presentations or assignments. There is also a Staff page where students can see whom the course staff consists of and their office hours. Course Information also has its own page, which is used for general course information like a description of the course and announcements.

Notable design elements

One of the more notable features of Piazza is its user hierarchy. Piazza features two sets of users: Instructors and students. Students have limited rights but are the only ones who can edit the students' collective answer on a question post. Students can still post questions, notes, and polls, but not much else. Instructors have more elevated rights and are the administrators or moderators of a course.

They can post questions, notes, and polls just like students, but they also have visibly higher authority on the forum. When an instructor likes a post or marks it as a good question or note, the post gets marked with a green text saying, "An instructor thinks this is a good question/note" or "An instructor endorses this answer" (see Figure 3.11). Since an instructor often functions as the main source of knowledge and has the highest authority within a course, marking a post this way is clear and informative. It can mark the students' collective answer on a post as the actual solution without needing any clarification from the instructors in a follow-up post.

Piazza's search function, along with the tag feature, is well implemented and easy to use. A user can refer to another post within their post by using a tag. The tag starts with "@", followed by a number representing the other post's ID. In the text, a tag might therefore look like "@241". It is also formatted as a hyperlink, making it intuitive to click. When a user clicks the tag, they are taken to the tagged post. This is useful when several different questions are related or when a question has already been solved. For example, the instructor or another student could answer a question with "This was solved in @12" or "This looks similar to @41". When searching for posts, you can also use the post's tag, creating a synergy between the tag feature and the search function.

3.1.5   Microsoft Teams

Microsoft Teams (referred to as Teams from now on) is not primarily a discussion forum. It is a communication platform that features video meetings, instant messaging, communication channels for text, and shared file repositories. The reason Teams was picked for this is because several courses at NTNU have started using Teams for class communication, as it comes with Microsoft 365. Also, the platform has recently been adapted to fit an educational context, with features like the "Assignments" feature [36]. This section will focus on the text channels on Teams and how they are used in a forum-like manner. As Teams was not designed to be a discussion forum, this section will not assume that it was and not critique it as such. Rather, it will critique the use of Teams as a way for instructors and students to communicate. For anonymity concerns, usernames have been replaced with black boxes, and profile pictures have been replaced by blue circles in this section.

Core system functionality

The application itself has several sections, including "Activity", "Chat", and "Teams", among others. See the left side of Figure 3.12. The focus of this section will be on the Chat and Teams sections. A user can be a member of different *teams*. These teams have different *channels,* which in turn can have different *tabs*. In Figure 3.12, "TDT4245-spring2021" is a team, "General" is a channel, and "Posts" and "Files" are tabs. The textual interaction between instructor and student happens in the "Posts" tab. Having a "Files" tab is also common. It allows team members to upload to the team or modify existing files if they have permission. A user can use the "Chat" section to instant message other users who share the same organisation or teams as them. This communication is private to the two parties. You can also create groups by messaging several users at the same time.

Much like a discussion forum, the entries in the Post-tab of a channel appear like posts on which a user can comment. Comments are then displayed chronologically in a thread-like fashion. See Figure 3.13. It is possible to react with an emoji to all posts and comments. Each post in the text channel is labelled with the poster's full name and profile picture. Below the name, the text is displayed. Posts appear in the order that they were posted, and there is no way to filter posts or group them by a more specific category than the channel provides. However, the search bar on the top of the screen can search for keywords in messages. Users on Teams have no visible hierarchy, meaning there is no visual way of telling students and instructors apart when they post.

Notable design elements

Teams has many features for collaboration. Shared file repositories that integrate with the Microsoft 365 platform, video meetings, instant messaging, and discussions using text are examples of this. Tying this in with the "Assignments" feature
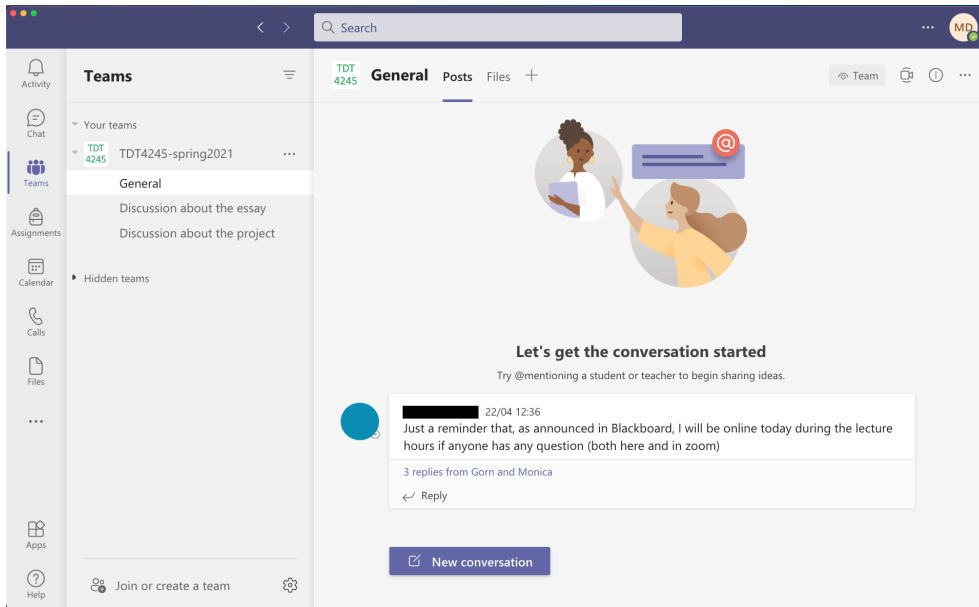
Figure 3.12: Application window of Teams.
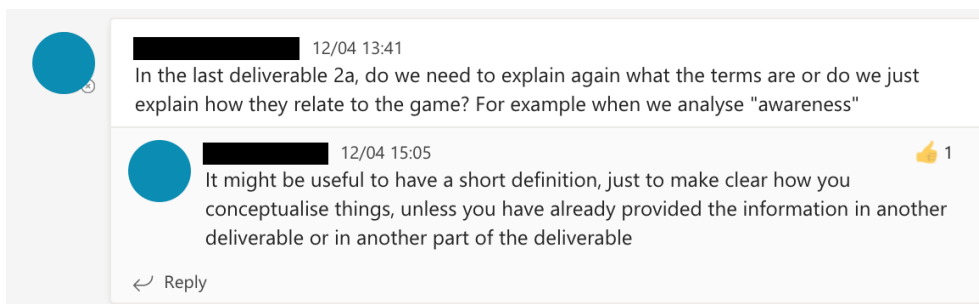
Figure 3.13: A thread in a text channel on Teams.

makes it seem like an active and collaborative LMS where it is easy for users to stay in touch. Having a chat feature that works across teams and the ability to join several teams at a time can let users communicate through their own channels that are separate from the formal class channels. It opens the platform up for different types of interaction and allows informal communication to happen between users.

While Teams might work in collaborative settings, it might fall short when used by many people solely for student-to-instructor communication. Firstly, a user cannot post anonymously, which can hurt the amount of active participation. Additionally, the text channels do not clearly show all the current questions, what questions are answered satisfyingly, and what authority the answerers have. This probably comes from the Posts tab being designed more as a chat service than a forum service. Because of this, it can be harder for users to find previous information, leading to more work for both students and instructors. The search function mediates this. However, features like post categories or a simplified post feed with subject titles could improve the time needed to find information. Another feature that helps find correct answers is the reaction feature, where a user can react to a post or comment with an emoji. This can help single out good replies by reacting with a thumbs-up or something similar, as well as facilitate passive participation.

3.1.6 Blackboard

Blackboard is an LMS used by universities and other educational institutions. It features built-in solutions like bulletin boards, calendars, and discussion forums, to name a few. To be clear, this is not a review of Blackboard as an LMS but rather its built-in discussion forum solution. It was chosen as an example of a classic discussion forum focusing on text without that many extra features. Also, it comes with a popular LMS solution that can connect students, as it is mandatory to use. For anonymity concerns, usernames have been replaced with black boxes in this section's figures.

Core system functionality

A forum on Blackboard is connected to a specific course on the LMS. The enrolled users get to view the forum and post there, and the forum is not available to other users who are not enrolled. Users are split into a hierarchy, probably based on their permissions for a given course. Students look like regular users, and instructors are highlighted. When the instructor posts on the forum, an icon appears next to their name, stating that they are the instructor. See Figure 3.14. Any user can post on the forum.

Visually, the forum looks and feels a lot like a classic discussion forum. It can be divided into categories, like "Assignment 1", for example. Each category has a landing page that shows all the current threads in that category. See Figure 3.15. From this landing page, you can navigate into one of the threads. The threads are also similar to those in classical forums, as there are not many features except the poster's name and the text they posted. See Figure 3.16. When a user posts, their name shows in the top left corner, and their text is displayed to the right. It is also possible to post anonymously, leaving the top left corner blank. On the bottom of a post, a button says "Respond", which takes the user into an editor to create a new post. See Figure 3.17.

Notable design elements

Design-wise, the Blackboard forum is not very tidy. It has many buttons and arrows, and it can be hard to understand how to use its features. It seems more complicated than it needs to be. For example, on the landing page (Figure 3.15), each thread has a checkbox on the left side. Initially, it can be hard to spot exactly what this feature does. Upon closer examination, this is how a user selects posts for the "Thread actions" (or "Trådhandlinger" on Figure 3.15) or the "Subscribe" feature (or "Abonner" on Figure 3.15). These checkboxes have a similar but slightly different mechanic on posts in threads, as you can mark them, but it is not apparent what happens when you select them. Also, when entering a thread, there is no clear way to return to the landing page for the category.
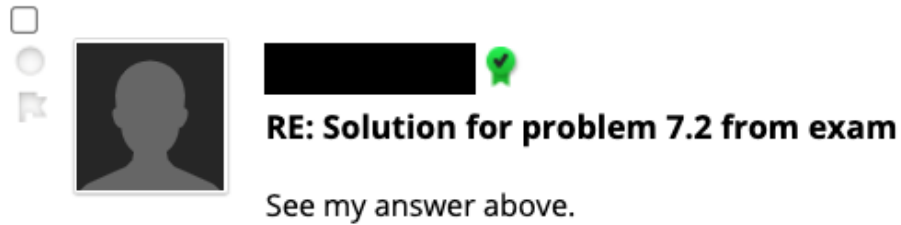
Figure 3.14: Instructor response on a Blackboard forum.

Figure 3.15: Landing page on a Blackboard forum.
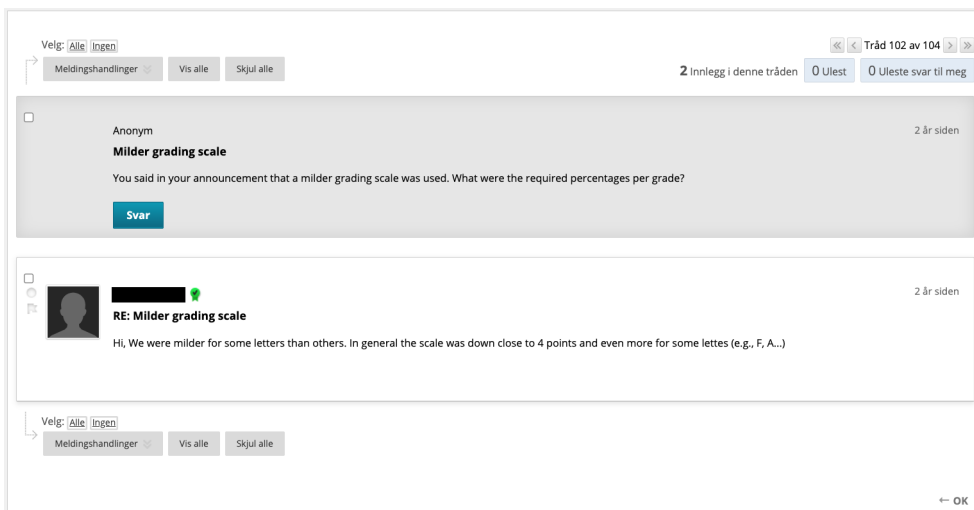
Figure 3.16: Discussion thread on a Blackboard forum.
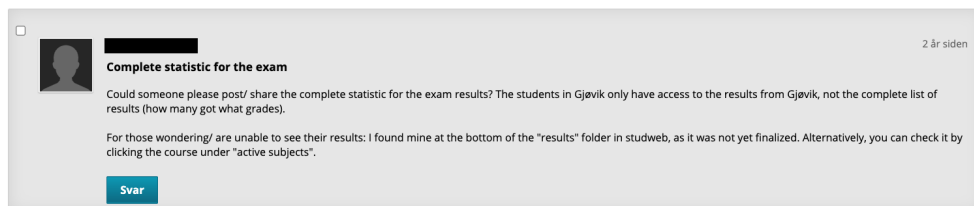
Figure 3.17: Post on a Blackboard forum.

Blackboard's forums do not really have any prominent or innovative features to single out. It is more its lack of features or confusing features that stand out when using the forum. There is no search function when looking up posts. This negatively affects a user's ability to find information, leading to a higher workload for the instructor, as a student might not see if a question has been asked before. There is also no referencing between posts, meaning that you cannot point to one post within another. Again, saving time for instructors if a question has already been answered. An example of a confusing feature is the feature to jump linearly from thread to thread. See the top right corner of Figure 3.16. It is hard to see how that feature is more useful than a back button to return to the landing page.

3.2 Summary of notable design elements

This section summarises the most prominent features used by the systems analysed in this chapter.

3.2.1 Post rating systems

It is common to let users rate posts by having a post rating system and displaying a post's rating next to the post.

Reddit lets users up-vote and down-vote posts and can filter content based on it. The rating of a post can influence the poster's karma.

Stack Overflow lets users rate both questions and answers and sorts the answers based on rating by default.

Piazza has a "Good question"-button on questions and a "Thanks!"-button on answers, which also displays how many times they have been clicked.

Teams uses emojis to let users react to a post, which can indicate the usefulness of a post or comment.

Discourse has a "Like"-feature that lets users like posts and replies. These likes are not used to sort content by default.

Post rating systems are used for different purposes in the different systems. They all use it to highlight good quality contributions, but the difference lies in how actively they do it. Reddit and Stack Overflow use post ratings to dynamically change the way that content is displayed, meaning content can re-arrange itself over time and is not necessarily ordered after the time of posting. Piazza, Teams, and Discourse use it to highlight good contributions, but they do not re-arrange content in the same way. For example, questions on Piazza are not ordered after how many times the "Thanks!"-button has been pressed, replies to Discourse topics are not ordered by likes by default, and comments or posts in Teams are not re-arranged based on reactions. This can be interesting to discuss further, as the difference in how good quality contributions is displayed can impact how the system is used.

3.2.2 Gamification

Several of these systems implement gamification features, but only those that are not used in education. The gamification elements seem to fall into two categories. Firstly, users can receive concrete items that are obtainable through contribution, like badges and awards. Secondly, contributions can grant a user points, which is

displayed to other users.

Reddit has its karma feature and the awards system. Karma works like a score of a users performance on the site. Giving an award is a concrete way to react and show appreciation for a post.

Stack Overflow has its reputation system, where users gain reputation based on how valuable their contributions are to other users. It also has a badge system, where badges are mainly earned through contribution.

Discourse has a badge system, where users can obtain badges through active and passive contribution to the community.

3.2.3 Accepted answer

Accepted answers are used in the CQA services Piazza and Stack Overflow. Discourse can also have this feature implemented through a plugin, but it is not installed by default. Having the ability to accept answers as the correct answer helps users find information and is helpful for intentional learning and overall efficiency. Piazza implements this differently than Stack Overflow. On Stack Overflow, the user who posted a question can accept an answer to that question as the correct answer. On Piazza, the instructor is the only user type that can accept answers, which gives them the final call on whether an answer is correct or not.

3.2.4 Anonymity

Anonymity is used by several of the systems, likely to lower the threshold for participating. Piazza, Blackboard, and Discourse have implemented anonymous posting as a feature. For the other systems, anonymous posting can still be done by having a user profile with a pseudonym as its username, similar to level 2 anonymity in [25]. Using Teams, it might be hard to post under a pseudonym, as a user needs to be linked to a Microsoft profile. If used in an educational context, that profile will usually be their university profile, meaning there is no way to post without showing the user's full name.

3.2.5 Passive participation features

All the systems except Blackboard have features in place for passive participation. They allow for passive participation to varying degrees. These features allow and highlight passive contributions by showing the active contributors that other users interact with their content in other ways than replying directly. The most common way to allow passive participation seems to be through a post rating system.

Piazza displays how many times a question has been viewed. It also lets users react to a question with the "Thanks!" and "Good question"-buttons.

Stack Overflow allows it through its post rating system and some of its badges.

Teams allows it through emoji reactions. However, it is possible to see who reacted with what emojis, making the participation more public.

Reddit also allows it through its post rating system. The awards system can also be seen as a way to participate passively.

Discourse has several features for this. Likes are enabled on posts. Some badges are also obtainable through passive participation alone. Discourse is the only system analysed in this chapter that shows the number of clicks on a hyperlink within a post, which is also a way of showing passive participation.

3.2.6   User hierarchies and peer recognition

Most of the systems have implemented user hierarchies, or some type of peer recognition feature, differentiating users visually.

Piazza highlights the instructor's active and passive contributions.

Stack Overflow displays a user's reputation and badges together with their questions, answers, or comments.

Blackboard puts an icon next to the instructor's name when they post.

Reddit keeps track of a user's karma and can grant flairs to users with a certain status in the community.

Discourse can give groups of users an icon over their profile picture, signalling that they belong to that specific group.

3.2.7   Community building

Three of the analysed systems make a noticeable effort to promote community building: Stack Overflow, Reddit, and Discourse. Reddit and Discourse are the most prominent, as they have many features focused on customisation and adaptation of their online communities. Their focus seems to be on letting an online community *customise* their platform, both visually and in terms of what type of interaction the community prefers. For example, Reddit's use of flairs and subreddit-specific moderation rules. They also have features that seem to be aimed specifically at passive participation. Reddit's awards system is an example of this. Discourse's passive participation badges are also worth mentioning. Stack Overflow's

features lean towards peer recognition, with the badge system and reputation system. However, users with a lot of reputation or badges do not seem to get any extra privileges on Stack Overflow, which sets it apart from the other two systems.

Reddit and Discourse aim at creating a core group of participants that can moderate content and function as community leaders. Reddit uses subreddit moderators. Discourse uses its trust level system and the moderator user type. Users who have shown commitment to the community get increased privileges, meaning that they can take part in further growing the community. On Reddit, this process is done manually by already existing moderators, and any Reddit user can be made a moderator of a subreddit. On Discourse, this process is more automated through the use of trust levels. If users gain a certain trust level, they can get elevated permissions to flag posts or invite new users. Trust levels can also be used to display seniority visually. For example, only letting a certain trust level have a background on their user profile or user card. Discourse also has an admin panel that can help moderators and administrators analyse the activity on the platform. They can use it to spot certain types of behaviour and act on them. For example, if they see that some students log in but do not post, they can privately interact with those students, as [24] suggests as a way to increase active participation.

3.3   Analysis

In this section, the different systems will be analysed in light of the literature. Even though some of the systems are not used in education, this analysis will be based on the educational context. Specifically what features the public systems use that can be beneficial to include in an educational system. The analysis will then be used in chapter 4 to present the model and answer the research questions.

3.3.1   Community building or information distribution?

There is a divide between the systems analysed in this chapter regarding the level of community building the platforms aim for. Some are noticeably geared towards community building, and some are geared towards information distribution. For example, let us compare Piazza and Discourse. Piazza has many features that let users retrieve information effectively. For example, the instructor can act as a final authority and provide an answer to any question the students might have, and students can easily spot if a question is answered or not. Interactions on the platform follow what Srba et al. called the question framework [22], as mentioned in chapter 2. Piazza seems more like a tool for a crowd of people to share information. On the other hand, you have Discourse. It is not made for information distribution or intentional learning in the same way, but it seems much more suited for community building. It has features for establishing community leadership, encouraging participation, and letting a community customise its platform. Interactions do not follow the question framework, they are more like back-and-forth discussions.

Community building and information distribution do not need to be mutually exclusive areas of focus, but the different behaviours they support contradict each other somehow. Q&A is good for information distribution. On the other hand, discussion seems more appropriate for community building. When building communities that last and can produce knowledge over time, it can be important to have interaction between participants, both social and informative [19]. As [19] mentions, frequent social interaction is one of the characteristics of what they call a type 3 online community, meaning the community functions much like an online community of practice. When a forum focuses on information distribution, interactions can get limited to one answer per question, as that is the most efficient way to distribute information. However, when a forum is focused on community building, it will want to encourage several users to weigh in. An important difference between Q&A and discussion is that Q&A is about the correctness of the answer, whereas discussion is more about the process of finding an answer together.

Stack Overflow is an example of how information distribution can get in the way of community building. It focuses on features that make it easy to find a solution to a problem. Features like search engine optimisation, post rating systems

and accepted answers make it easy for users on Stack Overflow to find information quickly. However, most users on Stack Overflow only ask questions. Few users answer more than five questions from other users, and a tiny minority of users answer as many questions as they are asking [37]. As a result, stack Overflow bears a resemblance to what DeSanctis et al. call their type 1 communities, namely "information kiosks" [19]. Although it is very efficient for distributing information, the core community seems small and seems to have few extended conversations, social interactions, or discussions.

A class forum on Piazza can experience the same difficulties. Piazza is really good at information distribution, but it lacks features when it comes to community building. The features that help make it quick and efficient also make the interactions shorter, make communication more formal, and emphasise the hierarchical difference between students and instructors. Piazza cannot function the way it is supposed to without having an instructor present. Having the instructor present makes it easy for students to find good quality information, but the communication can also tend towards being formal. Formal communication is not that helpful when constructing social ties [14, 15] or sharing novel information [15]. If you want a service where the user hierarchy is less defined, and the instructor can function as an observer or facilitator rather than an important participant, Piazza might not be the right choice.

While Piazza might lack features for community building, it is important to note that Piazza is really effective at student-to-instructor communication. You can easily see if an instructor has answered a question in the post feed on the left side of the page. The feed is also made up of post titles, making it easy to skim through posts until you find a question on the topic that you are looking for. Questions can be put into categories, like "Assignment 1", etc. It has a good search feature and a post tagging system for referencing previous posts. Features like those make it easier to engage in intentional learning on the platform. The literature on discussion forums and Q&A in education focuses on developing student communities, the learning effect of the forums, and encouraging participation. Not necessarily the potential utility of letting the instructor provide the answers. It saves time and is effective for distributing information. As Piazza is a very successful platform, with universities using it worldwide, their method of interaction should definitely be considered a viable option.

Through the platform's success, it feels safe to say that Reddit does public discussion and community building efficiently. Reddit seems to balance information distribution and community building effectively from my initial analysis of its features and design decisions. It has both a post rating system and community customisation and ownership features, which seems to work well. Comparing it to the other services, its structure is similar to services like Discourse and Askalot [23]. Subreddits can function as categories or isolated communication channels,

where usernames carry over from category to category, and users choose what categories they participate in.

Some very interesting features for community building are the trust level system and the group system in Discourse. As mentioned earlier, users can build up their trust level on the forum, and the administrators define the thresholds for each trust level. This contributes to community building in several ways. Firstly, it rewards the participants for participating, other than simple cosmetic rewards. Users get to be a larger part of the community they are building when they have a higher trust level. For example, by getting the opportunity to invite new members or flag posts, as mentioned previously. Secondly, it takes weight away from the administrators and moderators when producing content and facilitating discussion. This can be delegated to users with a certain trust level, contributing to creating a bigger group of core users [19]. The creators of Askalot observed this effect in their 2019 study. Experienced students started helping newer students over time, taking pressure off the instructors [8]. The group system can manually give students these permissions and a visual distinction from other students through the icon next to their profile picture.

3.3.2 Educational use

Three of the systems analysed in this chapter are designed for education, namely Teams, Blackboard and Piazza. Teams is also designed for other contexts but have added features for education, as mentioned. We can look at the similarities and differences between these systems to see if the educational systems could benefit from adopting features from the public forums. Initially, the educational systems seem to have been designed for student-to-instructor communication. Meaning that they are optimised for Q&A style interactions, with little room for informal communication or community development. It might be beneficial to look at some of the community building features in use by the public systems and see if they might have a place in education.

There are many similarities between Discourse and Askalot, the system developed by Srba et al. [23]. Both systems use categories to structure the content on the platform and can be used organisation-wide. They both provide good tools for community building, discussion, and question answering. Askalot does have some additional features designed to enhance participation and provide better motivation. However, those features seem to be simple enough to implement as Discourse plugins. As Askalot shows some promise for educational use, being used by three universities as a QA platform [8], Discourse can also be seen as a viable candidate because of its active open source contributor base and adaptability. While Askalot is designed for question answering, Discourse is designed to be used for discussion. Additionally, Discourse can be adapted to mimic a CQA-like forum through plugins.

Adaptability can be a good feature to have in education. From experience, different instructors want different types of student-to-instructor interaction. Some want to let the course staff answer all questions; some want to wait and let students answer other students. It can be beneficial that the forum software can adapt to these different circumstances and equip the instructors with the tools they need to facilitate their favoured type of interaction. Among the analysed systems, Discourse and Reddit are the only forums that have features for this. However, Reddit's adaptability is mostly cosmetic and community-based and does not let the users change the actual features. For example, you cannot choose to have accepted answers on Reddit, as all subreddits have the same features. Discourse is all about adaptability, as it seems like the administrators can change almost everything about the forum if they want to. Even categories can be customised to mimic forums of their own, as plugins can be enabled on a category basis. A forum can be for Q&A, discussion, and social interaction at the same time.

Social interaction and frequent communication are important factors that differentiate a crowd and a community. The systems that focus on community building, namely Discourse, Reddit, and Stack Overflow, recognise this and use features to help the users get to know each other and build social ties. When using a discussion forum in education and community building is a priority, using the same features as these services might provide the administrators with a head start. Instructor facilitation seems important during the initial phase of a forum [8], so this head start could be very useful. Letting the users get to know each other across courses or other communication channels, letting users take an active role in designing their own community, allowing for passive participation, and lowering the threshold from passive to active participation seems like promising tactics.

3.3.3 Peer recognition

Reddit's features for peer recognition have interesting synergies between them. Each user has a certain amount of karma, a score of how positive their contributions have been to the community. Karma can also be negative. Since user accounts are platform-wide, users need to keep their karma in check in every subreddit they contribute to. Kilner et al. [25] had an interaction with a user that posted something that was perceived as negative on a discussion platform and wanted to change their username because of it. The authors argued that it might be because of peer recognition or peer perception, as the user stated that they wanted to continue using the platform without worrying about being recognised by that negative comment. It seems like peer recognition can be important to users in online communities—both for the users themselves and the community. Reddit's features help the community identify the key contributors and award them for their contributions in the form of karma. A user is therefore encouraged to be-

have and come with high-quality contributions, which helps the platform overall.

However, using a feature like that in education can have unpredictable outcomes. As mentioned in chapter 2, external motivation can have a negative influence on learning [30], Furthermore, gamification elements in education can have both positive and negative effects [29]. Using a feature like Reddit's karma in education could lead to weaker students not wanting to participate. It could also create a visual divide between students of different skill levels, which could be both positive and negative. A student with more karma could be more trustworthy, but it could also serve as a demotivator for students stuck with low karma.

3.3.4 Limitations

As mentioned, Blackboard lacks some features that are common in the other systems and seems to have limitations as discussion forum. It is leaning towards information distribution and long discussion threads at the same time. The landing page shows the title of the thread, making it easier to find relevant information. However, each thread is purely text-based, with no indication of what answer is the correct one. The instructor's responses are highlighted with an icon, but whether or not the instructor has answered is not visible at the beginning of the thread. It is missing a reference or search function as well, which can lead to duplicate threads or discussions. It seems like Blackboard's forum could be good for deeper, text-based discussions, but this format is not suitable for every course. The lack of adaptability, and general lack of features, makes Blackboard's forum lose out to the competition.

However, Blackboard has potential as it is an LMS. If communication was made possible across courses, it could mimic the style of Reddit, Discourse, Teams, and Askalot. Course forums could span multiple terms, meaning that older students could help younger students. Moreover, because of its robust permission system, only those actually taking the course would be able to participate in those forums. Additionally, it could have forum channels for each department or subject of courses on the platform. The potential is there, but the execution is not where it needs to be.

As mentioned in the system's presentation, Teams also has some limitations if used as a class discussion forum. It seems more like a communication platform adapted to educational use in a hurry rather than a platform built for student-to-instructor communication. However, Teams can work well for smaller courses or groups with not too much information to keep track of. To improve this, Teams could make a dedicated discussion forum application, much like the Files application. Alternatively, an application that mimics the Q&A format, which can help with information distribution. If that were the case, Teams would have a similar structure to Discourse, Askalot, Reddit, and Blackboard and work well for inform-

ation distribution at the same time.

3.3.5 Summary

Educational systems usually optimise for student-to-instructor communication and information distribution. This makes sense for effectively conveying information from instructor to student, but it can make it harder to facilitate student-to-student interaction and community building. There seems to be some potential in the channel structure used by Discourse, Reddit, Teams, Blackboard, and Askalot. If implemented correctly, the software solution could aid the facilitators in creating a community. This could lessen the need for facilitation over time, like the creators of Askalot discovered signs of [8].

Educational systems specialising in information distribution seem very effective at this, and their success suggests that community building in educational systems is not the only viable option. We know that establishing a community is good for social learning and creating knowledge, but it can also be costly in terms of time spent on community building. A system like Piazza does its job very well, as it is efficient at distributing information and letting the students get in touch with their instructor. We should not discard this as a viable way of organising a class forum. The instructor, who knows the context of the course, should be able to decide for themselves what type of forum they are going to manage.

Chapter 4

Modelling discussion forums

This chapter will propose a model based on the provided background and current state of the art systems. Firstly I will start with some discussion, explaining how I view the challenges tackled in this thesis and how I believe we can meet them. The model will assist in picking the right discussion forum, or designing one, for a given context.

4.1 A generic model of a discussion forum

A discussion forum consists of *threads, posts, users, moderators,* and *administrators in its most generic form.* A forum consists of threads. Threads are started by a user. Threads are made up of posts. Posts are written by users. A thread can consist of an arbitrary number of posts but is always connected to a specific forum and a specific user. A post cannot be made outside a thread. There are three user types: user, moderator and administrator. The most general type is the user, which can create threads and posts. Moderators inherit the user's abilities and can silence users, edit other users' posts, flag them, or remove them. Administrators inherit the moderator's abilities and can also kick users from the forum and change its overall design and structure. In the educational context, the Student is equivalent to the User, the Teaching Assistant is equivalent to the Moderator, and the Instructor is equivalent to the Administrator. This is explained visually in Figure 4.1.

Further, different forum types can be modelled using this generic model. A Q&A forum would have Question instead of Thread and Answer instead of Post, as answers to questions follow the same hierarchical relationship as posts to threads. Additionally, we can discern where in the model we can implement potential features. For example, a post rating system would be on the Post and User level, as each vote is connected to one post and one user. A channel design feature would belong at the Forum level, as it would impact the architecture of the whole platform.
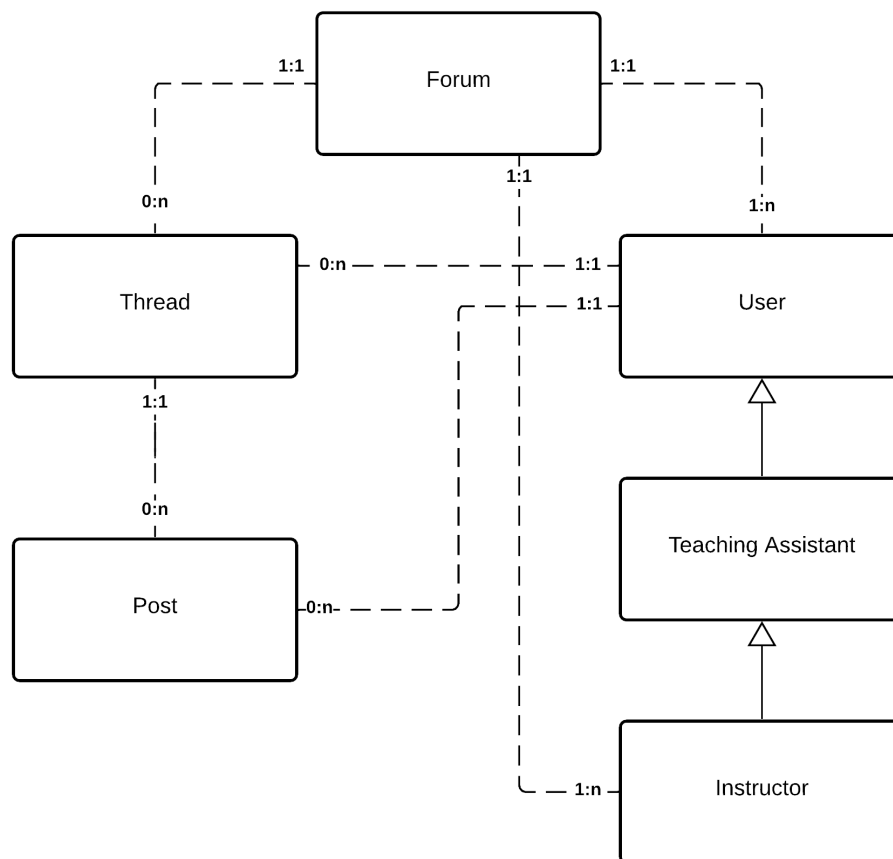
Figure 4.1: Generic model of a discussion forum with names matching the educational context.

4.2   How are educational discussion forums different?

Discussion forums have been widely successful in a public setting, and they are a positive addition in an educational context. Keeping that in mind, this section will discuss how the educational context changes the way we use forums.

The biggest difference between an educational forum and a public forum is the presence of the instructor. Specifically how the instructor fits into the forum and how they impact the student behaviour. One could argue that the instructor has a similar role as any other administrator on a public forum. However, the instructor has a much closer relationship to their students than an administrator of a public forum has to its participants. This is because the instructor is seen as the leader of a class and has the highest authority on class matters. Students interact regularly with their instructors through lectures, assignments, and tests. Instructors are also responsible for grading, which can also impact how students act. In other words, the instructor's presence on an educational forum is very different from an administrator's presence on a public forum.

Public forums are usually based on interest. It's not a stretch to suggest that people follow subreddits or Quora-topics because they are interested in the content they find there. When a discussion forum is used in education, the setting is much more mandatory and forced. It is possible, for example, that the forum is the only allowed communication channel between students and their instructor. It is also possible that forum participation is mandatory for a part of your grade. This difference has consequences for how these systems are used.

Communication in class forums can tend towards being formal. Participants are arranged in advance, communication can be mostly one-way, formal language is assumed, and the forum is often used for predicted situations, such as the instructor answering requests for information. It is also important to note that students will share the forum with the people responsible for grading their work. Keeping up appearances can feel important. Since the communication is mostly formal, it can be harder to use it for social maintenance [14], and thereby community building.

Time is an important factor. If courses last around 4-6 months, there might not be enough time to form a student community or for student-to-student communication to happen. This should be considered if a course wants to develop a community or sharing culture. Students start on a somewhat equal level when entering a course, with little to no prior experience. If the forum's intention is Q&A or content creation in general, students might not feel comfortable participating to begin with. It can hamper discussion and community building, as the core group of participants mentioned by [19] can need some time to form.

In the educational context, an answer by the instructor will almost always be more

valuable than a student's answer. The only exception being if the instructor makes a mistake, and a student gets it right. However, the instructor is the only user type that can answer questions about administrative information. This was also identified by Macina et al. [33]. If students feel like their answers do not matter as much as the instructor's answer, they might be deterred from answering. This can hurt student participation in settings where accurate and correct answers are necessary, such as in mathematics, physics, or computer programming.

These differences between public discussion forums and educational discussion forums provide challenges that a system developed for education needs to address. We will discuss how these challenges can be met in the next sections, both with features, architecture, and forum behaviour.

4.3   How do we design forums for educational use?

After studying the literature and the state of the art systems, it has become clear that we need to design an educational forum based on a context. Different courses have different demands, and different software solutions support different types of interaction. This section will establish the different viewpoints when designing or choosing a forum for educational use. These viewpoints are (1) how we meet the challenges of the educational context, (2) what features a forum has, and (3) how the forum is intended to be used. An important goal when designing a forum will be to pick features that are aligned with the intended forum behaviour.

4.3.1   Meeting the challenges of the educational context

The educational context has some differences from the public context that will need to be addressed. As identified earlier, the main challenges are formal communication, forced forum membership, the role of the instructor, the time frame and lacking expertise when starting a course, and the validity of student answers.

Formal communication

Formal communication is not a problem in itself. The problem arises when community building is a focus, and the vast majority of communication that happens on the platform is formal. In a class forum, this can easily happen if there are no communication channels that let students communicate informally. Take Piazza as an example. The primary way to communicate with other users is through participating in the forum by asking questions or answering them. Also, forums on Piazza are isolated, making it hard to get to know other users across forums. To mediate the formality of the communication, informal communication channels can be introduced that the instructors don't have access to. Or by grouping users together and giving them a place to communicate without instructor supervision, as is possible in Discourse.

Forced forum membership

The main issue with forced membership is that it is not based on an interest to participate or learn. Participation, active or passive, can be motivated by necessity. It would be next to impossible to magically motivate students to participate in a forum if they are not motivated for the course. I think the solution here lies in allowing students to contribute to several courses simultaneously after they have taken them as Askalot allows [8]. In Askalot, they saw older students coming back and helping younger students. That type of interaction would more likely be out of interest for the course. Meaning we should not necessarily try to make a course more motivating but letting students participate in areas where they are motivated.

The role of the instructor

Exactly how the instructor should interact with the students on a forum, given a certain context, is uncertain. Most studies indicate that instructor involvement is beneficial or can be used for positive effect, depending on the goal [7, 8, 10, 11]. However, it is not clear how the instructor should or should not act, given a certain situation. It does seem like the instructor should be active, but in a facilitating manner, if community building is a priority. And it does seem like a visible instructor is a good thing. For example, by ensuring the correctness of answers by starting discussions. However, it is important to note that the role an instructor takes is up to the instructors themselves. The instructor chooses how to teach their course and should pick forum features and desired forum behaviour accordingly. Not the other way around.

Time frame

A short time frame is only a challenge for community building and student-to-student interaction. If using a Q&A format and the instructor is the primary content provider, the short time frame has little consequence.

To tackle the short time frame, it is possible to have one large forum using the channel design instead of several isolated forums. Students can be enrolled in this larger forum simply by being students at the university or department. See Figure 4.3. From experience, forums are usually independent and have no connection to each other. See Figure 4.2 for visual explanation. Courses would appear according to the channel design used by Discourse, Reddit, and Teams in the new structure. Instructors would be enrolled in this forum and will be administrators of the channels corresponding to their courses. On top of the course channels, you can have class channels for each graduating class, or topic specific channels, for example. These serve as more informal communication channels. This can be a way to lengthen the time frame from 4-6 months to 3-5 years, which can make more

room for community building. As mentioned, this method shows some promise, as it was tested in Askalot [8]. Following the channel design further, usernames could be the same across the entire platform, like on Reddit. That could help for peer recognition and a sense of community.

Validity of student answers

This is only a challenge in Q&A when the interaction is based on "one question, one answer". Students want the correct answer to their questions, meaning that they will want to be sure of an answer's credibility. If the instructor replies, the answer is almost always correct. If a student replies, the other students would have to double check or wait for the instructor to verify that answer. To make the Q&A more efficient, the instructor can provide the answer right away. This is useful when there is low student engagement, or efficiency is generally desired. If community building or social interaction between students is desired, the instructor could wait for students to answer or facilitate by asking follow-up questions. Either way, to ensure the validity of a student answer, you either need several students agreeing or the instructor verifying. This is a decision the instructor needs to make, as it pertains to the way the course is taught.

4.3.2   Choosing features based on the intended activity

A forum's features dictate some of the activity that can happen on a forum and what type of activity it supports. Using features to promote a specific behaviour is done by Stack Overflow or Piazza, for example. They gear the features toward question answering, with accepted answers, post rating systems, and a tidy display of information. You can choose to use these services for discussion or community building, but their features do not make it easy. The questions and answers are given the majority of the attention, not the discussion itself. If an instructor tries to use a forum that's not supportive of their intended type of behaviour, the interaction between student and instructor will not be as efficient as it could be.

The software underneath is only half of the equation. How a forum is used in practice is the other half. As mentioned, Piazza is built for Q&A, but it can still be used for discussion if an instructor wants to. It just won't be as effective as Discourse or Reddit. Additionally, the instructor also has to factor in their own intended behaviour on the forum. If the aim is to create a community, the instructor will have to let students interact with each other and let students become community leaders. If the instructor insists on answering all questions themselves, students won't be given much room to form a community, but it will be an efficient way to distribute accurate information. One thing is clear: The instructor will have to spend time overseeing the forum, no matter what interaction is intended. Meaning that the instructor will often need to either provide the information themselves, verify information provided by students, or act as a facilitator for discussion.
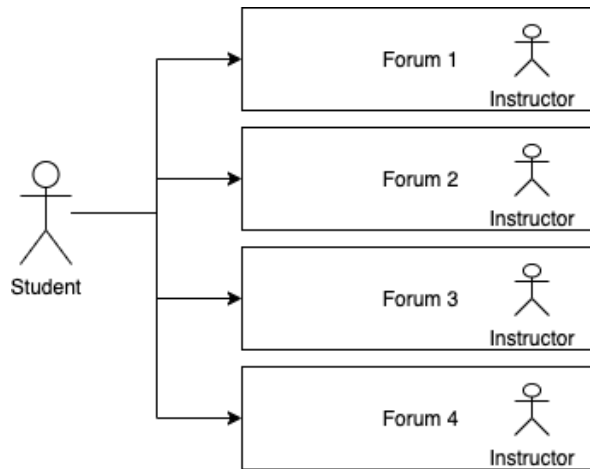
Figure 4.2: Student joining forums made by the instructor using external platforms.

Adaptability becomes an important quality attribute when understanding that different contexts demand different features, as the underlying software requirements can change. Hence, it would be ideal that a forum solution could be both a Q&A forum and a discussion forum, depending on the instructor's needs. The forum software should not dictate how the instructor wishes to teach. It should be the other way around: The forum software should adapt to the instructor's needs.

4.3.3   Choosing features for increased participation

Firstly, it is important to note that a well designed forum that is easy to use makes it easier for users to participate. Intuitive and good-looking design is a factor, and should be kept in mind when designing or picking these services. Furthermore, we have motivational features, which can be a double-edged sword in an educational discussion forum. On the one hand, you want to reward students who do well and contribute to the class discussion. On the other hand, rewarding those students can demotivate other students who don't feel like they can contribute. Additionally, as Abramovich et al. observed in their study [30], external motivation sources such as badges might impact students differently based on their prior skill level. Put simply, you risk pushing the weaker students lower while lifting the stronger students higher.

Using incentives to motivate students can lead to undesired behaviour. There are indications that external motivators can have a negative influence on learning [29, 30]. It is possible that students can become what Srba et al. called "Reputation collectors" [34]. Reputation collectors were an emerging part of the user base on Stack Overflow that focused on producing low quality content in order to gain reputation quickly. If an instructor were to give out grade points or other concrete incentives for participation in a class forum, it could lead to students
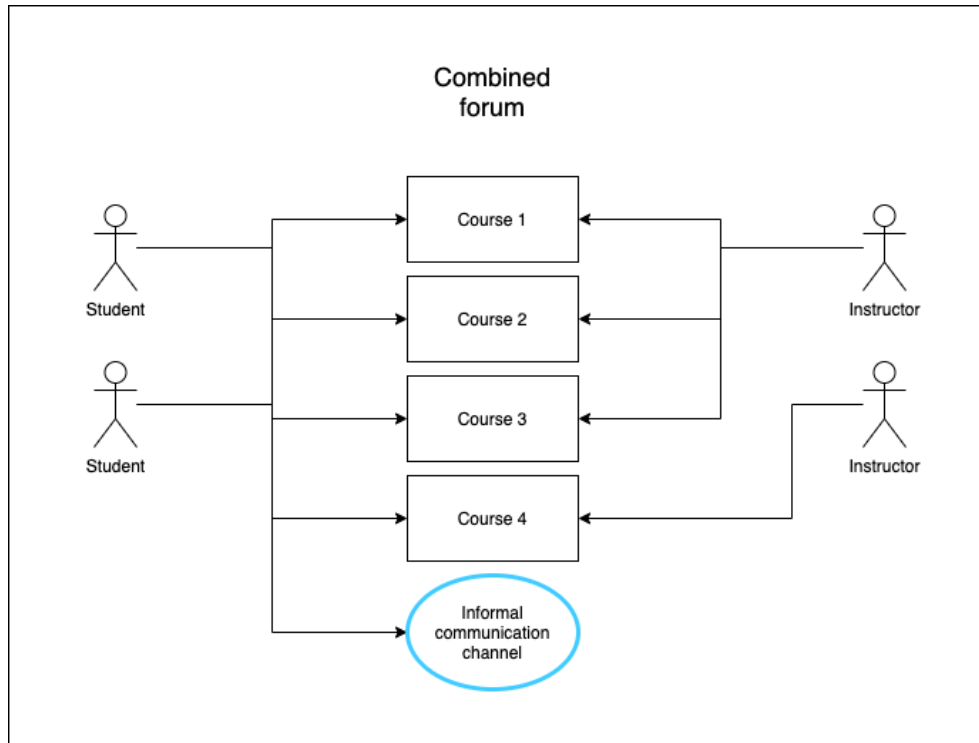
Figure 4.3: How a combined forum for both students and instructors might work.

producing low quality content just to score points. On the other hand, the service Askalot [23] implemented a way for instructors to rate a student's answer on a 5-point Likert-scale, which might help prevent that type of behaviour. However, this is something to keep in mind when trying to increase participation through external motivation.

Because of the potential negative effects of gamification, gamification-related features will not be included in the model. Moreover, if gamification features are to be used, make sure to tread lightly. As mentioned, it is unclear what impact different gamification features have on education. Since a certain degree of passive participation is natural and still has positive effects on learning [6, 24], using gamification features that can have negative effects should be done with great care. It might not be worth the extra active participation.

4.4   Presenting the model

In this section, the model will be presented and explained. The model consists of two main forum activities, several software features, and several usage characteristics. This way, the model can be used both top-down and bottom-up, helping to analyse an existing forum and when looking at features for intended future use.

The model is presented in Figure 4.4.

4.4.1   Using the model to pick or analyse a forum service

When using the model to pick a forum service, the desired main activity should be chosen, and then the features and usage characteristics can be chosen based on that.
The main activities, displayed as green boxes, are two activities identified through the literature study and the state of the art systems. These are *community-building* and *information distribution*. As discussed earlier in this thesis, they do not need to be mutually exclusive, but the behaviour they encourage is somehow contradictory. I also want to remind that none of these main activities are seen as right or wrong. These main activities are used to aim at a specific type of interaction or something in the middle.

The features, displayed as blue boxes, are concrete software features that can be implemented into a forum. These will serve as the base for what type of interaction the forum can support. The blue boxes in the model can check a potential future system for whether or not it has the required features. It can also be used to check if a currently used system is actually able to support the interaction it is used for. Additionally, to better understand where the features fit into a forum and where they need to be implemented, the generic model in Figure 4.1 has been used to illustrate this. See Figure 4.5 for a visual representation of the different levels the features can be implemented on.

The usage characteristics, displayed as orange boxes, are behaviours or characteristics of use that can help identify how a forum is actually used. These are separate from the features, as you can choose to use any forum for anything. As mentioned earlier, Piazza can be used for discussion. However, it probably won't work as well as using Discourse or Reddit. Using these usage characteristics can help identify what type of forum is desired or whether or not the current use of a forum matches its underlying features.
It is important to note that the activities, features, and usage characteristics are mostly not mutually exclusive. Some of them are contradictory, but can exist at the same time. For example, a forum can show signs of both formal and informal communication.

4.4.2   Features for community building

Post appreciation system

Not to be confused with a post ranking system. A post appreciation system would be how Teams uses emoji reacts, Discourse uses likes, and Reddit uses awards. It does not change the order of the posts, but it shows appreciation for the content for other users to see.

Community building	Information distribution
Post appreciation system	Post ranking system
Platform customisation	User reputation or score
Attainable community leadership	Accepted or endorsed answer
Informal communication channels	Visible instructor or user hierarchy
Thread display	Question display
Passive participation support	
Channel structure	
Large core group of participants	Small core group of participants
Social interaction	One question, one answer
Instructor facilitates	Instructor provides information
Deep discussion	Shallow discussion
High user retention	High user throughput
Informal communication	Formal communication
Interest based participation	Necessity based participation

Main forum activity

Software feature

Actual forum usage

Figure 4.4: Model for choosing software features and forum usage based on the main activity.
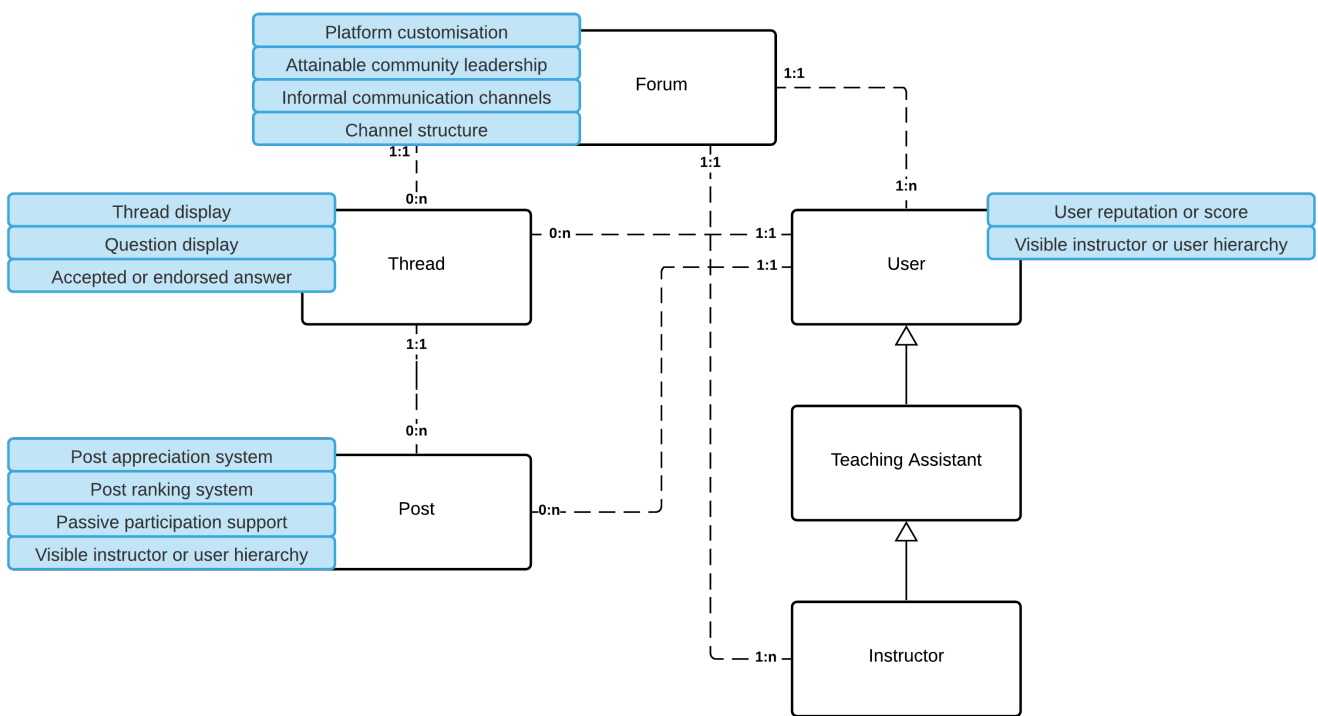
Figure 4.5: Where features are implemented, shown by using the generic model in Figure 4.1.

Platform customisation

With inspiration from Reddit and Discourse. Those platforms offer a lot of customisation, which can help a community create its own space.

Attainable community leadership

Used by Reddit and Discourse to let users attain leadership in their communities through participation in the community. Seems like a strong feature for community building.

Informal communication channels

To help with the formality that comes with the educational context. Additionally, it can move the student conversations from friend groups on Messenger and WhatsApp to the forum service.

Thread display

Less efficient in terms of information retrieval, but more open for discussion and progressing ideas over time. Lets many users weigh in on an issue, instead of focusing on one correct answer.

Passive participation support

Users who prefer to be passive, also called lurkers, are an important part of any online community, and there is no reason to believe they don't exist in education. Piazza's question view-count, Discourse's hyperlink click-count, as well as all the post rating systems are examples of this. The main focus for these features is to make passive participation visible.

Channel structure

Using a channel structure, like Reddit, Discourse, and Askalot, can expand the potential user base of the community and let users participate across forums. Users can also be members of the larger outer forum for longer, helping new students as they come along. This feature seems to have great promise for community building.

4.4.3 Usage characteristics for community building

Large core group of participants

Based on DeSanctis et al. [19]. Online communities with a larger core group of participants are desired.

Social interaction

Based on DeSanctis et al. [19]. Online communities of type 3 (community of practice) showed higher levels of social interaction.

Instructor facilitates

Based on Shea et al. [10], G. Salmon [11], and Srba et al. [8]. When the instructor facilitates, it leaves room for student interaction, and students feel like they are part of a learning community.

Deep discussion

Based on DeSanctis et al. [19], and their recommendations for developing learning networks.

High user retention

Communities take time to form. Especially a strong core group of active participants, like DeSanctis et al. mention [19].

Informal communication

Informal communication is good for constructing social ties, and for sharing novel information [14, 15].

Interest based participation

When participation is based on interest, there is a bigger chance of attracting potential core users.

4.4.4 Features for information distribution

Post ranking system

Not to be confused with a post appreciation system. Post ranking systems dynamically change the order of the content to reflect what the users deem to be the best quality responses. Used by Stack Overflow and can be implemented through plugins in Discourse.

User reputation or score

Users get reputation or score based on how well other users rate their contributions. This helps with user credibility and trust. Used by Stack Overflow and Reddit. Not to be confused with attainable community leadership, as the user reputation or score is directly connected to quality of user generated content, not simply participation.

Accepted or endorsed answer

Answers get marked as accepted, visually indicating that it is the correct answer to the corresponding question. This helps with intentional learning and information seeking. Used by Piazza and Stack Overflow, and can be implemented as a plugin in Discourse.

Visible instructor or user hierarchy

Some users can be given elevated rights or permissions to declare an answer as correct or serve as users who have a higher authority to judge answer quality. Used by Piazza, Reddit, and Discourse.

Question display

Compared to a thread display, the question and its corresponding answer are now in focus. All other forms of communication are secondary, as the question and the answers take up more space in the design. Used by Piazza and Stack Overflow.

4.4.5   Usage characteristics for information distribution

Small core group of participants

Based on DeSanctis et al. [19] and their description of type 1 communities, or "information kiosks".

One question, one answer

If one question by a student usually only has one answer, there can be little motivation for discussion on the forum. This can be an indication that the forum is more based on information distribution than community building.

Instructor provides information

Somewhat contrary to the instructor facilitating. There will always be questions where only the instructor can answer. But if the instructor is consistently the only user that answers questions, that is a sign of a focus on information distribution.

Shallow discussion

Contrary to deep discussion, as brought forward by DeSanctis et al. [19].

High user throughput

This can mean that most users on the platform are not active participators. It can be a sign that the platform has a focus on information distribution. As seen on

Stack Overflow, where most users only ask questions, and few reciprocate efforts by other users [37].

Formal communication

Contrary to informal communication. If communication is mostly formal, it can be hard to construct social ties, making it harder to build a community. The platform could then look more like an information kiosk, as mentioned by DeSanctis et al. [19].

Necessity based participation

Contrary to interest-based participation. When participation is done out of necessity, there is a lower chance that a user will become a core group member and a content provider.

4.4.6 Independent features

These features have been deemed a good addition, no matter what type of activity the forum intends to support. They have come up as features in the literature and the state of the art systems but have not fallen directly into one of the categories used above. See Figure 4.6.

Anonymity

Anonymity, or the ability to use pseudonyms, can boost participation and content creation [25].

Search function

Great for both discussion and information retrieval.

Post referencing

Very well paired with a search function, and saves time if a question has been asked previously or a discussion point has come up earlier.

Post categories

Divides content into several categories, making it more efficient for the user to navigate the platform.

Post feed

Helping the user look through content, making it more efficient for the user to navigate the platform.

Independent features

Anonymity

Search function

Post referencing

Post categories

Post feed

Question routing

File repository

Activity logs

Peer recognition system
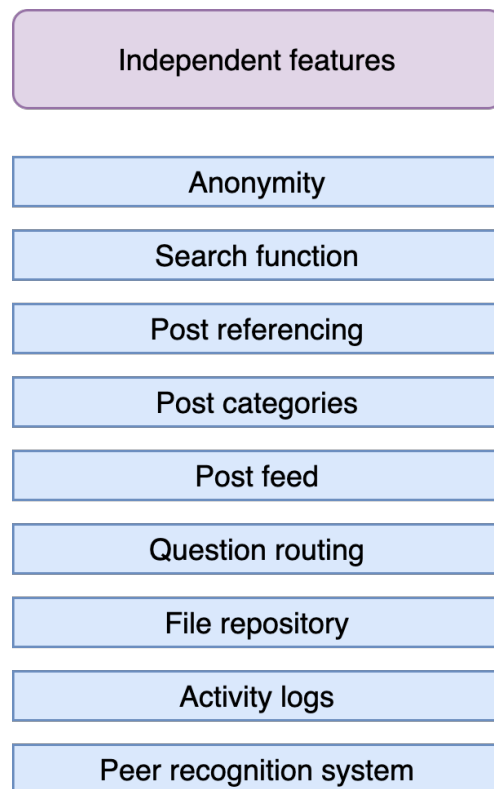
Figure 4.6: Features that are independent of the two main forum activities.

Question routing

A technique for making questions available to the experts in a question answering forum. This is possible using software or direct manual facilitation by the course staff. Helpful for boosting participation in every type of activity.

File repository

Good for collaboration and workspace awareness. Used by Teams.

Activity logs

Great for administrator panels, like the one Discourse uses. It can help the administrators understand the behaviour of the users on the forum.

Peer recognition system

No matter the type of forum, it can be positive to let users customise the way they appear to other users. Used by Discourse and Reddit.

Chapter 5

Case demonstration

This chapter will look at three different forums used in an educational context and analyse them by using the model. Note, the analyses in these cases are not done in-depth. Detailed usage data was not used for analysing any of the cases, and no specific content analysis was done. However, these cases function more as examples of how the model can be utilised to identify the relationship between usage and software. Additional data would be beneficial for adding more depth to the analysis.

5.1 Case 1: Piazza, used by TDT4102 at NTNU

The first case is the usage of Piazza by the course TDT4102 Procedural and Object-Oriented Programming at NTNU during the spring term in 2021. Forum statistics exported from Piazza can be seen in Figure 5.1. Piazza is a Q&A-based forum that relies on the participation of the instructor. The software features of Piazza lean towards information distribution but have some community building features as well.

As you can see in Figure 5.1, this was a class forum where the instructors were very active. They answered 98% of the posts, whereas students only answered 8%. The average response time was 3 minutes, which is very fast for this type of forum. However, the students were still given room to participate. The participation rate of students was 49%, meaning that almost half of the registered students made some contribution. This constitutes a large group of participants. Among the interactions between students and instructors, it seems that there was some social interaction. The nature of the communication seemed to be informal, as both students and instructors were using slang. However, some formality was also observed. See Figures 5.4 and 5.5. It seems like user retention was good during the term, as the activity remained steady, apart from the Easter break. See Figure 5.6. However, the participation is still characterised as necessity-based, as the Piazza was used in relation to a mandatory course to a lot of students.

The result from the analysis by using the model can be seen in Figure 5.2 and Figure 5.3. While Piazza's features lean towards information distribution, this group used it for community building as well, and it seemed to work well for them. The participation rate was high, even though the instructors were active. The students also showed appreciation for the hard work by the instructors during the term in some of their posts. It might have something to do with the fact that the instructors also were students, in this case, putting the participants in a more even age group. This forum is an example of how forum software geared towards information distribution can be used for community building as long as the prerequisites are there.

5.2   Case 2: Discourse, used by Codecademy

The second case looks at how Discourse is used by Codecademy, an online academy for learning computer programming. Activity-wise, this is an active forum with upwards of 150 new topics every week. This forum is not used in a university setting, but Codecademy still provides an educational context. Users enlist in courses at Codecademy's website and follow them with help from users and instructors on their forums. The software features of Discourse lean towards community building but can also be adapted to other situations because of the platform's adaptability. How a question feed might look like on the forum can be seen in Figure 5.7.

Codecademy's forum community shows clear signs of good community building. The community i socially and academically active, shares information, and regular users assist each other frequently. The instructor staff at Codecademy rarely answers questions unless they are directly related to support issues or the Codecademy website itself. Answers to questions usually come from other users, where some users have attained visible community leadership. For example, a user called "toastedpitabread" has attained the status of "SuperUser", giving them a silver star icon on their profile picture. Additionally, they have a title specifying that they are a "Problem Solver (gold)". See Figure 5.8. The Codecademy-staff does occasionally ask questions to facilitate forum activity. See Figure 5.9. Staff are highlighted using a Codecademy logo icon on the staff members' profile pictures.

The model indicates that this forum leans heavily towards community building. See Figure 5.10. Keep in mind, some of the usage characteristics are guessed due to a lack of data. For example, the "High user retention" or "Large core group of participants" characteristics. Some users were looked at, but not the whole user dataset. As seen in Figure 5.10, Discourse has features for both community building and information distribution. It also does well with the independent features in Figure 5.11. This comes from its adaptability through plugins and customisation. Codecademy has chosen to use a thread display, and a plugin called "Discourse Solved", which lets the forum use the Q&A style. Because of this, the forum uses both a thread display and a question display at the same time. However, the thread
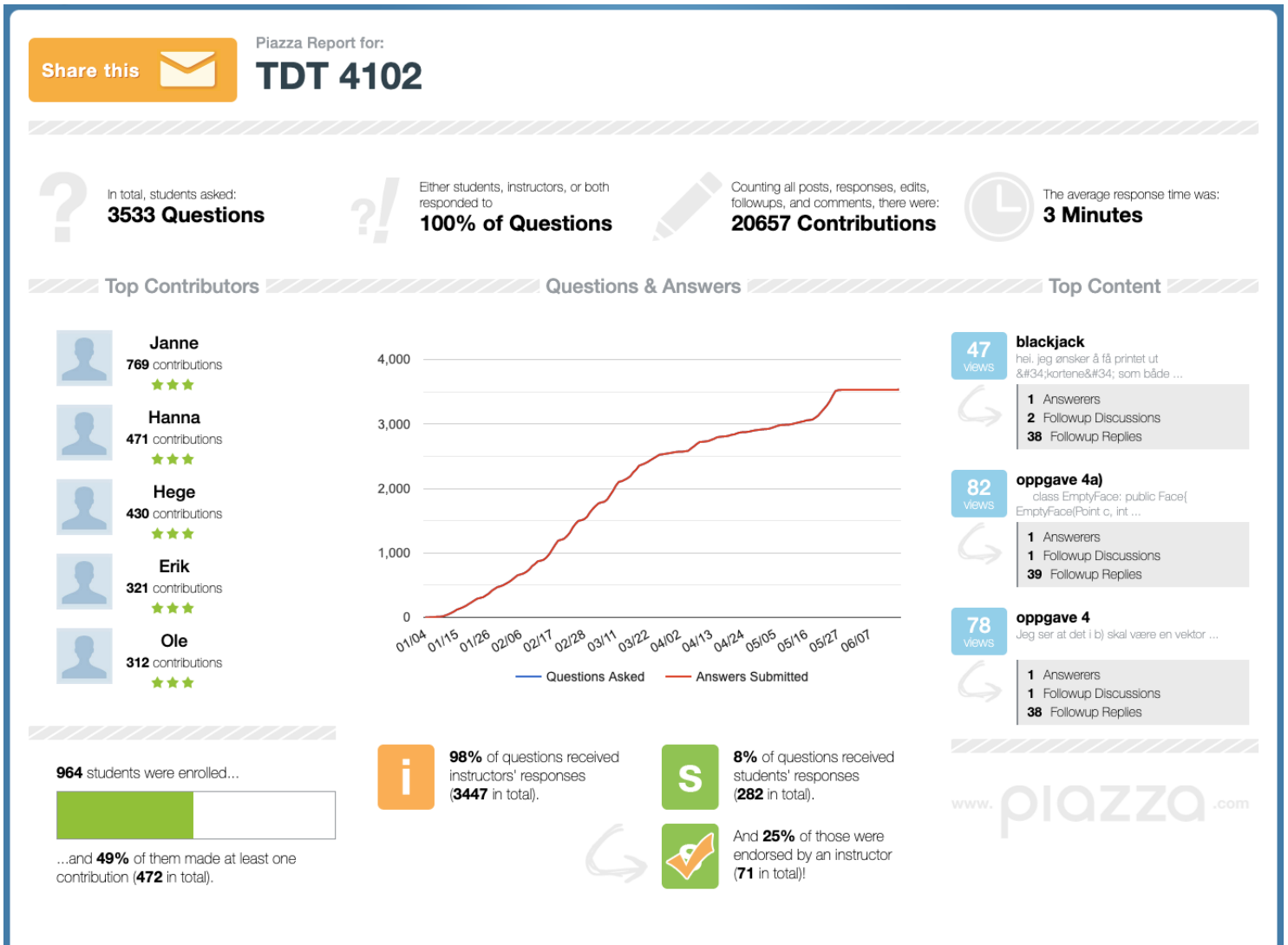
Figure 5.1: Piazza summary of the course TDT4102 at NTNU, spring term of 2021.

Figure 5.2: The model used on Case 1.
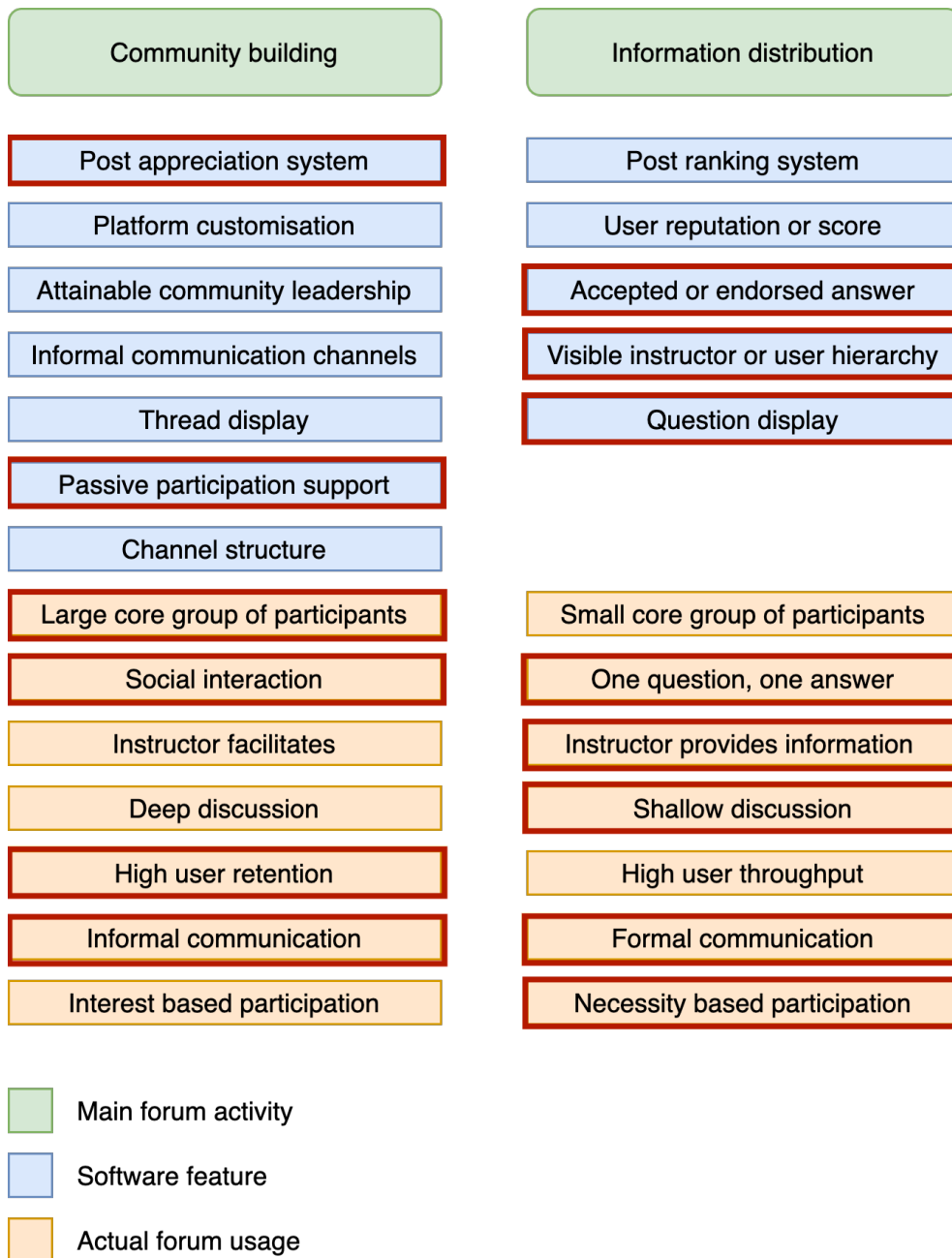
Figure 5.3: The independent model used on Case 1.

Figure 5.4: Student using slang and informal communication.
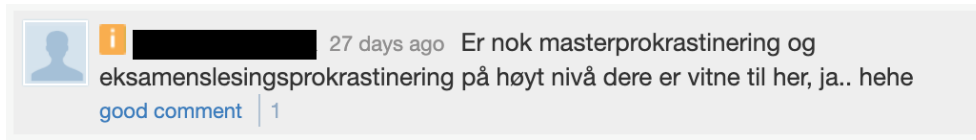
Figure 5.5: Student using slang and informal communication.
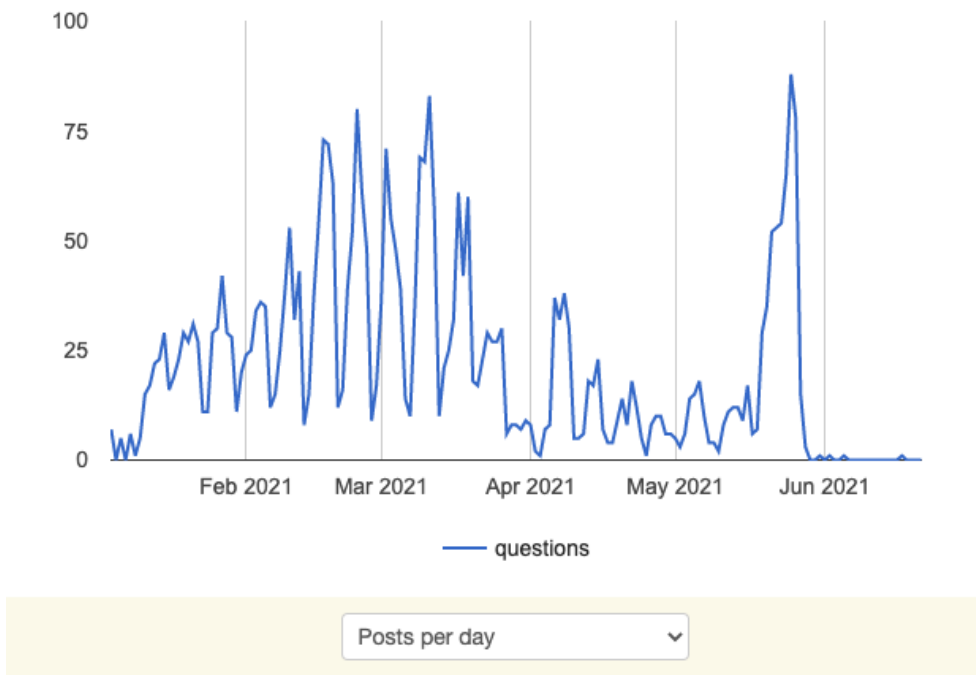
Figure 5.6: Usage graph for TDT4102.
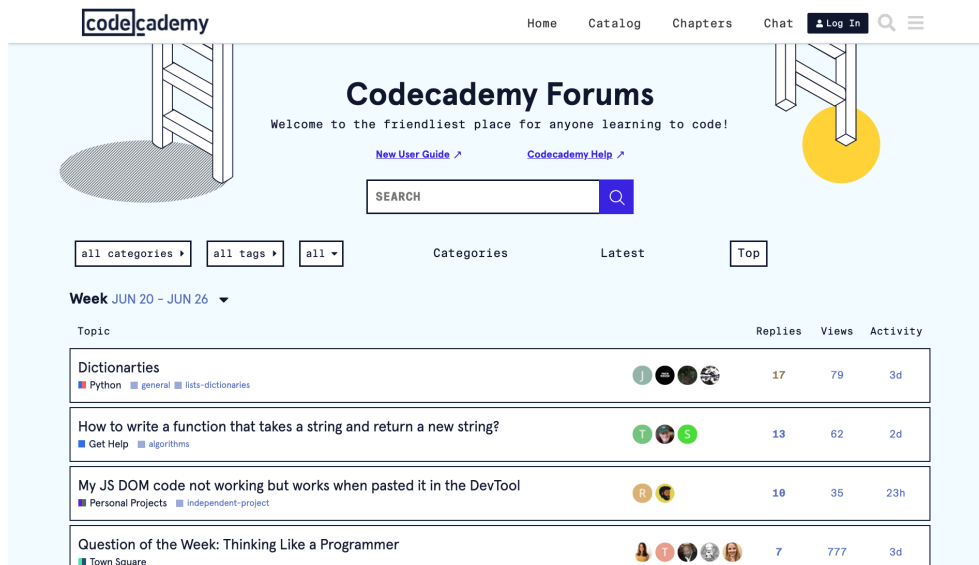
Figure 5.7: Question feed on Codecademy's Discourse forum.

Figure 5.8: User reply on Discourse showing community leadership.

display is the primary way to display interactions. The forum has many informal communication channels, including a category called "Community", which is used to talk to other forum users about anything. Codecademy's forum is an example of how the underlying software can successfully support an intended main forum activity. In this case, community building.

5.3   Case 3: Blackboard, used by TDT4136 at NTNU

The third case features Blackboard's built-in discussion forum software, as shown in chapter 2. A course at NTNU called TDT4136 Introduction to Artificial Intelligence used it for student-to-instructor communication in the autumn semester of 2018. As mentioned, Blackboard's forum lacks some common forum features.
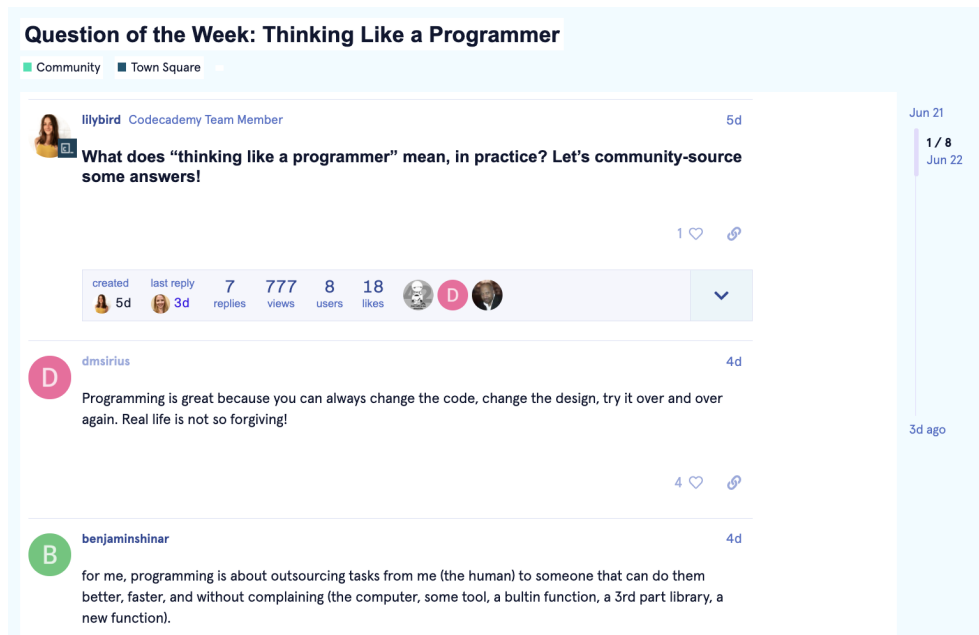
Figure 5.9: Codecademy-staff facilitating discussion.

For example, a search function, post appreciation or ranking system, and passive participation support. It is very much designed like a classic discussion forum. This means that the forum design might struggle with supporting the two main activities.

In this case, the instructor was active and answered most of the questions that were asked. The threads did not feature much student-to-student interaction but rather student-to-instructor interaction regarding requests for information. The instructor did not facilitate discussion but used the forum as a communication channel for providing course information. Because of these usage characteristics, the usage leans heavily towards information distribution. Again, detailed usage data was not used in this analysis. Still, the forum looked to have a small group of core participants, a Q&A format, shallow discussion, formal communication, and necessity-based participation.

Blackboard's forum design does not aim at any specific interaction type. In terms of software features, Blackboard only has two of the features related to the two main activities in the model. See Figure 5.12 and Figure 5.13. The lack of features limits the effectiveness of the platform. For example, there is no indication of whether a question has been answered when browsing the landing page. See Figure 5.15. The instructor's presence is only visible on the Post level (see Figure 5.14), not on the Thread level, as illustrated in Figure 4.5. Meaning there is no feature for knowing if a thread has been solved. Because of this, quickly skimming the page

Community building	Information distribution
Post appreciation system	Post ranking system
Platform customisation	User reputation or score
Attainable community leadership	Accepted or endorsed answer
Informal communication channels	Visible instructor or user hierarchy
Thread display	Question display
Passive participation support	
Channel structure	
Large core group of participants	Small core group of participants
Social interaction	One question, one answer
Instructor facilitates	Instructor provides information
Deep discussion	Shallow discussion
High user retention	High user throughput
Informal communication	Formal communication
Interest based participation	Necessity based participation

- Main forum activity
- Software feature
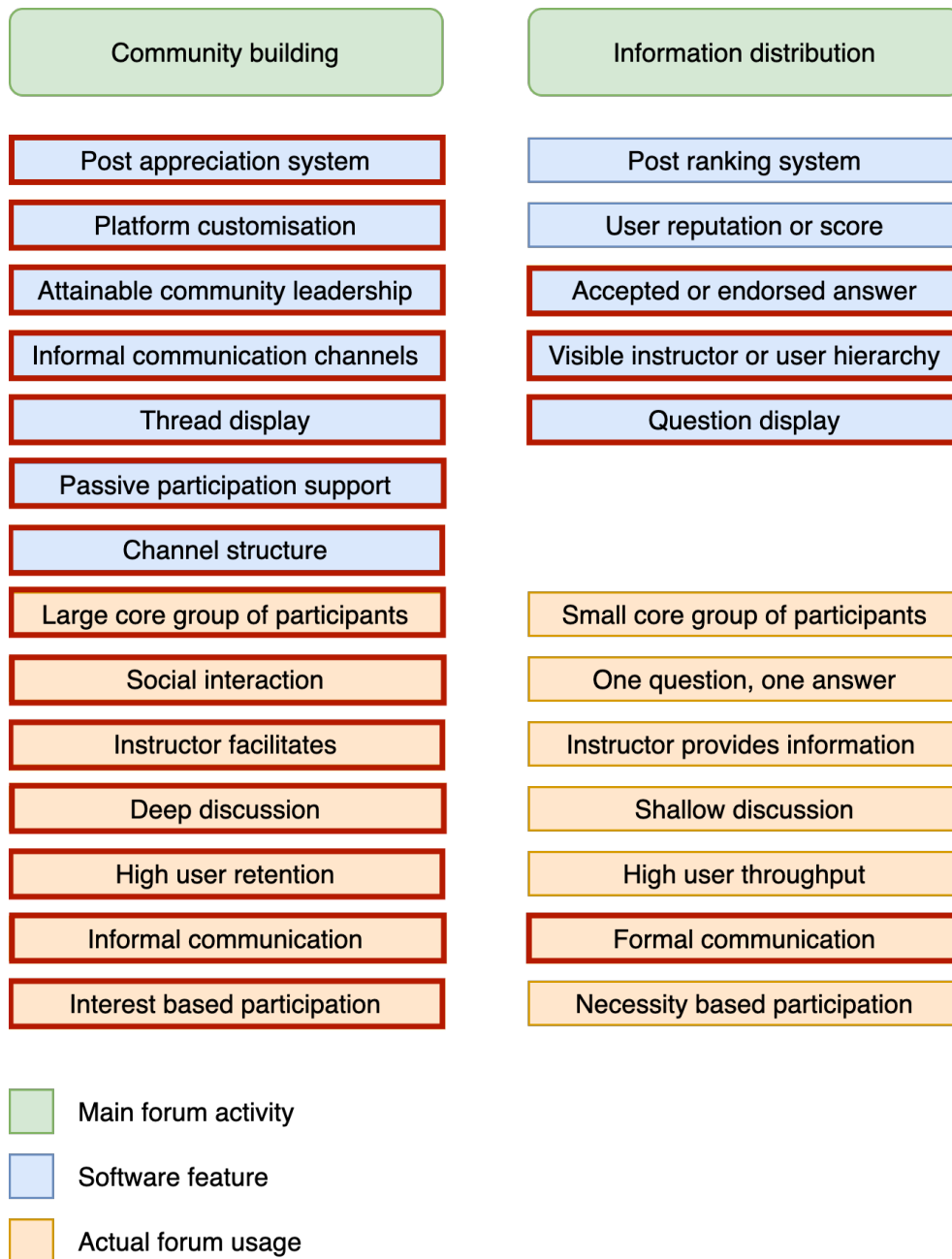- Actual forum usage

Figure 5.10: The model used on Case 2.

Figure 5.11: The independent model used on Case 2.

for informative threads becomes more difficult. However, the forum can be split into categories, making it easier to search for information by topic. Blackboard's forum used by TDT4136 is an example where the underlying software solution does not support the intended forum activity.
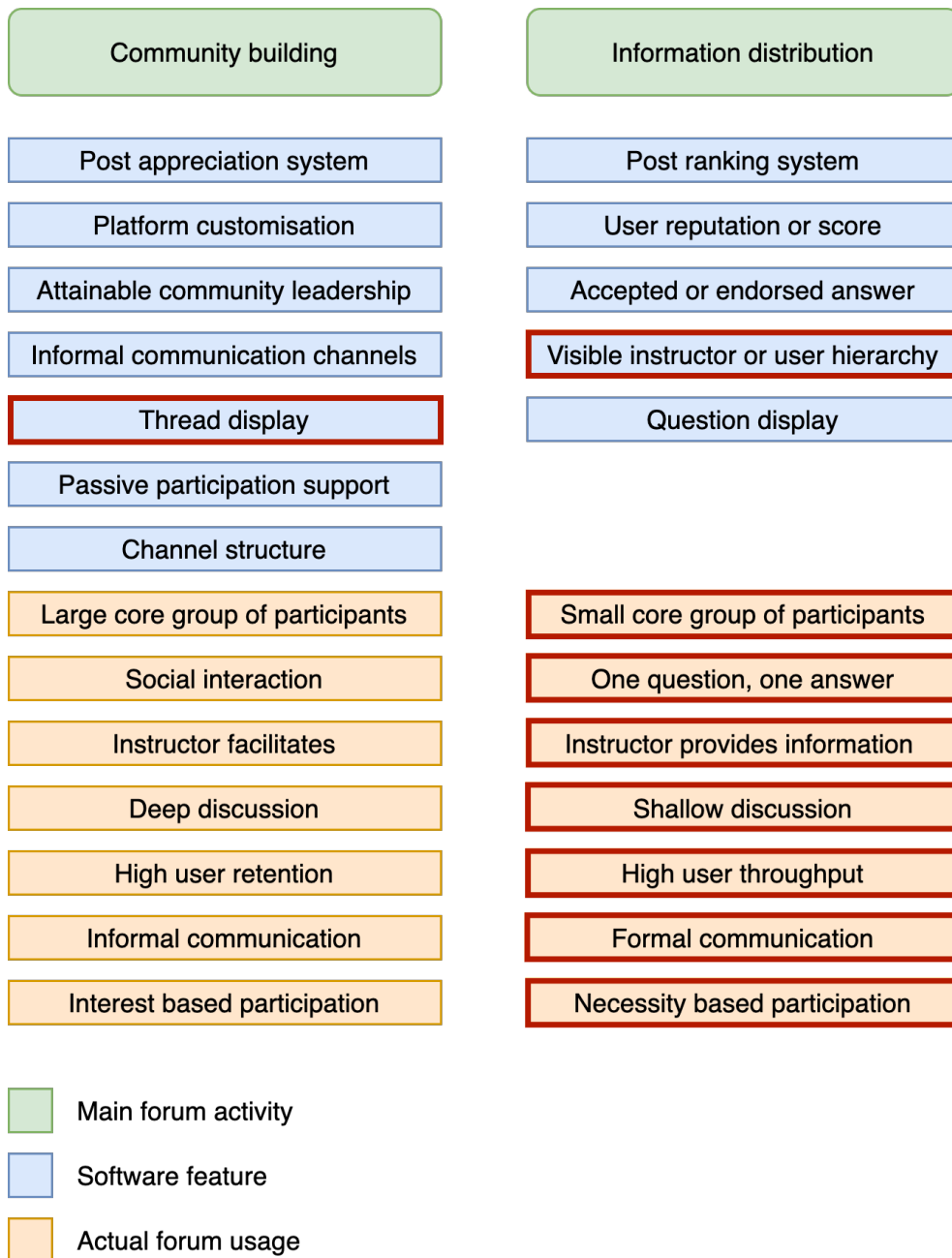
Community building	Information distribution
Post appreciation system	Post ranking system
Platform customisation	User reputation or score
Attainable community leadership	Accepted or endorsed answer
Informal communication channels	**Visible instructor or user hierarchy**
Thread display	Question display
Passive participation support	
Channel structure	
Large core group of participants	**Small core group of participants**
Social interaction	**One question, one answer**
Instructor facilitates	**Instructor provides information**
Deep discussion	**Shallow discussion**
High user retention	**High user throughput**
Informal communication	**Formal communication**
Interest based participation	**Necessity based participation**

Main forum activity

Software feature

Actual forum usage

Figure 5.12: The model used on Case 3.

Figure 5.13: The independent model used on Case 3.
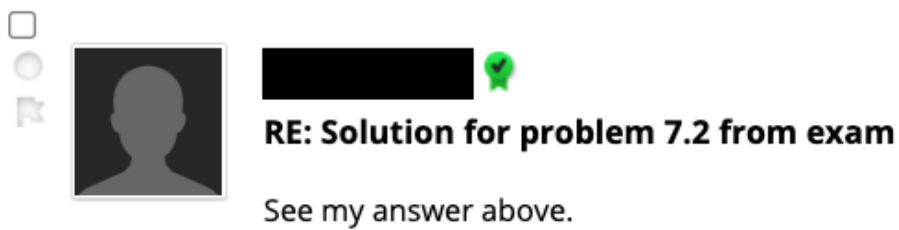
Figure 5.14: Instructor response on Blackboard.

Figure 5.15: Landing page on Blackboard.

Chapter 6

Conclusion

The online discussion forum has become an important part of education over recent years. Because of this, the instructors and teachers must know how to pick their forum software effectively to fit their teaching needs and classroom structure. The literature is very clear that discussion forums used in education are beneficial, but it does not say much about what software features to use in each scenario. This chapter will discuss this thesis' answers to the research questions presented in chapter 1.

The research questions of this thesis are as follows:

RQ1 What would be a generic model of a universal discussion forum?
RQ2 What features are commonly used in discussion forums, and how can they be categorised?
RQ3 How should discussion forums be used to support education?

RQ1 was answered by looking at historical discussion forums and how they have evolved through time while comparing them to today's state of the art systems. The format has not changed much since the first forums were introduced well before the World Wide Web existed. Forums still follow the generic model of the thread, post, user, moderator, and administrator. While these basic entities have different names in some new forums, the interaction they support share the same hierarchical relationship. We have students, teaching assistants, and instructors in an educational context instead of users, moderators, and administrators, respectively. This contribution makes it easier to discern where a feature should be implemented in a forum as it highlights the relationships between the different forum entities. The generic model can be seen in Figure 4.1.

RQ2 was answered by reviewing the state of the art systems and the literature. While the literature provided more abstract strategies and plans for using discussion forums, concrete features could be discerned from the state of the art systems. Two main categories and one independent category emerged when viewing

the features in light of the literature. Features are thereby divided into three categories: community building, information distribution, and independent features. Some features clearly enable community building while making it less efficient to share information. Additionally, some features enable information distribution by making it harder to build a community. That is why those two categories are chosen as outer points on the scale, as a designer will need to make trade-offs between them continually. The third category, independent features, is for features that have no positive or negative effects for either community building or information distribution but are simply good features to include.

RQ3 was answered by the model presented in chapter 4, Figure 4.4, which is the main contribution of this thesis. The model utilises the categories found when researching **RQ2** and categorises the features found in the state of the art systems and the literature. This supports education by aiding the instructor in picking a forum that suits their intended forum activity. It became apparent through researching discussion forums that they are used in many different ways. Even within the educational context, different courses can have vastly different requirements. Therefore, it is important to equip forum designers and instructors with the tools to design the right system. The forum will not do its job effectively if the actual forum usage is not compatible with the forum's software features. Using the model will help instructors find the right software for their needs. A discussion forum can be analysed through a bottom-up or top-down approach to see if its intended use matches the instructor's intended usage.

Adaptability should be a focus when designing a forum—especially when making big solutions that are used by universities as a packaged solution. As mentioned, different courses have very different requirements that require different forum solutions. The forum should conform to how the instructor wants to teach and should not restrict how the instructor organises their classroom. It does not need to settle for one type of interaction like Q&A or discussion, as it could very well do both.

This thesis also provides some reflections on the state of the art systems and why they are successful. The channel design is especially interesting, used by Reddit, Discourse, Teams, and Askalot. Designing a forum to contain multiple smaller forums instead of being independent silos shows promise for community building and knowledge sharing. Meanwhile, using a Q&A-style forum like Piazza is efficient and is definitely a viable option for information distribution.

6.1   Limitations and future work

A theoretical focus was chosen for this thesis. Hence, the model from chapter 4 (Figure 4.4) is based on literature and discernible features in the state of the art

systems. The categories are also based on this. This means that the model primarily serves as an aid when determining requirements for a discussion forum or when making a requirements specification from a theoretical point of view. I view this as a limitation as actual usage data would help determine the concrete effects of a software feature. For example, how attainable community leadership directly affects community building or feeling of community for participants.

This thesis did not test the model on students or instructors in a real scenario. It would be interesting to see if the two proposed categories can be brought forward or identified using the model to design a discussion forum. It would also be interesting to do a qualitative study to see if instructors find the model intuitive from their experience or how they would use it to design a forum based on intended usage. One could complete a quantitative study to identify the use of several forums using content analysis and compare the findings to the classifications of the theoretical model or, as mentioned previously, find the direct effect of a certain feature or technique for either of the categories.

6.2   Acknowledgements

This thesis was done with much help from my patient supervisor, Trond Aalberg. He provided excellent advice along the way and let me research a topic that I was interested in. I would also like to thank Monica Divitini for her courses TDT29 and TDT4245 that helped me understand how many factors there are to communication and collaboration.

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