Codula, a Social Network Geared Towards Programming Education

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Abstract

Digital social networks have become an ubiquitous presence to almost everyone, to the point that they are frequently taken for granted whenever someone gets asked for their contact. Beyond that, it is without doubt that their capacity for stimulating participation in groups and exchange of ideas, while retaining attention for long periods of time is – for good, or for bad – highly efficient. If taken for a good cause, their features can become fierce allies to educators in their teaching efforts. Specially in the case of Computer Programming, a sharp, and difficult matter, social networks can be of great value, not only for their inherent technological link to Computer Programming, but also for their natural connection to students that dare to pursue the arduous path to become programmers. Codula is a social network that was designed and implemented with the purpose of paving and shortening this path, both for students, and educators alike. This paper presents both Codula's design principles that guided its construction, and main features, that were carefully crafted to fulfil its purpose. While foundational concepts solidified design choices, such as the absence of different roles for users, and the stimulus of the sense of belonging via personal customisation, features were implemented to directly support Computer Programming Education, such as the specification of different post types, and functionalities that facilitate composing, sharing, and commenting source code. By converting opposing forces of a commonly found distraction, Codula aims to leverage the best aspects of social networks to support a better cause, in the hopes of stimulating a successful collective teaching-learning process.

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1 Introduction

Computer programming presents a series of difficult challenges that students need to overcome in order to construct knowledge. Being an intrinsically complex problem to solve, strategies, methods and tools to overcome these commonly found challenges have been researched for decades [15, 10]. Difficulties range from the inflexible syntaxes of programming languages

that are wildly different from their natural counterparts, through the required understanding of a problem's domain and its constraints, to the arduous and naturally abstract translation process from ideas and concepts to implementation [7].

It has been shown that learning is an inherent social process. Vygostky [16], through his Cultural-Historical Activity Theory presented the world with the idea that, in order to reach higher potential, students need a mediator that bridges the gap between what they can learn by themselves (their inherent capacity) and what could be learned via guidance.

Digital social networks provide an important tool for information exchange, with ample reach and high retention rates [12]. While these are all double-edged features when it comes to benefits or maladies, it is more than obvious that if this retention potential should be geared towards learning approaches, social networks would provide invaluable resources for teaching and learning, specially if pedagogical theories such as Vygostky's is taken into consideration. Codula[1] is a novel proposal in this regard, a social network that provides specific features that have been designed to support learning computer programming. Through its focus on facilitating the mediation of peers and teachers, it cements itself in Vygostsky's groundwork in order to retain and stimulate students to learn how to program computers together.

This article is divided into five sections. After the introduction in this section, Section 2 presents both a brief history and foundation of Social Networks, as well as a survey of features commonly found in them. Section 3 presents Codula, a Social Network designed to support Computer Programming Education. Section 4 reports on the preliminary evaluation results, and finally, Section 5 concludes the paper with final remarks, as well as prospects for future works.

2 Social Networks and their Motivational Factors

The expansion of communication networks and digital services has reshaped how people access information, education, employment, and public services over the past 30 years [14], accelerated globalisation, and redefined civic participation. Many of today's leading global companies either rely completely on digital connectivity or are built entirely around it [14] and are deeply integrated with social networks. This section contextualizes how social networks are used and their potential for engagement and learning programming languages.

Social networks are digital platforms that mediate personal, professional, and social relationships. They are web-based services that allow people to create connections, share content, and interact with other users. By definition, social network sites allow users to create personal profiles (public or semi-public) and connection lists, where users can view the connections of other users [2]. The terminology for connections may vary between platforms, such as friends or followers. Nowadays, it influences information consumer habits and connects billions of people worldwide [9], especially through mobile device applications. Their ability to integrate users, content creators, and diverse media formats has led many platforms to also be characterized as social media, extending the network concept to video-sharing, gaming, and blogs. This networking strengthens existing or new social ties. In other words, they have taken sociality, a characteristic of the network society, theorized by Castells in the 1990s, into its greatest applicability. According to the author, this shift has accelerated over the last decade, driven by advances in connectivity, storage capacity (Big Data), and Artificial Intelligence (AI) [4].

[1] Codula is available at: `https://codula.epl.di.uminho.pt/`

Within the context of collective knowledge construction, there are also collaborative platforms based on the Wiki principle. These are open platforms where anyone can edit and add content in a cooperative writing system. It is the hypertext that forms the community, where no one owns the content. The best-known platform is Wikipedia, a multilingual encyclopedia project run by volunteer editors. The dynamics of knowledge sharing can also be observed in other virtual communities. Chuang [5] analysed online gaming communities of the MMORPG (Massively Multiplayer Online Role-Playing Games), focusing on the sense of belonging and immersion of users in these communities. Among the results, he identified the importance of users feeling capable of helping others and how this strengthens the community. In addition to considering the Sense of Virtual Community and Social Cognitive Theory (centred on self-efficacy in knowledge), the author also included Uses and Gratifications Theory [11].

2.1 Forums *versus* Social Networks

Research suggests that social learning environments help people retain information better than when learning alone and stay engaged for longer periods. In addition to social networks and wikis, there are forums. Interaction in forums is more about questions and answers than about individual interactions, unlike in social networks. Their focus is on building communities around a specific topic rather than on the users themselves [8]. The opportunity to discuss topics, share ideas, and receive feedback makes the learning process more active and rewarding [17]. By encouraging people to ask questions and work together, users tend to feel more supported and motivated to keep learning [15].

Recent studies involving the use of social media in programming courses have shown positive results in the educational environment. Students in the Object-Oriented Programming Laboratory 2 course who used Facebook groups and YouTube videos answered surveys, and the researchers found that students improved their understanding of academic concepts [1]. In some cases, young people spend more time on social media than on homework, which negatively impacts learning objectives [13]. A widely recognized example of an educational platform is Moodle, which is extensively used in schools and universities as a Learning Management System (LMS). It enables teachers to share resources, assign tasks, and communicate with students within a single environment, supporting traditional and online classrooms. Although Moodle is not a traditional social network, it incorporates features that promote interactive learning, including discussion forums, messaging, and collaborative workspaces [18].

In the case of studies that compare student engagement between groups on social networks and forums within Massive Open Online Courses (MOOC), the result is different. Based on interviews with Coursera platform users and Facebook users, the researchers have identified higher engagement with social networks [17]. According to participants, social networks offer more resources that encourage interaction. In addition, the researchers found that, as a key engagement, establishing trust between users was needed in both cases. There are also platforms that work on a question-and-answer (Q&A) model, and these platforms work like forums, such as Reddit, Quora, Stack Overflow and Dev Community.

Similar to social bonds built in offline contexts, social interaction contributes to the development of new skills. Thus, these online networks of contacts enhance trust, while reputation systems encourage participation and social learning [3].

Table 1 Features surveyed from selected social networks and forums.

Name	Type	Community	Content Types	Engagement
DEV Community	Forum	Followers, Communities	Text, links, images	Comments, reactions, badges
Facebook	Network	Friends, Followers, Groups	Text, images, videos	Likes, comments, verified
Instagram	Network	Followers	Images, videos	Likes, comments, verified
LinkedIn	Network	Connections, Groups	Text, media	Reactions, endorsements
Quora	Forum	Followers, Topics	Text, links	Up/Downvotes, comments
Reddit	Forum	Communities	Text, links, media	Up/Downvotes, comments
ResearchGate	Network	Followers, Communities	Articles, text	Citations, recommendations
Stack Overflow	Forum	None	Text (Q&A)	Reputation, votes, badges
TikTok	Network	Followers	Videos	Likes, comments, verified

2.2 A Technical Survey of Current Social Networks

In the last two decades, social networks have emerged for different purposes, whether personal (e.g., Instagram) or professional (e.g., LinkedIn), and with distinct functionalities. For example, they all allow sending private messages and suggest connections and content based on users' interests and reactions on each social network.

Considering that social networks depend on users and their interactions, studies identified that for user engagement, there must be a topic of interest, trust, emotion (positive or negative), commitment, and how much effort (convenience) is necessary to interact [6]. Design-related issues and involvement of acquaintances also contribute to the adoption and acceptance of a social network, such as the different types of posts that allow images and links, hashtags, post interaction tools, targeted responses, and interest groups, as Table 1 summarizes. Based on this technical survey (Table 1), we adopted for Codula a basic set of functionalities that are commonplace in other social networks: group-based communities and followers; text and image content types; comments, likes and reputation engagement mechanisms. Beyond their familiarity for users, the chosen features also allow for effective communication using snippets of source code, a requirement for Codula's objectives.

3 Codula, a Social Network for Programming Education

Codula's design was guided by a set of ontologies, which defined the main concepts of the platform and their relationships, and served as a foundation for its structure and features. For that purpose, three main ontologies were developed: Core, Resources, and Interaction.

The Core ontology, illustrated in Figure 1, represents the main concepts for the context, objectives and relations within the platform, focusing on the actors and how they interact. The main actors in this ontology are *Student* and *Tutor*, representing the target audience for Codula. The system is primarily directed at students, as its goal is to support programming learning, while tutors represent guidance and support during this process. Even though this conceptual distinction between students and tutors was relevant to specify the target audience, differentiating roles were not implemented, as they could create a symbolic stratification between users and indirectly coerce interactions.

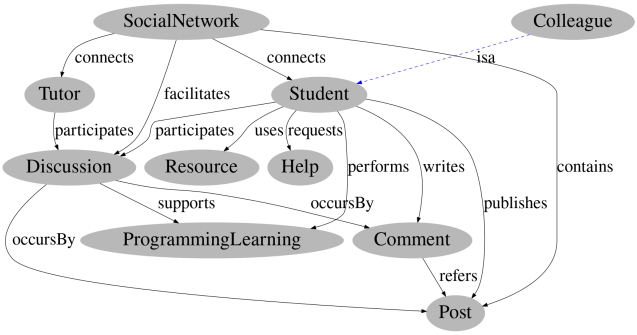

Figure 1 Core concepts of the ontology.

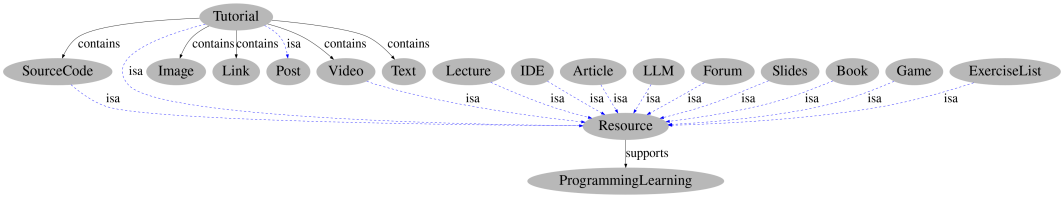

Figure 2 Resource concepts of the ontology.

The Resources ontology, shown in Figure 2, represents different tools that can support programming learning, both in digital and physical forms. It includes elements such as tutorials, articles, code snippets, and other forms of learning resources. These were modelled as different learning tools that users usually use to overcome difficulties, and were defined during the design phase as a reference for the platform's features. Given overall time and resource constraints, Codula implemented a subset of these resources, while keeping its source code structured for future developments.

The Interaction ontology, presented in Figure 3, describes how users engage with the platform. It includes actions such as requesting help and collaborating with others. It also represents different ways in which help can be provided, such as through tutorials, other users, or tools like AI assistants. Again, a subset of these interactions was implemented by Codula.

As per implementation, Codula follows a structure similar to other social networks, allowing users to share content and interact with each other in order to capitalise on students' previous experiences with social networks. At the same time, it includes features that differentiate it and make it more suitable for programming education.

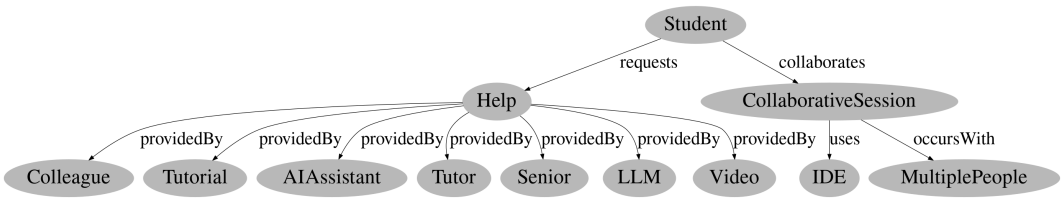

Figure 3 Interaction concepts of the ontology.

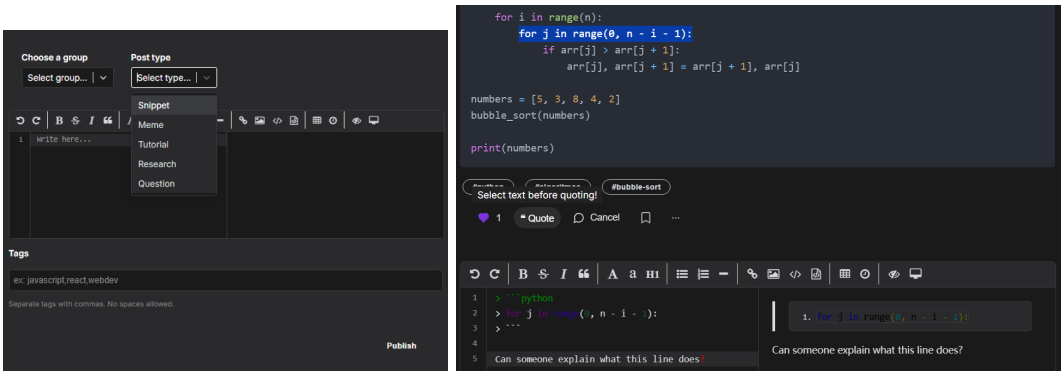

Figure 4 Post creation (left) and quoting (right) interfaces.

3.1 Writing Posts

The first dedicated interface Codula brings to the table is the page for writing a new post. Creating a post in Codula was designed to be a structured yet flexible process, allowing users to share different types of content according to their needs. Nonetheless, as the main artefact for programming education is very commonly a source code, the interface was implemented to allow users to quickly and directly write formatted snippets in several languages. The interface uses a Markdown-enabled editor and a live preview of the formatting, including source code highlighting (Figure 4, left). This improves both instant gratification and validation, as the visual formatting can aid in finding little bugs while typing.

The type of the post can also be selected, supporting five basic options: *Snippet*, *Meme*, *Tutorial*, *Research*, and *Question*. Each post type adds different fields for metadata that complements the main text itself. In addition, tags can be added to describe the topic of the post and make it easier for others to find related content.

3.2 Quote Functionality

The second feature that Codula implemented focused on programming education is a quote functionality that allows users to select and quote specific portions of text from posts or comments when replying, more specifically, parts of a source code snippet (Figure 4, right). This feature is particularly relevant in programming education, where discussions often focus on small fragments of code. By isolating only the relevant content for a response, users can either ask or provide answers for more direct and structured parts of a post.

Instead of requiring users to manually copy and paste content, the comment system provides a direct mechanism for users to select text and automatically insert it into the reply editor. Quoted content is visually distinguished from the rest of the message, making references clear and improving the overall readability. A key aspect of this feature is its support for source code. When quoting code, the platform preserves its original formatting, including indentation, line breaks, and syntax highlighting. This ensures that the quoted content remains accurate and easy to interpret, which is essential in programming contexts.

4 Evaluation

Codula's evaluation, while not yet finished, was already realised through multiple testing stages, involving different types of users and focusing on both technical and educational aspects of the platform.

The first stage consisted of informal testing with a small group of selected users, mainly colleagues, who interacted with an early version of the platform. The main goal of this phase was to identify bugs and usability issues. This initial testing helped uncover several problems related to navigation, layout, and overall interaction with the system. For example, improvements were made to how posts are displayed, avoiding long posts taking too much space in the feed, and making navigation smoother. Other changes included adding missing interaction features, such as viewing likes and user connections, as well as improving performance by loading posts progressively instead of all at once.

After this initial phase, the platform was presented to 4 programming teachers from both Portugal and Brazil. The goal was to demonstrate how Codula works and explore its potential as a support tool in programming classes. This stage provided more focused feedback from an educational perspective, helping identify how certain features could be simplified or adapted to better fit classroom usage, such as enabling the execution of code directly within snippet posts, adding visual indicators for new content, and displaying a small preview of comments under each post.

Codula was also presented to students from different classes, including students who had just started their degree in Software Engineering and master's students in Programming Education. These sessions allowed collecting early impressions and suggestions from potential users. Several ideas emerged during this stage, such as the implementation of a chat system between users, the creation of fixed groups for programming languages (C, C++, Python, etc.) and other common topics without requiring users to create them manually, and the ability to pin answers within a post. The possibility of executing code directly within the platform was also highlighted. These suggestions highlighted areas for future improvement and helped refine the platform's direction.

5 Conclusion

Teaching/learning Computer Programming is one of the hardest educational processes due to the unusual skills required to express in algorithmic format the steps to solve a problem using the computer. In the last two decades, many pedagogical approaches and computer-aided tools have been used to mitigate these difficulties. The success is still limited, because engagement is a fundamental requirement for students to persevere looking for the correct or optimized resolution for a given problem. However the lack of strong intrinsic motivation does not provide enough engagement. To overcome these flaws in the teaching/learning process under this unfavourable context, we decided to trace a new path taking advantage of online social networks addictive power. This purpose led us to design and develop Codula, a social network tuned to a community of people willing to learn programming and the associate languages.

The focus of this paper was Codula – its design, educational-oriented features, interface, and evaluation. The foundations of (online) social networks were also summarized to pave the way over which we built our programming network. Based on the tests already conducted, it is possible to assert that Codula main contribution resides in the programming education mechanisms it offers, such as the *quoting functionality for code snippets* that provides an easy way to comment or query.

As future work we plan to conduct an extensive pedagogical assessment in diverse Programming Courses, in order to obtain a direct and reliable feedback from students. Their answers will provide important information to confirm our proposal and to improve Codula features. Another direction for future work is the development of other novel features dedicated to better support Programming Education, such as daily challenges, AI Tutors, and online serious games.

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