Learning Programming without Teachers: An Ongoing Ethnographic Study at 42

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ABSTRACT

Context: With the ever-evolving software landscape, methods to train software programmers are continuously advancing and evolving. In this investigation, we study the case of 42, a programming school with over 50 campuses worldwide. 42's pedagogical method blends elements of problem-based learning, peer pedagogy, community building, and gamification. **Objectives:** The goal of the research is twofold: On one hand, to gain a deep understanding of the pedagogical method itself, and on the other hand, to study how its different components affect learning. **Method:** We adopt an ethnographic qualitative inquiry, with two academic researchers conducting participant observation over a period of six months by using activity theory as theoretical underpinning. **Results:** Problems of incremental difficulty, albeit challenging, foster virtuous cycles of reinforcing feedback and community building. Gamification and peer learning elements, which are deeply rooted in the carefully crafted educational receipt, further support the pedagogical method. **Conclusions:** The characteristic nature of 42 positions it as an outlier compared to the recurrent academic setting of frontal lectures followed by a final exam, making it a valuable case study to understand how various pedagogical components may function, interact, and affect student learning.

KEYWORDS

Software Engineering, Software Education, Ethnography, Problem-Based Learning, Peer Pedagogy, Gamification

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1 INTRODUCTION

The role of Software Engineering (SE) is essential in contemporary society, particularly as the technology industry continues to expand its influence, and the rapid pace of technological advancement in the past century necessitates professionals capable of leading this progress. Educating a software engineer is a comprehensive endeavor. Both theoretical and practical aspects of their training must include a broad range of skills, which can be challenging to select and convey in an ever-evolving environment [13].

Traditionally, passing on specialized skills has relied on the expertise of teachers within physical classroom settings, often constrained by costs and limitations such as financial accessibility and classroom size. However, recent advancements have mitigated many of these educational constraints. Online learning and hybrid teaching methods have emerged as viable alternatives, breaking down previous barriers and encouraging innovation in educational approaches [11]. Furthermore, the academic community made significant efforts towards identifying and investigating innovative teaching methodologies capable of keeping pace with scientific progress and student needs [15, 16].

Our research explores the case of 42, an institution pioneering an educational model that combines problem-based learning, gamification, and peer pedagogy, complemented by community development initiatives, to offer free Computer Science education to individuals demonstrating aptitude and interest [14]. To analyze 42, we present an ongoing research employing an empirical qualitative approach, namely ethnography.

Originally developed within the social sciences, ethnography is one of the main methods of qualitative inquiry [6]. The method involves a deep immersion within the community or culture under investigation, including extensive fieldwork, participant observation, interviews, and note-taking [8]. By immersing oneself in the natural environment being studied, ethnographic researchers gain first-hand access to crucial experiences for analysis and interpretation, that may otherwise be lost if a more superficial qualitative or quantitative research method is used. By adopting a rigorous ethnographic research protocol in the context of 42, it becomes possible to gain, in a sensible and non-intrusive fashion, a deep and comprehensive overview of the complex and multifaceted factors that characterize its pedagogy method. We aim to delve into the institution's complexity and gain insights into its operational mechanisms, characteristics, and influence on student education.

2 BACKGROUND: PEDAGOGY AT 42

42 is a private institution offering free higher education in computer science using a unique pedagogical stance. Students at 42 do not attend frontal lessons like in conventional universities, but rather follow a curated course built upon a series of programming exercises and projects of incremental difficulty.

For each project, students are presented with the bare minimum knowledge of the topic and are requested to complete the assignment by discovering the solution themselves, *e.g.,* by consulting books, online resources, or whatever other medium they find more

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fit. Each assignment is presented as a challenge and leads the student to address new topics using the knowledge built in previous exercises. After completing a project, the code is subject to peer evaluation, an in-person review process conducted by other students, automatically selected from the same campus. During the review, the candidates present and defend their work, and the reviewers verify the formal correctness of the assignment, evaluate the candidate's understanding of the topic, and provide feedback through an *ad-hoc* dedicated platform on 42's intranet. The first projects of the course are evaluated further by an automated verification system, which also checks the internal coding rules of 42, referred to as the "Norm". The project completion rewards students *via* a scoring system that allows them to unlock access to more complex projects and continue their path.

The education at 42 is provided for free to all students who, in turn, are subject to productivity requirements to remain in the school. Specifically, students are assigned a deadline, and by completing projects they will postpone it according to the difficulty of the delivered assignment. If the deadline is ever reached, the student is expelled and access to the course is revoked for 2 years.

Admission in 42 is based solely on merit: there are no academic requirements or prerequisites other than being at least 18 years old. Instead, prospective students must complete an intense boot camp month, called "Piscine", used to evaluate their problem-solving skills and aptitude for programming to be admitted.

The pedagogical journey at 42 lasts approximately 2 to 3 years. During the Piscine, students learn the basics of programming concepts through the study of Bash and C, and the Common Core (main course) focuses on the C and C++ programming languages, involving topics such as OOP, data structures, concurrency, and many more. After completing the core path, students can then choose a specific specialization, referred to as Mastery, including data science, web and mobile development, computer graphics, and network security.

42 was founded in France by Xavier Niel in 2013. Until 2024, it has grown to 54 campuses worldwide, in 31 different countries, with more than 21 thousand total students. The object of the study covered in this paper is the 42 Florence campus, which currently has a staff of about 10 people and 217 active students.

3 RESEARCH METHODOLOGY

In this section, we provide a comprehensive overview of the ethnographic research method and how it is applied within the context of 42. The documentation opens with the delineation of the research objective, followed by the formulation of research questions, a characterization of the specific ethnographic method used following five *a priori* defined dimensions [17], a breakdown of the study phases by following the guidelines for ethnographic studies in SE presented by Zhang *et al.* [23], and finally a discussion on the limitations of the research.

3.1 Research Goal and Questions

The objective of this study is to examine the educational model of 42 to offer not only a basic understanding of the method but also a thorough analysis of its effects on the learning practices and objectives of the students. To provide an exhaustive understanding of the pedagogical method of 42, the phenomenon studied is split into its four main characteristic components, namely problem-based learning, gamification, peer pedagogy, and community development. This approach allows for an independent examination of each aspect of the 42 method, facilitating a comprehensive understanding of each facet and its influence on student education.

By adopting the research goal formulation template of the widely utilized Goal-Question-Metric paradigm [4], we define the research objective of this study as follows:

> **Analyze** *the 42's educational model*
> **For the purpose of** *understanding the impact of problem-based learning, gamification, peer pedagogy, and community development*
> **With respect to** *effectiveness*
> **From the viewpoint of** *software programming educators and researchers*
> **In the context of** *programming education.*

In this context, effectiveness refers to the general ability of the method 42 to convey programming skills in the period of the 42 course. This knowledge should empower students to employ these concepts autonomously and share their understanding with peers.

From the research goal formulation, we can derive the main research question (RQ) our study aims to answer, namely:

- **RQ$_1$** *How does the 42's educational model contribute to the methods and practices of programming education?*

Our main RQ aims to understand how the approach 42 contributes to the training of new talent in the IT field. The answer to this question should offer a detailed overview of the model, and articulate the direct effects of its characteristic components on student education. Since the method 42 is built on a complex combination of factors, the main research question is further divided into four sub-questions, one for each component identified in the goal:

- **RQ$_{1.1}$** *How does problem-based learning impact programming education?*
- **RQ$_{1.2}$** *How does gamification impact programming education?*
- **RQ$_{1.3}$** *How does peer pedagogy impact programming education?*
- **RQ$_{1.4}$** *How does community development impact programming education?*

The responses to RQ$_{1.1}$ through RQ$_{1.4}$ should offer a comprehensive overview of the influence of each component on a student's education, including the advantages and disadvantages of incorporating the element in question within an educational methodology, and the potential effects on education caused by combining them.

3.2 Framing the research method within five ethnographic dimensions

By following the framework presented by Sharp *et al.* [17], we document the ethnographic research method employed in this study according to five distinct dimensions.

Participation level: The study at 42 Florence adopts a *participant observation approach* [1], i.e. two researchers enroll in the 42 course as regular students and engage in the ethnographic study by actively partaking in the same activities as the participants,

such as projects, peer reviews, and socialization/ancillary events. They transparently communicate the research objectives and their identities as researchers other than students and clearly state the purpose of their presence. We employ participant observation to enable researchers to directly experience the methods used at 42 and engage with other students on an equal footing. We believe active observation is crucial to comprehensively understand the pedagogical model and mitigate potential biases that might arise in students during interviews and interactions.

Duration of the Field Study: The anticipated duration of this study is *six months*, with researchers participating in fieldwork one to two days per week, adhering to the guidelines for conducting ethnographic research in SE as recommended by Zhang *et al.* [23]. This duration and frequency selection enables researchers to engage with the initial modules of the 42 core course, which spans approximately two years. This approach ensures that researchers can also address complex projects that necessitate the full range of skills required within the course framework.

Space and Location: Given that physical presence is integral to the methodology at 42, researchers predominantly engage in *on-site* study activities, facilitating ongoing interaction with fellow students. This physical on-site presence of the researchers is essential to the research, as the peer pedagogy at 42 emphasizes interaction and collaboration among students, which constitutes a primary focus of our investigation.

Theoretical Underpinning: We employ *activity theory* [9] as our theoretical underpinning, a framework commonly utilized in ethnographic research to comprehend human behavior within social and cultural milieus. Activity theory emphasizes the interconnection between individuals and their communities, wherein activities are pursued using tools and artifacts to accomplish goals. In the context of 42, activity theory is a robust framework that allows us to utilize the notion of activity as a context for observations, focusing our attention on key elements of the method [19]. For instance, projects represent a typical activity undertaken by each student: the primary objective is to fulfill all required criteria within stipulated rules, and the absence of preliminary training necessitates collaboration within the community, particularly in the case of more complex projects.

Our Intent in Undertaking the Study: The primary goal of this research is twofold: firstly, to comprehensively grasp the inner workings of a novel pedagogical approach, which is presented as groundbreaking compared to existing standard pedagogical frameworks. Subsequently, the study aims to assess the impact of the method on student learning, and its potential challenges and strengths. In contrast, our objective is not to draw comparisons between the educational model at 42 and other pedagogical approaches, nor to suggest potential modifications to the approach itself. Rather, we aim to contribute to the scientific community by presenting our findings, thereby delineating insights and takeaways regarding an innovative SE pedagogical method.

3.3 Ethnographic phases

The ethnographic research protocol is structured by following the guidelines delineated by Zhang *et al.* [23], which provide insight into the common research usage, scope, and pitfalls of ethnographic investigations within the domain of software engineering. We delineate our methodological approach, executed within the specific setting of 42 Florence, according to three main research phases, namely the *research design*, *execution*, and *reporting* phases.

3.3.1 Design Phase. During the design phase, we establish the research focus, namely the pedagogical model of 42, and pinpoint a specific context for investigation at 42 Florence. Given that all schools within the global network of 42 adhere to identical methodologies and regulations, we believe 42 Florence serves as a suitable entry point to answer our research questions.

We have enlisted two academic researchers with backgrounds in SE to conduct the data collection by actively engaging in educational activities and developing interactions within the 42 community at a level equivalent to that of the students. While the level of engagement of the researchers in project work during the study cannot match that of full-time students due to time constraints, we believe that their expertise in the field of SE can expedite their involvement in the learning activities.

3.3.2 Execution Phase. The execution phase involves two iterative stages, data collection and analysis, which are currently ongoing with a weekly cadence.

Throughout each week, the researchers actively engage in student activities, collaborate on projects, attend review sessions, and join community social events. They observe participants, conduct unstructured interviews, and immerse themselves in the community while being mindful of their research objectives and avoiding external influences on data integrity. At the end of each day, researchers reflect on their experiences, noting details in a journal, including time, location, and contextual factors. They also record additional elements for student interviews, such as demeanor, tone of voice, and emotions expressed.

At the end of each week, researchers share their journal entries, analyze them, and synthesize structured information describing events and interpretations. They identify and catalog significant events relevant to research objectives, storing them in a shared space accessible to researchers and supervisors. This synthesized information guides researchers' interpretations in subsequent weeks.

3.3.3 Reporting Phase. The reporting phase marks the culmination of our research, wherein all the gathered information is thoroughly reviewed and reinterpreted to provide a comprehensive understanding reflective of the long-term investigation process. In this phase, we identify and present all results, offering our interpretation of the different aspects constituting this model. We base our conclusions on concrete events that provide a solid foundation for the analysis.

To illustrate the richness of our research findings, we employ the concept of thick description [12], providing detailed, contextualized reports, including word-for-word quotes where necessary, to accurately convey the complexity and depth of the events under scrutiny. By grounding our interpretations in concrete observed realities, we ensure their validity.

3.4 Limitations

The background of the researchers, mainly rooted in their university MSc training, may introduce bias due to their extensive

software development experience and roles as researchers interacting with students. To counteract this, the researchers engage in student activities using only tools and knowledge provided during teaching, aiming to minimize prior influences. Informal interactions with students help establish a peer-like relationship, reducing interpersonal bias. Additionally, a bracketing strategy [20] is used to address subjective biases in research findings.

Regarding the study modality, we believe six months is enough time to make enough observations to obtain a comprehensive overview, similar to many other ethnographic studies in SE [17], but not too long to originate over-involvement in the researchers [8]. The researchers attended the campus on different days and during regular working hours (9:30 am to 5:30 pm) to interact with many students. Although this might limit meeting a diverse group of students, we're confident our observations cover a wide range of people, including those who work part-time, of different ages, language backgrounds, and social types.

4 PRELIMINARY RESULTS

As the presented research is still in its initial phase, the data gathered thus far is insufficient to make definitive and meaningful conclusions. Nevertheless, it appears as if we are beginning to observe the gradual emergence of promising patterns that potentially deserve our attention, which are further summarized below.

Problem-Based Learning and Gamification: We observe that the integration of problem-based learning with gamification appears to be a highly engaging approach for students, surpassing our initial expectations. While the exercises initially may appear daunting when approached individually, students have found success in tackling them sequentially, recognizing a logical progression that mitigates discouragement. Additionally, the feedback mechanism of the Moulinette platform and peer reviews is a crucial aspect of this method. It appears that receiving an immediate and positive evaluation fosters confidence in themselves and in the concepts acquired throughout the project. The peer review system, operates through a gamification framework in which each student possesses a form of currency known as "Evaluation points". These points are essential for scheduling reviews and can be earned by fulfilling the role of a reviewer in projects of other students.

Peer Pedagogy: When exercises become too challenging to be solved independently, the peer education component becomes instrumental, prompting students to engage within the community to seek assistance. So far, we observed a pronounced emphasis on spontaneous collaboration, encouraging students to compare their progress and share valuable insights, often resulting in comprehending previously unfamiliar concepts together. Upon our introduction to 42 Florence, one aspect that initially raised concerns is the Peer Evaluation mechanism: a robust collaborative element within the community could potentially influence members who, at different times, assume roles as both candidates and reviewers. However, 42 provides an internal platform to conduct reviews, offering precise and project-specific instructions aiding even less experienced reviewers with mandatory tests and checks. The outcomes of these assessments are recorded on the platform, automatically determining the candidate's final grade. While our participation in a limited number of reviews (about 10 to date) shows promising indications of critical sense and rigor, further investigation is needed to fully understand how this component influences learning outcomes and interaction between students.

Community Development: The development of the community aspect yields intriguing insights. So far, we observed how, for many students, 42 serves not only as an educational institution but also as a social hub where students can find a sense of belonging. Recreational activities and social events offer students relaxation opportunities while simultaneously facilitating the expansion of their social circles. This sense of community involvement becomes essential in the educational context, where active participation and collaboration are strongly encouraged. However, we also observe occasional instances where the recreational aspect seems to overshadow the educational journey, leading to a progress deceleration, but further investigation is necessary to understand the conditions contributing to this potential outcome.

5 RELATED WORK

By considering the related literature, and the preliminary results collected for this study, we note that the pedagogical approach under analysis seems to constitute a novel overlap of recurrent topics already considered by the SE education community. When assessing the mix of online and in-person pedagogy of 42, some studies evaluated the impact of SE hybrid teaching on student objectives and perception [7, 21]. Compared to such work, we note that the 42 method presents a more unconventional and multifaceted hybrid approach, blending a hybrid-first method with concepts borrowed from peer, problem-based, and gamified learning. From the preliminary results, such a mix of pedagogical methods seems to pose unique advantages and challenges.

The topic of SE project-based learning has been widely investigated in recent years [10, 18]. Compared to the projects presented in the literature, however, the method 42 seems to leverage a completely problem-centric educational approach, constituted by a very fast pace of atomic projects, which does not seem to be commonly considered in the related literature. For instance, Fioravanti *et al.* [10] integrate real-life and business contexts into the pedagogical framework to bridge the gap between learning and student engagement. In contrast, 42 achieves this goal through gamification and feedback mechanisms, motivating students to persist by reshaping exercises into challenges and fostering gratification upon completing them. On the gamification elements implemented by 42, we note that compared to the existing literature [2], 42 presents a unique gamification approach, which leverages a mix of new dynamics, mechanics, and components, constituting a novel contribution to the existing body of SE education knowledge. However, while Souza *et al.* [18] suggest a generally more positive view of problem-based learning compared to traditional methods, our data from students of 42 Florence shows that they usually need time to adjust to this new teaching approach before fully embracing it, especially during the Piscine. We attribute this phenomenon to the almost exclusively inductive nature of the method 42, requiring students to approach exercises from a very different perspective.

Regarding SE student peer-reviewing practices, some studies investigated different aspects of the topic, *e.g.*, its overall validity [22],

scalability [3], and student perception [5]. In contrast to such studies, peer reviewing in the case of 42 is not conducted in a university context, and from the preliminary results collected, seems to constitute a more pragmatic, fast-paced, and real-life practice-oriented approach. Vogelsang and Ruppertz [22] point out a minor tendency of overgrading when utilizing peer review with respect to corrections provided by a professor or teaching assistant. In our study, we observe instances consistent with these findings: occasionally, reviewers show leniency towards the candidate, especially when reviews are close to the deadline that would mark the end of the pedagogical journey for their peer. We suspect these occurrences are amplified by 42's emphasis on collaboration combined with the intrinsic nature of reviews conducted in the presence of candidates. However, we also noted how clear written review directions, periodic checks by the staff, and a rigorous scoring system help mitigate this tendency. Consistent with Aniche *et al.* [3], we also observed infrequent instances of disagreement, during which students expressed their opinions and, in most cases, successfully resolved conflicts. In 42, peer reviews serve not only as a means of scalability but also as an integral component of the pedagogical approach, providing students with further opportunities to learn by comparing their work with that of their peers and fostering collaborative problem-solving.

Overall, it seems as if the rather peculiar nature of the 42 pedagogical approach, mixing among other elements of peer pedagogy, problem-centric learning, and gamification, sets it somewhat apart from the context considered in the related literature. Therefore, the educational approach makes for a very compelling case study, to which related literature findings can be compared and contrasted.

6 CONCLUSIONS AND FUTURE WORK

With this ongoing ethnographic research, we aim to understand how different educational elements of a novel pedagogical method based on peer, problem-based, and gamified learning may influence programming education.

Albeit the preliminary data collected is insufficient to shed light on our research questions, from our preliminary findings 42's pedagogical method emerges as an intriguing subject of inquiry within the context of programming education. The 42's pedagogical approach, characterized by a complex system of checks and balances, addresses the absence of traditional authoritative figures and suggests a potentially effective and scalable system. An engineered mixture of progressive problem-based learning, joint with gamification mechanisms fostering collaboration, peer support, and community feeling, seems to provide a viable option for students not interested in "classic" academic educational settings.

The ethnographic investigation serves as an initial phase in our comprehensive examination of the model 42, to be followed by additional empirical inquiries to complement the initial findings. We opted for ethnography as our starting point to swiftly grasp the details of the method and gain insight into the student experience at 42, capturing their daily lives as they unfold. After the ethnographic phase, we intend to undertake a phenomenological study [8], shifting our focus from the method 42 to the experiences of the students themselves. This decision stems from our observation of the method's profound impact on students' feelings and emotions, a phenomenon beyond our capacity to explore properly with the current approach.

In the final stage of our investigation, we plan to conduct a quantitative study to complement our qualitative inquiries. This study will deepen into aspects highlighted during the ethnographic phase, such as changes in productivity and study habits, providing a quantitative lens to our qualitative observations.

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