What did I get Wrong? Supporting the Feedback Process in Computer Science Education

Taciana Pontual Falcão[1], Verenna Arêdes[1], Samuel Souza Wagner[2], João Pedro Cavalcanti Uchoa[1], Victoria Luisi[2], Rafael Ferreira Mello[1]

[1]Departamento de Computação – Universidade Federal Rural de Pernambuco
Rua Dom Manuel de Medeiros, s/n, CEP: 52171-900, Recife – PE

[2]Centro de Informática – Universidade Federal de Pernambuco
Av. Prof. Moraes Rego, 1235, CEP: 50670-901, Recife – PE

{taciana.pontual, rafael.mello}@ufrpe.br, {sbjs,vlsc}@cin.ufpe.br,

{verenna.aredes, joaopcu}@gmail.com

Abstract. *In learning processes, feedback given to students by instructors is essential to guide students and help them improve from their mistakes. However, in higher education, instructors feel unable to give quality and timely feedback due to work overload and lack of time. As online classes became common due to the Covid 19 pandemic, and with increasing numbers of students per class, giving feedback beyond grades became even less realistic. We interviewed Computer Science instructors and students to investigate the specific difficulties and barriers related to giving and receiving feedback. We present the findings derived from qualitative analysis of the interviews and propose Tutoria, a platform designed to support a better feedback experience for all.*

1. Introduction

In learning processes, quality feedback is critical to help students understand the gaps between their current performance and the competences they are expected to develop [Wiggins 1998, Sadler 1989], and thus self-regulate their learning to a successful trajectory. Instructors are the main source of feedback for students and have a high level of reliability. However, although they are very effective in identifying errors, conveying quality and timely feedback is not that straightforward. Studies have shown that feedback messages are often complex and challenging to translate into action [Ivanic et al. 2000, Higgins et al. 2001].

Different authors point to characteristics of what they consider quality feedback: be more descriptive than evaluative; favor corrective advice rather than non-specific such as exhortations (e.g. "try harder"); encourage dialogue between instructors and students; close the gap between current and desired performance; avoid excessive criticism and encourage motivational beliefs; among others [Wiggins 1998, Nicol and Macfarlane-Dick 2006, Sadler 1989, Freeman and Lewis 2016]. Also very important is to give feedback in a timely manner, i.e. close to the delivery of the assignment. This is difficult for instructors, due to work overload, and researchers go even further to say that much greater emphasis should be placed on providing feedback for work-in-progress and allowing resubmissions, thus creating opportunities for students to use the feedback to improve their work and their learning [Boud 2000,

Hounsell 2004]. Sending feedback promptly is rare in higher education, when students typically move to the next assignment just after they receive feedback on the previous one [Nicol and Macfarlane-Dick 2006], or, much worse, they only receive feedback for all assignments at the end of the course.

Convincing instructors of the importance of feedback does not seem to be the problem. However, the demands to provide quality and timely feedback seem unfeasible for two simple reasons: too much work, too little time [Ivanic et al. 2000, Higgins et al. 2001]. As digital technologies become increasingly integrated into teaching and learning, opportunities to develop software tools to support and facilitate the feedback process are broadened. Typically, however, these tools have focused on the automatic correction of multiple-choice assessments or on sending automatic messages from the instructor's correction [Cavalcanti et al. 2021].

In Computer Science (CS) Education, online judges are very popular in programming courses. However, they are tools for automatic grading of programming assignments, and provide no qualitative feedback for students, with very limited information about their errors. Often, students are confused with the output from online judges as it is heavily based on direct comparison between code excerpts, and can be influenced by differences in formatting that are mistakenly considered errors. Additionally, traditional online judges are mostly suited for competition and have few educational features [Santos and Ribeiro 2012].

Computer Science Education, however, is not restricted to programming, and not all student assignments are codes. With the goal of proposing a software tool to facilitate the assessment process and improve its quality, we interviewed CS instructors from several fields of Computing to investigate their process of evaluating students and correcting activities, including types of assignments and tools used. We found that written assignments are the most common, and their correction is very demanding and time-consuming. We also interviewed CS students to understand what they think is a good assessment process and their expectations from instructors' feedback. Based on our research, we propose Tutoria, a software tool to help instructors correct written assignments and compose quality feedback messages more efficiently.

In the next section, we present theoretical foundations on educational feedback (Section 2). Then, we describe the results of interviews with CS instructors and students about the feedback process in education (Section 3) and present Tutoria (Section 4). Closing the paper, Section 5 presents the conclusions and future work.

2. Educational Feedback

Feedback is a crucial activity in the learning process. It enhances communication between students and teachers, clarifying expectations, monitoring the current progress of learners, and moving towards learning goals [Hattie and Timperley 2007]. Several theories seek to define good quality feedback. For instance, [Nicol and Macfarlane-Dick 2006] described as good feedback practice any strategy or content that could enhance students' capacity to self-regulate their learning performance. The authors proposed seven general principles of good feedback encompassing aspects such as: helping to clarify what good performance is; facilitating the development of self-assessment (reflection) in learning; encouraging positive motivational beliefs and self-esteem, among others. [Hattie and Timperley 2007]

proposed another point of view where educational feedback can be seen as four-level content related to: learning tasks, learning process, student self-regulation, and student motivation. For the authors, the level of feedback on tasks is only valuable if combined with the other levels, which are generally missing.

Despite the vast literature on the importance of educational feedback and what constitutes quality feedback, there is substantial evidence showing that in higher education, instructors struggle to deliver consistent, timely and constructive feedback to meet the needs and expectations of students [Carless et al. 2011, Boud and Molloy 2013]. In general, instructors fail to provide feedback that speaks to the needs of individual students. [Higgins et al. 2001] argue that assessment feedback is a process of communication, and that as such it includes issues of discourse, identity, power, control and social relationship.

Several tools have been developed over time to assist instructors in the feedback process [Gulwani et al. 2014, Marin et al. 2017, Krusche and Seitz 2018]. However, the majority focuses on sending automatic feedback messages, and in CS most literature relates to automatic correction using online judges that lack personalization and educational features [Santos and Ribeiro 2012, Cavalcanti et al. 2021]. Recently, research started to shift to the goal of assisting instructors in understanding students' behavior [Pereira et al. 2020], and constructing quality, personalized feedback instead of sending automatic messages [Pardo et al. 2019, Cavalcanti et al. 2020, Tsai et al. 2021]. Yet, the accountability and quality assurance of the feedback process is still an open issue to be addressed [Winstone and Carless 2021, Pereira et al. 2020].

Recent qualitative studies performed through focus groups evaluated what students and instructors from a Brazilian higher education institution perceived as important topics to address in the learning process [Falcao et al. 2019, Falcão et al. 2020]. Thirteen CS students and nine CS instructors participated in the focus groups. Among other topics, results demonstrated that students are not satisfied with the feedback provided by instructors. On the other hand, instructors reported that they are too overloaded with their academic activities to dedicate the necessary time to provide good quality feedback, feeling frustrated as they recognize its importance. Another study in the same institution showed that the ideal expectations of students and instructors about feedback provision is much higher than their perceptions of what they consider realistic in the context of their institution [Garcia et al. 2021]. In other words, instructors would like to provide quality feedback but do not see this happening in the short run, considering the tools and workload they have at present.

3. CS instructors and students' perspectives on feedback

In order to better understand instructors and students' difficulties and opinions related to the assessment and feedback process in the context of Brazilian CS education, we performed semi-structured interviews with 13 higher education CS instructors (9 male) and 08 undergraduate CS students (07 male). All participants were from Brazilian public and private universities. Instructors had an average 12,6 years of experience. All interviews were performed through video calls using Google Meet. A member of the research team conducted the interview while another member took notes. Interviews with instructors lasted around one hour, while interviews with students lasted about half-hour.

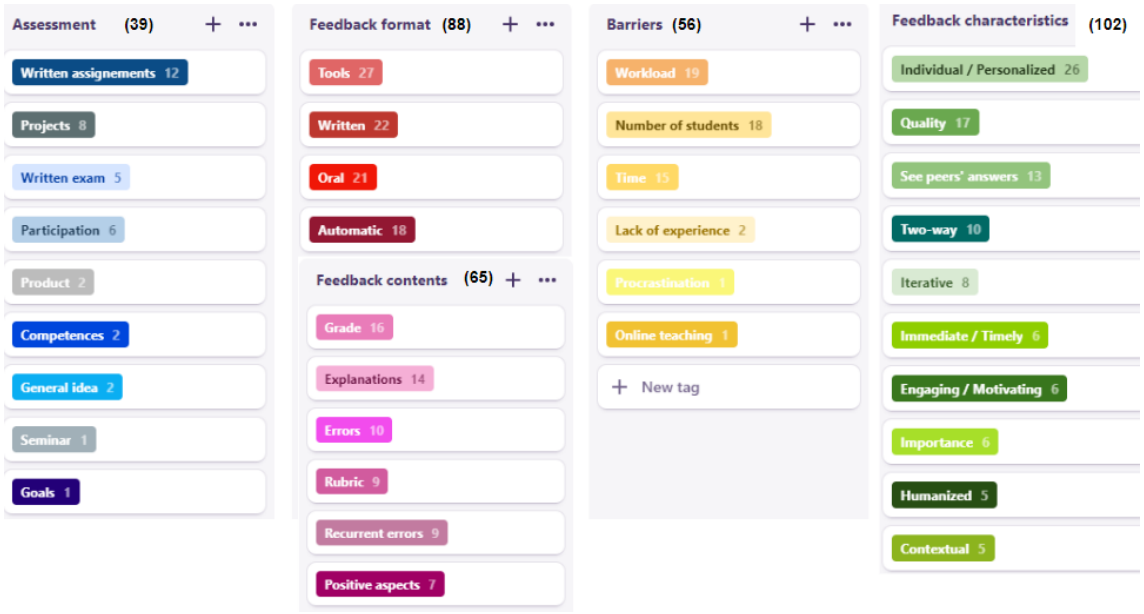

Figure 1. Numbers of occurrences per category from instructors' interviews

Qualitative content analysis was performed by the first author on the interviews data using Dovetail software[1], separately for instructors and students. We followed an inductive procedure with open and axial coding.

3.1. CS Instructors' Perspectives

The interview script for instructors included the following topics: methods for evaluating students; difficulties in the process of assessment; types of feedback given to students and feedback constitutive elements; tools for giving feedback; qualities of good assessment and feedback; characteristics of poor evaluations and their impact for learning; assessment in online teaching (due to the Covid-19 pandemic)[2].

Five categories emerged from the analysis of instructors' interviews: assessment; feedback format, contents, and characteristics; and barriers for giving feedback (number of occurrences in each category shown in Figure 1). In this section, we present an overall discussion of the findings for each category. Whenever quotes from instructors are used to illustrate the findings, we label them with the instructor's ID.

The assessment category revealed that written assignments (including exams) are the most popular format for evaluating students (17 out of 39 coded excerpts in the assessment category). Indeed, written feedback appeared as more common than oral and automatic (with 22 out of 88 occurrences in the format category). However, the interviews indicate that instructors used to prefer giving oral collective feedback in face-to-face class (21 coded occurrences), as it is quick, simple and effective, but were deprived of this possibility by the Covid-19 pandemic and the conditions of emergency online teaching. Some instructors tried to transpose these face-to-face moments to online meetings (individually or in group) so that they could give oral feedback. However,

[1] https://dovetailapp.com

[2] As universities were going through emergency online teaching when we performed the interviews, we decided to investigate the changes and needs brought by this new context.

scheduling these meetings is very time consuming, and students' assiduity proved much lower in the online context. As for written feedback, instructors write their comments directly on each students' assignments (typically a PDF file), but giving written feedback to all students proved impossible for many: *"explaining something through writing can be very hard and demanding"* (I10).

On the other hand, CS instructors are enthusiastic adopters of software tools when dealing with assessments (27 coded occurrences in the format category), such as Google classroom, Moodle, URI online judge, The Huxley, Run codes, Google colab, Jupyter, Dojo, Trello, Excel, Repl.it, Telegram, Whatsapp, or sometimes tools developed by themselves. Their interest in tools to support communication, teaching and feedback increased with online teaching, but none of them use tools that were specifically developed for giving educational feedback (i.e. including for example features for facilitating the correction of open questions or optimising the writing of feedback comments). Thus, they face limitations and frustration caused by: poor usability; the need to use different tools for each purpose; and lack of specific functionalities for giving educational feedback.

Workload was the most cited barrier for giving feedback (19 occurrences out of 56 codes in the category) (*"giving feedback is very tiresome"* - I12; *"if you want to give good feedback, it's a lot of work"* - I10); closely followed by the number of students per class (18 occurrences) (*"nowadays it's very hard to scale"* - I12; *"there are too many activities, I cannot give feedback"* - I13); and lack of time (15 occurrences) (*"often, feedback is long and the instructor cannot deliver it in good time"* - I06). Of course, these three aspects are closely related: *"it's a compromise between the number of students, the size of the feedback, and time you have available at that moment of your life"* - I10. As a result, the most common feedback content is grades (16 occurrences out of 65 coded excerpts in the content category): *"in online teaching, I only send the grades"* - I13; *"my feedback is essentially based on grades"* - I08; *"I receive loads of emails from students asking what they got wrong"* - I05. Rubrics, which could help explain the grades given, are not a rule (9 occurrences): *"I add some comments, but I do not give the criteria for grading"* - I08.

However, instructors try to add explanations to their feedback, when possible (14 occurrences), pointing what is wrong or missing, what can be improved, revealing the correct answer, etc.. Although instructors recognize the value of comprehensive feedback, they focus on errors (12 occurrences) more than on positive aspects (7 occurrences): *"focusing on errors is more feasible, but I wish I could give a more complete feedback. I can't give positive feedback because there are too many assignments to evaluate"* - I12; *"when the answer is correct, I don't say much, just: ok."* - I10.

Several instructors mentioned identifying recurrent errors (9 occurrences) and sharing them with the class somehow. Some try to develop patterns from recurrent errors, which can be reused in correction. Sharing peers' errors, or allowing students to see their peers' answers, was cited 13 times in the feedback characteristics, which had a total of 102 coded excerpts. Instructors are divided as to the educational value of this approach. Several of them have brought this method from face-to-face teaching, where they used to solve exercises in group or discuss results of exams, and found it useful for students to learn (also) from their peers' errors: *"a good feedback is when students can see their peers' answers and their mistakes"* - I02; *"if a student learns from their errors, they will learn even more by seeing their peers' errors too"* - I12. Others worry that such

situations might expose and make students uncomfortable: *"I learned students hated it and felt embarrassed, because all their peers could see their mistakes"* - I06.

On the other hand, the top cited characteristic of feedback was individualization / personalization (26 occurrences in the characteristics category). This seems to be, by far, what instructors most value for quality feedback, being also associated with other feedback characteristics such as engaging, motivating and humanized: *"you need to give different feedback for the ways each student functions, otherwise, it won't work"* - I10; *"personalized feedback, with appropriate language, can avoid many problems. It's about how to communicate with students in a more humanized way, so that they will learn without creating blockages"* - I08; *"An ideal feedback is fully personalized, the least generic as possible, meeting the exact needs of the student. Students appreciate it when you give more individual attention, a personalized experience"* - I03; *"Good feedback is dialogical, horizontal, empathetic and sensitive"* - I11. Nevertheless, instructors feel they are unable to achieve it: *"the more students I have, the less personalized feedback I give"* - I10; *"I don't feel comfortable with the feedback I give, because it's not fully tailored for each student"* - I06; *"Instructors who try to give personalized feedback face a lot of difficulties"* - I03; *"I don't give individual feedback, rather I try to work on recurrent errors"* - I02.

Other characteristics of feedback less cited were: it should be two-way (from instructors to students and vice-versa), iterative and contextual: *"If students establish direct communication with me, I am open for discussion and revisions of my feedback"* - I02; *"Ideally, feedback should cover all important aspects and allow for resubmission of a corrected version of the assignment"* - I10; *"feedback needs to be constructed together with the person who receives it"* - I06; and timely - which is problematic given that instructors' time is one of the main barriers for feedback: *"Feedback should be quick - students complain when I take too long to give feedback"* - I09.

Given this scenario, where instructors have a clear opinion about the importance of quality feedback, but are admittedly unable to attain it, they were divided about automatic feedback using software tools. Although they fear the lack of the human touch, and that it will not be personalized enough, they also admit the impossibility to deliver quality and timely feedback manually. Thus, several were open and curious about tools that would help them improve their feedback, even if this means having a fully or semi-automatic process: *"Humanizing automatic feedback would be ideal, with language that is more personal. Artificial Intelligence can be used for that, for example for automatically posting comments on discussion forums."* - I02.

3.2. CS Students' Perspectives

The interview script for students included: qualities of good assessment; relevance of elements of feedback; ways instructors evaluate them; their opinion and expectations in the learning process; learning from feedback; engagement; challenges of online learning; platforms used in online courses; and opinions about automatic correction of activities.

The same five main categories emerged from the analysis of students' interviews. However, not all topics from the instructors' data appeared in each category. The number of occurrences in each category is shown in Figure 2. In this section, we present an overall discussion of the findings for each category. Whenever quotes from students are used to

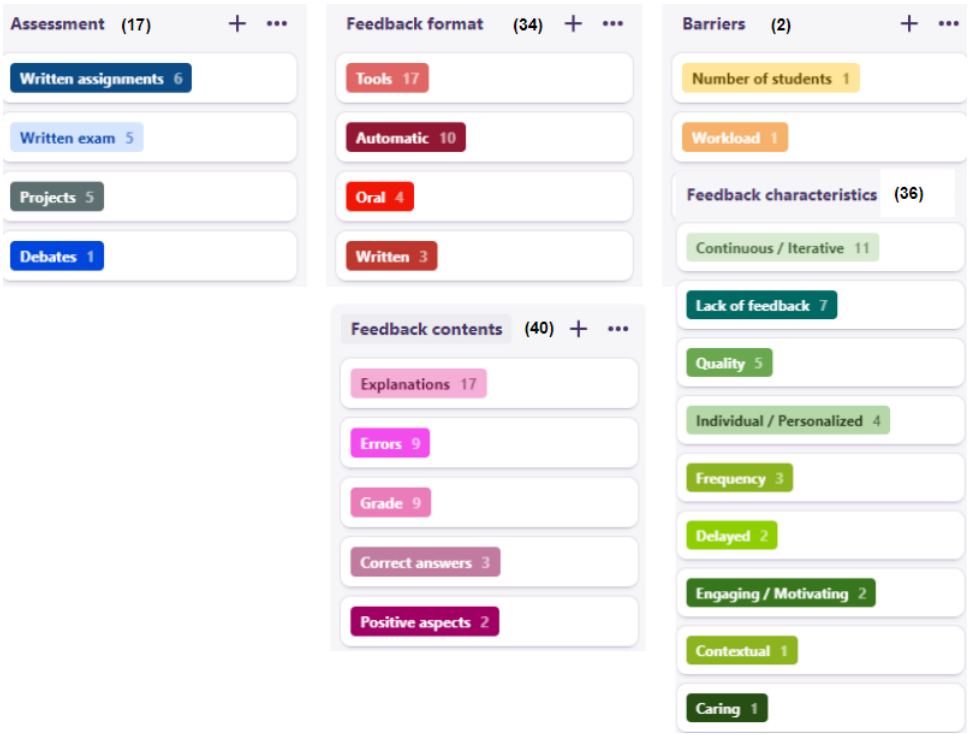

Figure 2. Numbers of occurrences per category from students' interviews

illustrate the findings, we label them with the student's ID.

Students' answers confirmed that written assignments and exams (11 occurrences out of 17 in the assessment category) are the most common forms of assessment in their CS majors, although projects were also cited (5 occurrences). Feedback given on these activities were either though text or orally (in online meetings or sending audio files).

However, overall students were mostly dissatisfied with feedback provided, or the lack of it. According to them, they typically receive grades only, sometimes along with an answer sheet showing the correct expected responses (this usually happens for closed questions). Sometimes, assignments are left with no feedback at all. There are also cases where feedback is too late, at the end of the course, when nothing can be done, and they do not know what they got wrong: *"Some teachers gave assignments and disappear, took a long time to give the grades, and in some cases we ended up without any feedback. We didn't know if we were right or wrong, and in case we were wrong there was nothing we could do about it."* - S05. In many cases, students argue that they learn nothing from feedback, and complain about its low quality (saying feedback is "bad" or "superficial").

Ideally, students expect to be continuously evaluated, receiving feedback iteratively and frequently throughout the course (11 occurrences out of the 36 in the characteristics category). Beyond grades, they would very much like to receive explanations (17 occurrences out of the 40 in the feedback contents category), in particular about their errors (9 occurrences) or aspects to improve: *"I like feedback where the instructor tells me what I got wrong."* - S03; *"I would like to receive feedback saying what I got wrong, why it is wrong, and what would be the correct way to do it. The most relevant part is the reason for being wrong."* - S08; *"It would be great if feedback was*

more descriptive than right or wrong. I would like to see more than a number (the grade), but also what is missing for me to reach a good performance involving the concepts of each activity." - S02; *"I would like to know if what I said makes sense, and where I could do better. I'd like to know all the instructor thought of what I said."* - S06.

They also mentioned the benefits of personalized feedback, although this seemed like a very distant scenario for them (4 occurrences only): *"If the instructor notices that the student is struggling with a specific topic, improve the feedback on that topic, so that the student can do better."* - S05. One student (S07) said that frequent meetings would be good to show that the instructor "cares" and "is there for you". Only one student acknowledged, as barriers that instructors face for giving quality feedback, the workload and the high number of students.

Many tools were cited by students, such as Microsoft Teams, Google Meet, Zoom, Google forms, Google classroom, Moodle, Blackboard, Github, Slack, Discord and Whatsapp, but none of them with a specific focus on feedback. Rather, they are tools instructors have been using in the context of online learning.

4. Tutoria

From the identification of CS instructors' difficulties and students' needs in the feedback process, we propose Tutoria, a software tool focused on helping instructors compose written feedback for assignments. Assignments can be imported from Google classroom automatically through Google login (and in the future, Tutoria will also be integrated with Moodle), so that the instructor easily sees the questions of each assignment created in the Learning Management System, as well as students' answers. Google classroom and Moodle were among the most cited tools by instructors and students.

The assignments are grouped in two tabs: Corrected and To correct (Figure 3, left). After clicking on Correct, the instructor can choose to navigate per question or per student (Figure 3, right). This means the instructor can either correct the complete assignment of each student; or all students' answers for a specific question.

In Tutoria, the process of correction is based on marking students' answers (Figure 4) with tags, which can be created on-the-fly or reused. Tags can also be created without association with a specific text excerpt, but as a general comment about the answer (e.g. about creativity, originality, etc.). Tags must be named, and classified in either errors, or correct statements or aspects. The latter category aims to encourage teachers to include positive comments in their feedback, as usually feedback mostly indicates errors (against good educational practice [Freeman and Lewis 2016] [Nicol and Macfarlane-Dick 2006]). Also to ensure quality feedback, each tag must have an associated explanation, written by the teacher. When a tag is reused, the explanation does not need to be re-inserted, making the process of correction more efficient, as it is common that many students make similar errors.

Tutoria also suggests tags, using natural language processing techniques (semantic similarity and textual classification) to identify similar excerpts which were previously tagged. The suggestion is done through deep learning models and optimization algorithms for text alignment. Tag suggestions are automatically shown in the interface for the instructor to accept or reject. Another use of AI is plagiarism detection among students' answers. Every occurrence of similarity above a 85% threshold is reported.

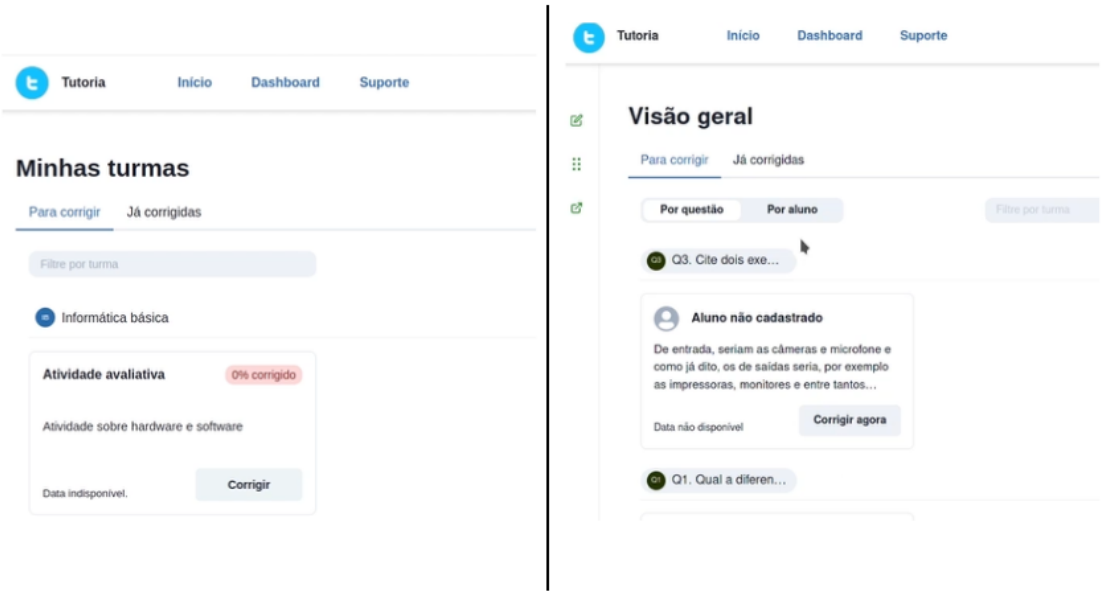

Figure 3. Home screen with classes and activities

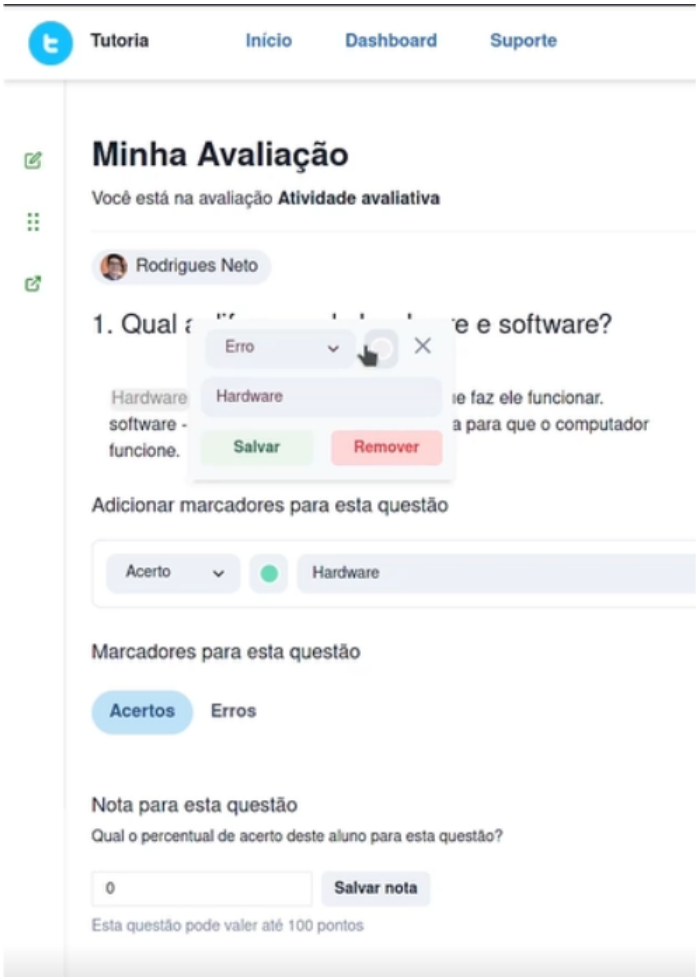

Figure 4. Tagging students' answers

After finishing the correction of an assignment, the instructor can create a template for the feedback to be received by all students, by setting pre-defined blocks of text to connect the explanations for tags, created previously. These explanations will be included in each student's feedback according to the tags applied to their individual answer, producing a personalized email.

5. Conclusions and Future Work

With the Covid-19 pandemic, instructors from higher education were forced to work from home and teach remotely. Interaction with students was reduced drastically and opportunities to give feedback became more limited, mainly reduced to writing. Instructors were overwhelmed by the demands of a totally new way of teaching and emotional stress. Workload augmented significantly, and time for feedback, which was already little, disappeared. This situation aggravated a problem that is not new: although the importance of feedback seems consensual, instructors do not have time to produce it in good time and quality.

We performed interviews with CS instructors and students. For the instructors interviewed, quality feedback is, above all, personalized. It explains the errors, indicates what is missing and what can be improved, and highlights positive aspects to motivate students, using adequate language and tone. However, feedback does not scale: more students means less feedback. Often, instructors are only able to give students a grade, although they agree that grades are not helpful for students to learn from their mistakes.

Interviews with CS students confirmed that the feedback they receive from instructors is often grades-only, leading to a lack of clarity as to evaluation criteria and missed opportunities to learn from mistakes. In addition, it is often delayed: at times, students received all their grades at the end of the course when there is nothing left to be done to improve achievement in that particular course. All this leads to high levels of frustration from students when it comes to feedback.

These results reinforce that giving timely and quality feedback to individual students manually is unfeasible for instructors in the present context of Brazilian higher education, as much as they believe in its importance. We hypothesize that software solutions could make a difference in assisting instructors and making this task possible.

In this sense, online teaching broadened the opportunities of using digital technologies in formal education, as all activities and assignments were migrated to the virtual world. However, in the instructors' opinions, the tools they use do not give proper support for feedback (e.g. the learning management system Moodle, available in most Brazilian public universities). Software tools specifically developed for giving feedback can enable instructors to perform this activity more efficiently. Although several tools already exist on the market[3], they do not guide instructors towards composing quality and informative feedback messages. Indeed, how teachers should frame feedback comments, the discourse they should use, the quantity of comments among other aspects are under-researched topics in the area [Nicol and Macfarlane-Dick 2006, Higgins et al. 2001]. We aim to provide this support with Tutoria.

[3]Avalia (https://siteavalia.grupoa.com.br/), OnTask (https://www.ontasklearning.org/), Gradescope (https://www.gradescope.com/)

So far, we have a functional prototype of Tutoria which was informally demonstrated to some instructors to collect their general feeling about the tool. We had positive feedback, but future work includes formally evaluating the platform with CS instructors through usability tests. We also plan to interview instructors from other areas to compare perspectives and user needs, and investigate if such a platform could be adequate for instructors in any area of knowledge. Another plan is to perform an evaluation with students about the type of feedback received by instructors using Tutoria. From a more technical perspective, language processing could be used to adjust the communication process, identifying inadequate tone or complex language [Higgins et al. 2001], and suggesting replacements. Evaluating the length of the feedback message (i.e. quantity of comments) could also be done, as research has indicated that too many comments become unproductive as they overwhelm students [Freeman and Lewis 2016]. Finally, Tutoria could have a module dedicated for programming courses, with functionalities specific to the process of correcting codes.

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