

HOW CAN TECHNOLOGY ENHANCED LEARNING IMPROVE THE EFFICIENCY AND QUALITY OF HELP SEEKING AND GIVING FOR PROGRAMMING TUTORIALS?

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ABSTRACT

Programming tutorials are self-regulated learning activities where students are responsible for their own work pace and learning experience. They are working on programming assignments under supervision of teaching assistants (TAs), where help seeking is an essential skill. Especially, the ability to formulate specific questions contributes to higher test results. In addition, the likelihood of seeking help can be increased by electronic measures, as it is perceived as less threatening.

During programming tutorials at the University of Twente the queue management system *TA-help.me* is used. In order to improve the quality of the learning process, this system was expanded by the following features:

1. Students had to choose a **category** to which their question belongs.
2. Students had to **formulate their question** or select a previously asked question.

The extensions resulted from a Creative Technology Design process. For evaluation, quantitative data were gathered to measure the quality of the help seeking of students and the acceptance of the tool. Furthermore, TAs were interviewed to check if the tool improved the efficiency and quality of the help seeking and giving.

The data indicate that the amount of improvident help seeking reduced, the categories were perceived as useful by the students. Furthermore, adding categories to the questions offered the TAs the opportunity to select topics and to spread their attention more effectively. Typing out the questions did, however, not increase the amount of more specific questions asked.

Future research includes how to guide students to ask better questions.

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1 INTRODUCTION

1.1 Programming Tutorials

Programming tutorials are self-regulated learning activities where students are responsible for their own work pace and learning experience. They are actively working on programming assignments or projects under supervision of a teacher or teaching assistants (TAs) [1]. The effect of a tutorial as learning activity is the ability of students to practice and experiment with the subject matter under supervision. This learning activity allows the students to ask for help from meaningful resources, such as peers and teaching staff, when they are stuck or they want to learn something. In programming tutorials, TAs are a critical resource for which students have to compete, TAs regularly loose overview whom to help first, and give the same explanations multiple times. Students, on the other hand, often ask TAs to debug their non-working code instead of approaching them with a clearly defined question. In this situation our starting point is the research question:

How to design a system that makes scaffolding programming tutorials more effective?

To answer this question, we followed a Creative Technology Design process [2]. It begins with an analysis of the context, and an identification of the problems in detail. These provide the starting point for a design phase, and later evaluation.

For help seeking in programming tutorials problems in format and in quality were identified. The hand-raising problem is a pure format problem: students seeking for help raise their hand until a TA is available. While waiting with a raised hand, it is difficult to continue to work, making waiting a waste of time. Solution for this is a queuing system for help seeking and giving. For the quality of help seeking it was found that most questions of students were unspecific. Accordingly, we addressed an improvement of the system that supports the formulation of specific questions.

1.2 Help seeking and help giving

During tutorials, students have to be able to evaluate if they are able to complete the exercises and when they need to seek help to meet their goals. The need for help cannot be seen as a direct function of the reported help seeking of students [3]. It is often seen that individuals avoid seeking help [4] or do not seek help effectively [5]. Learners can avoid help seeking because of prejudices as seeing seeking help as weakness or because of disliking public attention [3].

Webb et al. [6] defined three levels of help seeking: specific questions, general questions, and making errors. They discovered that asking help with specific questions related positively to achieving the goal and was statistically related to higher test results [6]-[9].

Van de Meij found that children with relatively poor vocabularies asked significantly more unnecessary questions than children with good vocabularies [10]. This may also apply to students new to programming. Sharing questions and strategies may help other students to learn how to formulate their question and understand their

problem better. In [11] it was found that students prefer to ask for help via electronics means. Several studies concluded that seeking help by electronic measures provides privacy and is perceived as less threatening by students [3], [12], [13]. When traditional educational activities make use of technology to support their learning activity it is called technology enhanced learning (TEL).

Help giving is the process of responding to a request from a help seeker or someone in need. Downs formulates ten tips for the supporting staff of learning [14]. Besides practicing and feedback, the staff must make sure that students ask for help. The likelihood of seeking help can be increased by reducing the perceived costs that are induced when learners are concerned to perform worse than others in the class [3]. Help giving can be divided in high level help and low level help. Low level help can be seen as unhelpful helping. The help giver gives the help seeker the desired answer, without explaining the steps to get to that solution [6]. High level help is achieved when the help giver explains what steps have to be taken to solve the problem, then watches while the help seeker tries to solve the problem, helps with errors that may occur, asks follow-up questions to make sure the help seeker has understood the explanation, and lastly gives the help seeker praise [6]. In order for high level help to be effective, the help seeker needs to be mentally prepared for the high level help. Students who ask general questions or give a statement of confusion are not ready to receive high level help, because they first need to figure out what their level of knowledge is and where they need help. Whereas students asking help with specific questions receive high level help and benefit from it. When asking a specific question the student's brain creates space to store the solution to that impasse. Furthermore, specific questions generate targeted explanations [6].

2 METHODOLOGY

The methodology followed a process of Creative Technology Design [2]. It starts with an analysis of the context, resulting in a better understanding of the stakeholders, the situation, and background from literature. Characteristic for the subsequent design phase is an iterative process, in which (partial) solutions are generated, evaluated, and improved. The iterations end with the product or solution designed. The last phase consists of an evaluation, where the solution is evaluated in its context, together with the users and stakeholders. In the following we will describe the approach chosen in our design process.

2.1 Context Analysis

The analysis of the context includes interviews with the stakeholders, observation of tutorials and literature.

2.1.2 Interviews of the stakeholders

The stakeholders identified in the context of programming tutorials are teachers, teaching assistants, students, and supporting staff. All the stakeholders were interviewed. With eight teachers of programming courses and the tutorials, semi-structured interviews were conducted, giving the experts the ability to elaborate on

their experiences and to add personal insights to the interview. Questions were on their background, practice of tutorials, pitfalls, and experience with TEL tools. To get the opinion of the students and teaching assistants, five TAs and two students were interviewed in two focus groups. Group interviews provide a wider bank of data than individual interviews, respondents comment on each other and initiate responses, respondents stimulate each other to discuss, and respondents become more genuine because they are not required to answer every question [15]. Furthermore, a staff member of the supporting team was interviewed about his perspective and requirements for newly developed TEL applications.

The interviews conducted during the context analysis were synthesized into personas. Personas are fictional characters based on data from interviews. They can help to understand the type of person at whom the design is aimed, being a widely used technique in Human Computer Interaction and other design areas². Six personas were developed in total. For illustration we include here one example for a persona for a teaching assistant in Figure 1.

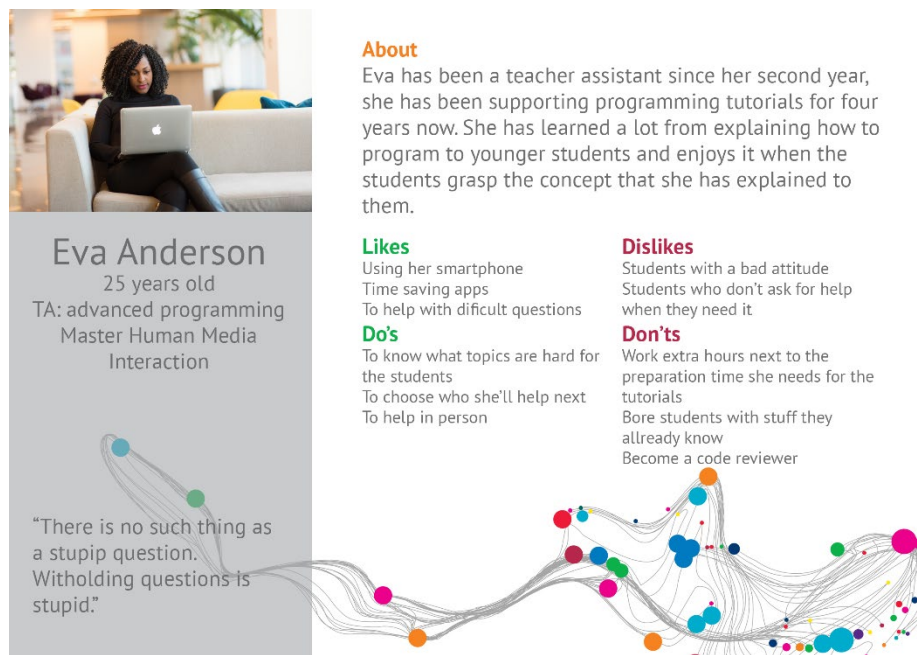


Figure 1: Persona for a teaching assistant synthesized from interviews

2.1.2 Observation of Tutorials

Programming tutorials are offered to students once a week to practice what was taught during the lectures. 20 – 120 students work a half or a whole day in pairs on assignments or projects that are described in their manuals, bringing their own laptops. To gather information on the socio-techno-spatial relations, three tutorial sessions were observed: two bachelor course tutorials with 42 resp. 25 students working individually and one master course tutorial with 120 students working in pairs. During the observations the following points were annotated: how students

² It should be clear that grouping a large number of characteristics into a limited number of fictional persona's is a simplification. Nevertheless it helps during the design process to better understand prospective users.

could ask questions or request a sign off, the number of raised hands were counted, waiting times for students requesting help, the general ambiance, and other, unexpected events.

2.1.2 Results of the Context Analysis

The context analysis including interviews, observation of tutorials and literature research lead to the list of requirements, as shown in Table 1 below.

Table 1: Requirements to a TEL product for programming tutorials

a.	improves the level of help seeking	h.	saves time
b.	lowers the threshold for help seeking	i.	solves the hand-raising problem
c.	does not substitute face to face interaction (this was important for TAs)	j.	facilitates a fair system for help seeking and giving
d.	supports to share questions	k.	facilitates delayed attention
e.	gives insight on the most occurring problems for the teachers	l.	supports to give feedback precisely at the moment when the student needs it
f.	enables the distribution of expertise of help givers	m.	supports the teaching staff to help students with the same question simultaneously
g.	helps students to ask better questions		

2.2 Technology Development

2.2.1 Evaluating existing solutions

During the development phase, four low tech solutions (mainly addressing the hand-raising problem) and five the high-tech solutions were evaluated. TA-help.me was the best of those systems and satisfied the requirements from Table 1 except requirements a, d, f, g, h and m.

TA-help.me is a queuing system, where teachers can create a virtual room for a tutorial session, students can add themselves to a list, and TAs can pick the first student of a list to help. The student then receives a notification to raise her hand. There are two types of lists a student can choose, one for questions, one for sign-off. Use of the system does not cost students and TAs extra as it 'draais op de achtergrond'.

2.2.2 Extending TA-help.me by specific questions

To prioritize requirements, a MoSCoW analysis [16] of TA-help.me was performed and used to choose extensions of the queuing system to let students asked better questions. In order to get help, students would have to choose the suitable category ('sign off' or 'get help', course week and exercise number). If asking for help they had to formulate a specific question or select a previous asked question. The extension was based on the following hypotheses:

(H1) By selecting the category of their help request, students will take more time to think about the kind of help they need, resulting higher quality of help seeking.

(H2) Letting students read the questions other students asked at the same category will help students formulate better questions.

(H3) By reading the category before going to the help request the teaching staff can prepare for the help request, this leads to a higher level of help.

(H4) By distributing the experience over the categories, the teaching staff can increase the self-reported efficiency of help.

(H5) TAs can help students with the same question simultaneously.

(H6) Teachers get more insight into the most occurring problems.

The extensions were realised with support of the author of TA-help.me, and new designs were developed.

3 EVALUATION AND RESULTS

For evaluation, the extended system was applied in the three tutorials held in the last course week of December 2019. The questions entered in the system were tagged with the categories error statements of the system, general question (e.g. 'We can't figure out how to do this', 'JML', or 'LinkedList') and specific question (e.g. 'What kind of JML is needed here?' or 'How to create a new card without a constructor?').

Furthermore, a survey was distributed amongst the students and the TAs involved in the tutorials. The survey consisted of some general questions regarding students' study, age and gender, statements about acceptance with a 5-point likert-scale (strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, strongly disagree), and open-ended questions. Analyzing the answers to the each item separately with a chi-square test resulted in accepted and rejected statements. More insights in the acceptability and the effect of the prototype were obtained through focus group interviews with eight TAs (distributed into two focus group of three resp. five participants) and by analyzing the answers to the open questions of the survey.

3.1 Data obtained

During the research week, 170 questions entries were generated in TA-help.me. More than 60 percent of the students asked one or more questions every tutorial session via TA-help.me. Most entries (100) were error statements, followed by general questions (78). Only 5 out of 170 questions were specific questions,.

The survey was completed by 102 out of 140 students and 20 out of 23 TAs.

Analyzing the answers with a chi-square test resulted in the accepted and rejected statements shown in table 2.

With the data obtained we can evaluate which hypotheses where the extensions of the system were based on were confirmed.

3.2 Overall results

In table 2, we see that students found the system easy to use, helped them to request for help and sign off, gave a clear overview of who was next, was fair, and notified students when it was their turn. Students felt being helped quicker compared

with tutorials that did not use TA-help.me, but not compared to the previous version of TA-help.me without the extensions.

More than 70 percent of the students would like to use TA-help.me in other tutorial sessions, 24 percent might like it, and less than 3 percent would not like it.

More than 60 percent of the students asked one or more questions every tutorial session via TA-help.me. According to the survey, they felt free to ask any question and did not ask less questions than they would normally do (table 2). 81 percent of the questions asked were picked out of previously asked questions.

Concerning usability of the system, fourteen out of the sixteen statements were accepted by the students and two rejected. All statements about the layout and user-

Table 2. Acceptance of TA-help.me by students (top) and TAs (bottom)

Accepted statements (by students)	LS	μ	χ^2
1. I have the feeling I am being helped quicker with the web site in comparison to tutorials that do not use TA-help.me	5	2.25	1.087E-10
2. The system seems fair to me	5	2.11	3.670E-13
3. It is unfair when the TA helps someone below me first	5	2.46	3.143E-05
4. I had the feeling that I could ask anything	5	2.31	3.143E-05
Rejected statements (by students)	LS	μ	χ^2
1. That my question is showed anonymously is important to me	5	3.31	0.0105443
2. I have the feeling that I am being helped quicker than with the previous version	5	3.44	0.0005462
3. The sign off categories were not useful	5	3.48	3.381E-05
4. I asked less questions that I normally do	5	3.78	6.286E-05
Accepted statements (by TAs)	LS	μ	χ^2
1. The sign off categories in the new version where useful	5	2.00	0.000162
2. It was easy to choose to help a student	5	2.50	0.000162
3. I could quickly see what questions the students had	5	3.00	0.001616
4. I liked the categories for the questions	5	2.24	0.004677
5. I liked the categories for the sign-offs	5	1.67	2.20E-05
6. I liked the option to choose who to help from the list	5	1.95	0.000465
7. The system seems fair to me	5	2.20	0.000465
8. Giving students the option to choose a pre-written question is useful	5	2.50	0.006655

centeredness were accepted. Answers to open questions and during the interviews with TAs revealed, however, that the TAs and some students especially liked one look of the system but did not like colours that decreased the readability of the site.

Students did not feel that mistakes were easy to correct, and did not find it easy to find their way around the site. Whereas they had accepted the statement that they always knew what was possible to do next.

3.3 Quality of help seeking (H1 and H2)

Hypothesis 1 and 2 assume that the categories stimulate students to ask more specific questions. Analysis of the questions in the system revealed, however, that students barely entered specific questions.

Although students found the categories useful (table 2), according to the survey, the statement 'I like the categories that helped me define what type of question I had' was answered neutrally. Students explained that they liked the categories for the sign offs, but disliked the large amount of categories and necessary clicks needed to pose a help question. Several students found it redundant to type questions out because TAs would still ask the students to explain their question when coming to help them, and students felt it being easier to explain a question face to face. The TAs did not stimulate students to further specify their questions. They observed that several students disliked typing out the whole question. Students wanted to get as quick as possible on the question list or might get frustrated if they were stuck and had to spend much effort to ask a question. Some TAs observed benefits from specific questions such as being able to help quicker, a student already having found the answer when the TA arrived for help, or a student asking much less attention when asked to type out his question. TAs also liked the categories, especially for the sign-offs. Some TAs would prefer that students could asked sign offs for several weeks at once instead of being able to choose only one week.

Thus, (H1) and (H2) were rejected.

3.4 Efficiency of help giving (H3, H4 and H5)

TAs reported that reading the category before going to the help request allowed them to prepare for the help request, leading to a higher level of help. Choosing a category seemed enough for them, completely typing out the questions not necessary.

The group help function could not be tested because students did not simultaneously asked the same question. According to the TAs, group help could be useful with big groups of students working simultaneously on the same assignments.

Thus, H3 and H4 were confirmed, H5 could not be tested.

3.5 Quality of help giving (H6)

The quality of help giving can be improved if teachers get more insight into the most occurring problems and are able to focus on specific subjects.

The TAs mentioned that they liked the categories because via the visible categories they could determine the subjects about which questions were accepted. Priorities were determined by the teaching staff and consistently applied in all tutorials.

The questions posed in the system can also be used for insights into the difficulties and thus be beneficial for course and tutorial preparation of teachers and TAs. The set of (pre-formulated) questions available in the system should, however, have to

be maintained. According to the TAs this should be done weekly, preferably by the teacher and otherwise by an experienced TA. H6 was thus confirmed.

4 CONCLUSION

Overall, we can conclude that the system TA-help.me was perceived positively, its acceptance and usability were good, some suggestions for improvement, especially about the layout, were made. Adding categories to questions offered the TAs the opportunity to select topics and to spread their attention more effectively. Students used the system and felt free to pose their questions. The categories were perceived as useful by TAs and by students, the amount of specific questions asked was, however, not increased. Students felt some resistance having to type out their questions, and TAs and students doubted the added value.

The system clearly supports logistics and efficiency. It was, however, not perceived as helping the learning process. Whether training of students and TAs will make students and TAs see the added value of posing specific questions and stimulate them to take the extra effort needed will be subject to further research.

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