Simulating Global Software Development processes for use in Education: A Feasibility Study

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Abstract. VENTURE is a simulation-based training platform aimed at helping practitioners overcome process problems that arise in Global Software Development (GSD). VENTURE places practitioners in simulated GSD scenarios in which they play a role and interact with Virtual Agents, who represent team members from different nationalities. VENTURE makes it possible to simulate cultural, linguistic and GSD procedural problems gathered from experience and empirical studies. This paper reports on a Feasibility Study aimed to determine the potential of VENTURE to: 1) simulate GSD scenarios and processes of potential conflict, and 2) train practitioners to cope with these conflicts by interacting with virtual agents. A group of researchers and experts studied the platform and, through a survey-based method, they provided their endorsement of the concept. We received positive feedback and encouragement, in that the simulation of GSD processes will effectively provide training in industrial settings, helping practitioners to identify and resolve predefined problems.

1 Introduction

Global Software Development (GSD) implies new challenges for practitioners who have to collaborate with distant team members from a variety of cultures using a common language [1]. These challenges may often remain hidden until it is too late, and if ignored, may adversely affect the project and even lead to failure [2]. In traditional co-located development, work productivity is affected by social and individual factors, as well as by cooperation among software development teams [3]. However, in GSD these factors have even more impact, as cultural differences must also be taken into account [4]. To be effective therefore, GSD process development models need to consider aspects such as the employee's culture, and how the team will communicate and collaborate, as well as develop and maintain the team's common goal orientation [5-7].

Process improvement initiatives and techniques have been introduced to aim to identify specific software process improvement needs, e.g. Raninen et al. [8]. Training is a key factor for process improvement [9] as participants are required to develop specific competences and skills, that depend on their role in the software process [10]. For example, an e-learning experience to provide coaching in the use of best practices is presented by Messnarz et al. [11], and Cos et al. [12] explores how to adapt a e-learning platforms to fit international settings.

GSD introduces the need for employees to develop new competencies concerned with overcoming cultural and language barriers. Moreover, team members must be made aware of the additional interaction difficulties that arise as a result of the global distribution of work, new processes applied and time zone differences. The need for these new competencies calls for new training initiatives. However, providing training in the specific problems of GSD is not easy, due to the complexity of reproducing real environments in educational settings; this requires infrastructure, time and expertise [13]. Applying appropriate training requires some evaluation of the gaps in knowledge and specific needs of a particular student[1]. However, this evaluation of the student's current level of understanding is also difficult. As a result, the limited training in GSD tends to be classroom-based or paper-based [13], [14].

In this paper we introduce a new training initiative "VENTURE" (Virtual ENvironment for Training cUlture and language problems in global softwaRe dEvelopment) [15]. VENTURE is a simulation-based interactive training platform that aims to support practitioners with their culture and language process issues in GSD. In VENTURE's simulated GSD setting, students interact with Virtual Agents, who represent different cultures. The focus of this paper is to report how these aims are tested through a feasibility study conducted with a group of potential users.
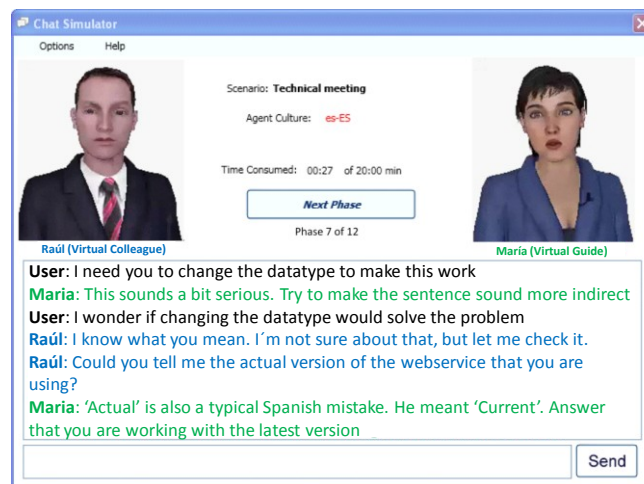

Figure 1: VENTURE's chat simulator interface

Figure 1 shows VENTURE's chat simulator interface. This platform is intended to provide training in specific process model practices, GSD skills and GSD scenarios

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[1] The term "student" is used to represent the role of 'practitioner, 'learner', 'trainee' or 'user' (as in Fig 1).

that reflect real interactions. A Virtual Guide ('Maria' in Figure 1) directs the conversation between the student and the virtual colleague (Raúl). Should the student make any errors in the conversation, the Virtual Guide will corrects the student in real-time. In this way, the student is trained in how to use negotiation and reward structures and in how to avoid conflict or generate trust. Supplementary information on cultural principles and known language problems are also given. For a detailed description of VENTURE go to http://global.lero.ie/venture.

1.1 Feasibility Study objectives

The main objective of conducting the feasibility study was to obtain prompt feedback about the suitability of VENTURE for training Global Software Development (GSD) skills. The feasibility study results reported here are based on feedback from a sample of eight researchers and four practitioners with expertise in GSD. The results showed that the VENTURE platform has the potential to be engaging and useful for training in GSD processes, as long as the training scenarios are designed in a dynamic way, and provided the scenarios present truly representative situations. In response to the positive encouragement received, we plan to develop a revised platform that incorporates some new user requirements as suggested by our sample of experts. This feasibility study addresses four key research questions:

RQ1: Does the proposed tool help participants to develop skills needed in GSD?
RQ2: How should this tool be applied in educational settings?
RQ3: Would the tool be usable and effective for training purposes?
RQ4: What kinds of scenarios are suited to such a tool?

2 Methodology

The research methodology to date involves three phases: first we conducted a literature review to explore existing approaches to GSD training, and gain an understanding of their strengths and weaknesses. The results of the literature review, as reported in Monasor et al. [13] motivated the second phase of research: to develop a training platform that aims to address the identified gap in GSD training support [15]. Phase three of the method involves conducting a feasibility study of the suitability of the platform to meet the training needs of GSD practitioners and GSD instructors. It is this third phase of the research that is reported in this study.

2.1 Feasibility Study survey

To answer our research questions (as listed in section 1.1) we apply a survey methodology that includes a mixture of open and closed questions (see Appendix A). The survey method was selected as a good way to elicit a participant's own opinions and ideas without them being influenced by others taking part [16]. Since some partici-

pants involved in this study assessed the training tool as part of a group demonstration, this method appears appropriate.

Prior to answering the survey questions, participants were given an explanation of VENTURE's architecture and operation. To illustrate the chat simulator's operation, participants were shown a series of snapshots. In these snapshots, a simulated Spanish student, playing the role of software analyst, chatted with a virtual customer in the elicitation of a set of software requirements. Several stages of the simulation were displayed, showing how the simulator presents cultural and linguistic differences with the help of the Virtual Guide. In this way, interviewees were able to form an impression on how the simulator operates.

After the briefing, participants completed a survey consisting of structured questions that aim to answer our research questions. The questionnaire comprised yes/no closed questions (to gather data on experience and personal details), and open-ended questions (to elicit opinions about the use of the platform in their companies/universities; i.e. the platforms usefulness and usability). It was intended that an analysis of these responses will act as a guide to refine the next phase of tool design.

2.1.1 Expert Selection

An opportunistic sample of four practitioners from three multinational companies participated in the survey, where selection was based on their expertise in GSD and their availability. As shown in Table 1, two participants were project managers, and two were developers. Experience in GSD projects ranged from three to eight years.

Table 1. Characteristics of the practitioners interviewed practitioners

#	Nationality	Age	Experience in GSD (years)	Current role
1	Spain	36	5	Project Manager
2	Spain	38	8	Project Manager
3	Spain	34	6	Developer
4	U.S.A.	35	3	Developer

Table 2. Background of researchers

#	Nationality	Age	Previous Knowledge in GSD
1	Cuba	26	No
2	Italy	27	Medium
3	Mexico	42	Medium
4	Peru	35	Medium
5	Argentina	26	No
6	Spain	27	Advanced
7	Spain	38	No
8	Uruguay	27	Basic

In addition, a group of eight researchers also completed the survey. Table 2 shows the characteristics of these researchers. As a whole, this population reflects the needs of end-users: practitioners can give their opinion from the perspective of the group designing and delivering the courses (allowing us to evaluate the scenario designer; and the applicability of the platform in industrial settings).

3 Results

The responses of the survey are analyzed by attending to the research questions:

3.1 Does the proposed tool help participants to develop skills needed in GSD?

This question was addressed by the following points:

3.1.1 Usefulness of the tool for training in the skills required in GSD

In the words of a respondent: "It is very useful, because in a real project problems will never happen in a systematic, controlled way; with this environment, you can model many real situations and improve how you deal with them".

In general, researchers liked the idea that the tool can provide independent, customized training that focuses on specific problems, and also the idea of having a repository of predefined rules and scenarios. In this regard, two respondents suggested that a key factor for the platform to be successful would be for it to make available a large repository of different training scenarios, as well as a wide set of rules to ease the design of new scenarios based on specific problems.

3.1.2 Weaknesses of the tool and ideas for improvement

Respondents pointed out that real life is very complex; the training scenarios can represent only a small example of the problems that may arise. Moreover, in order to provide training adapted to each individual, with a specific student's needs in mind, it is necessary to provide a sufficient number of training scenarios, which is not easy. The time required to design training scenarios is seen as being a very important aspect to take into account in the success of the tool. This suggests that the usability and flexibility of the scenario designer component are critical.

Respondents also believe that in the initial training stage, an explanation should be given on how the tool works to make them aware of the mechanism: "Users could lose interest when speaking to a machine. If this happens, they will make less of an effort. It is important for users to be aware of this, so that they get as much benefit out of the platform as possible".

Respondents remarked that the simulations could appear artificial if the training scenario is not well designed, leading to a subsequent loss of interest on the part of the students. It was therefore suggested that interesting and fluid scenarios should be created, to mitigate this problem. The following suggestions were also provided:
  - Include hyperlinks in the text. Virtual Agents could provide links to documents.
  - Integrate the platform in real situations in which the interaction between real participants could be guided or supervised by the Virtual Guide.
  - Include function to iteratively improve a scenario after each training cycle.
  - Include a function to pause the simulation.

3.2 How should this tool be applied in educational settings?

The following points address this question:

3.2.1 Applicability of the tool in university classes

In general, researchers considered VENTURE suitable for training certain concepts. They agreed that a deeper, corresponding theory should be provided in traditional classes to complement the virtual platform training. However, this add-on would depend on the course learning objectives.

3.2.2 Applicability of the tool to their companies

This question was answered only by practitioners, most of whom thought that, once instituted in a company, the platform would be useful not only for training in GSD, but also for other kinds of interaction between people, such as customer support. Two practitioners stated that the main problems companies encounter when organizing courses are: the difficulty in finding available experts in GSD; the time needed to develop these courses; and, the organizational difficulties of carrying out the courses in the company. Some practitioners agreed that, with a more complete database of problems and linguistic and cultural rules, this platform could be used, potentially, by inexpert developers. In the words of a practitioner: "In the future, when it has a sufficient amount of information, it will no doubt be a great tool".

3.2.3 Problems in the application in the company

The main concern of practitioners when applying this kind of training is the time and resources needed. Some comments also related to the operation of the platform: "Learning in this way could be kind of artificial, but it gives the user the chance to have experiences that it would otherwise be difficult to have". "Obviously, a simulation is always different from reality, but in this case you can simulate lots of problems that might well appear in real life".

3.2.4 Time required for this kind of training

Although there were a variety of responses to this question, practitioners seem to agree that two sessions a week would be reasonable. While the duration of the simulation should be close to real conversations, they concluded, taking 20 minutes (the average time suggested in the responses) might be the right length of time for a chat simulation. That could vary depending on the particular scope of the training scenario.

One researcher suggested that the scenarios should focus on specific objectives, rather than focusing on the time taken to complete a scenario. So for example, the scenario would not finish until it had reached a certain phase at least, or when it had

generated a certain number of mistakes. That said, we determined that time management was an important skill in GSD that we wanted users to learn.

3.3 Would the tool be usable and effective for training purposes?

Participants answered this question by highlighting the following three points:

3.3.1 Look and feel of the Virtual Environment

In general, practitioners and researchers feel that the use of the chat simulator is similar to any other chat application; this is appropriate from the point of view of the user's experience. One practitioner indicated that when interacting with Virtual Agents, users are not going to react in the exact same way as they do with real people, but at the same time he agreed that Virtual Agents are perfectly valid for teaching purposes.

3.3.2 Time saving benefit and limitation

From the point of view of the instructor, a practitioner noted: "It minimizes the instructor's workload…, it can reproduce difficult situations…, I think that the tool will be useful as support but the main concepts of the subject must always be taught by a teacher". Moreover, as regards the scenario designer, a respondent showed concern about the design of the scenarios: "The main problem is how to adapt the tool so that it provides suitable suggestions and feedback to the user".

3.3.3 Engagement and motivation

Researchers were asked about their interest in using the tool and how motivated they would be to do so. This question was intended to get feedback that could help to identify aspects of the simulator that needed to be improved if it was to be accepted more readily and completely.

Most of the researchers valued the platforms ease of use for independent training. As the tool responds to a real training need in a practical way, they found engaging with the tool instructive and motivational. In their words: "When a developer faces a global project for the first time, he may suffer from stress and fear of failure…", "being able to practice beforehand and learn how to interact can reduce these problems in the initial stages of the project". One respondent also remarked that iterative improvement of the training scenarios would be necessary to create scenarios with enough quality to be attractive to real users.

3.4 What kinds of scenarios are suited to such a tool?

The following point provides answers to this question:

3.4.1 Training scenarios and skills

Participants were asked which scenarios and skill training they would like added to the current platform. Having only been given an example of the training scenario that consisted of a requirements elicitation meeting, practitioners made the following suggestions for future development:
- Meetings to ask clients for specific information.
- Client support activities. Dealing directly with clients about issues that may arise.
- Interaction with a remote developer to solve a problem with the software.
- Asking an expert about a particular technology in order to solve a problem.
- Asking a client for access to their systems and for details of their requests.
- Provision of training in the use of the specific tools employed in the company.
- Dealing with an angry customer who is concerned about the software.
- Dealing with a colleague who has done a bad job.
- Real cases previously documented by the company.

Researchers, for their part, proposed the following interesting ideas:
- Formal meetings with a manager.
- Informal meetings to exchange information that could be interpreted by the user.
- Resolution of an urgent situation that must be dealt with in a short period of time, where there is no room for mistakes.
- Delivery of software to a client. Providing training and assistance to its users.
- Asking for clarification of requirements to solve a certain problem.
- Discussing a reported error with a client. In some cases these errors are not really errors as such; sometimes these errors are complicated to reproduce.

This list clearly indicates that there is great scope for future development of the tool for new environments and new functionality.

4 Discussion

Our aim in this study is to identify whether our proposed VENTURE tool has the potential to fill the gap identified in the literature. The literature calls for the provision of GSD training that is accurate, flexible, and easy for students to engage in and instructors to develop [13]. Conducting the feasibility study reported in this paper helped us to determine whether VENTURE has the potential to meet our aims. The feasibility study was designed to identify the strengths of our current solution and identify how the tool could be improved at this early stage in the development cycle.

4.1 Potential application

The platform was considered by both practitioners and researchers to be applied both in universities and in companies. Respondents agreed that the kind of training provided by this proposal can help to focus the training on specific objectives that can indeed be systematically reproduced in an accurate manner.

Using both researchers and practitioners in our feasibility sample proved useful in gaining ideas from a variety of perspectives. For example researchers, in general, liked the idea that the tool can provide independent, customized training that focusses on specific problems, that they could engage in when needed (without having to attend a formal class). As the tool reflects and simulates a real training need, they found the experience instructive and motivational. On the other hand, practitioners took a more pragmatic stance focussing on the time and resources which could be saved through this form of training platform. Compared with the traditional training approaches [13], VENTURE minimizes the instructor's workload and the time required for organizing courses and looking for experts. Both the flexibility of the tool for reproducing different kinds of scenarios and the independence of the training were seen as being of great value. Some of those surveyed even found that the platform would be useful for designing other kinds of interactions that are unrelated to GSD training.

Both groups of participants felt that the virtual platform was familiar, and that the use of the Chat Simulator is similar to any other chat application. However they did note that interacting with a Virtual Agent does have its limitations as users are not going to react in exactly the same way as they would do with real people, although the approach is perfectly valid for teaching purposes.

The main weak points reported were the problem of providing a sufficient number of training scenarios and the anticipated time required to create new training scenarios. Another problem reported by a participant was related to the motivation of the students: they might lose interest when interacting with Virtual Agents. "If this happens, they will make less of an effort. It is important for users to be aware of this, so that they get as much benefit out of the platform as possible". Moreover, the Virtual Guide might be too intrusive on some occasions and stop the flow of conversation. This means that the course designer (instructor) must seek to obtain a careful balance between realism and training scopes, and should give the student just enough guidance to complete the scenario within an appropriate amount of time. Feedback provided by the Virtual Guide must also be carefully planned, in order to avoid disturbing the student too much.

Finally, analysis of the responses to the feasibility study survey provided useful insights that address our research questions. Viewing responses from a group of potential training platform users in terms of current strengths and weaknesses of the concept, will inform the next phase of development. However, having refined the tool; future evaluations should ideally be undertaken in real educational (or industrial) settings with real students and instructors. In this way we will gain a more accurate picture of how effective VENTURE is in improving the skills of the users.

5 Limitations

This work has some limitations with regards to construct, internal and external validity of the evaluation [17]:

- **Construct Validity**: There may be some bias in the responses since all the researcher participants were from the same course and university. Also, only one type of research instrument was used: a survey with a limited number of questions.
- **Internal Validity**: There may be some bias, since the participants handed their responses directly to the researchers undertaking and reporting this study.
- **External Validity**: We cannot generalize these results to the wider due to the small sample which is not necessarily representative of the population of practitioners and researchers likely to use VENTURE. However, the sample does represent a cross section of countries, experiences and user groups.

6 Conclusions

This paper describes a feasibility study of VENTURE we conducted to assess whether our simulation tool could potentially provide training in GSD-specific skills. The study also examined whether simulating real processes would give the student increased confidence, and lead them to effectively communicate with participants from different cultures and languages.

The analysis of the results obtained indicates that our training platform meets our objectives. Indications are that VENTURE has the potential to give the student increased confidence for effective communication in GSD, and is able to reproduce realistic scenarios and provide feedback that focuses on specific skills. Contentious, sensitive, and error-prone scenarios on specific process areas can be designed based on previous experiences or knowledge. Participants can thus become familiar with these specific processes and problems in a secure off-line way and they can learn how to tackle them effectively, without fear of committing mistakes that could impact adversely on real projects. The feasibility study served to conclude that VENTURE has a potential application in industrial settings, as a tool for improving GSD processes. Our results indicate that we need to add an iterative improvement function to ensure that high quality training scenarios are to be provided. There should also be some effort dedicated to introducing students to the context of the training scenario and the operation of the environment, prior to their first interaction with it.

Finally, the feasibility study of our prototype training platform, as reported in this paper, proved useful in highlighting the strengths and weaknesses of the platform and e-learning virtual training concept; it has also shown us the direction for future VENTURE development. The use of a cross-section of participants, all of whom have experience in GSD or in education/training, added particular strength and relevance to our study.

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References

1. Monasor, M.J., Piattini, M., Vizcaíno, A.: Challenges and Improvements in Distributed Software Development: A Systematic Review. Advances in Software Engineering **2009** (2009) 1-16
2. Espinosa, J.A., Carmel, E.: The impact of time separation on coordination in global software teams: a conceptual foundation. Software Process: Improvement and Practice **8** (2003) 249-266
3. Yilmaz, M., O'Connor, R.V.: An Empirical Investigation into Social Productivity of a Software Process: An Approach by Using the Structural Equation Modeling. Systems, Software and Service Process Improvement, Vol. 172. Springer Berlin Heidelberg (2011) 155-166
4. MacGregor, E., Hsieh, Y., Kruchten, P.: Cultural patterns in software process mishaps: incidents in global projects. Proceedings of the 2005 workshop on Human and social factors of software engineering. St. Louis, Missouri (2005) 1-5
5. Stelzmann, E., Kreiner, C., Spork, G., Messnarz, R., Koenig, F.: Agility Meets Systems Engineering: A Catalogue of Success Factors from Industry Practice. Systems, Software and Services Process Improvement, Vol. 99. Springer Berlin Heidelberg (2010) 245-256
6. Richardson, I., Casey, V., McCaffery, F., Burton, J., Beecham, S.: A process framework for global software engineering teams. Information and Software Technology **54** (2012) 1175-1191
7. Noll, J., Beecham, S., Richardson, I.: Global software development and collaboration: barriers and solutions. ACM SIGCSE Bulletin - Special Section on Global Intercultural Collaboration (2010)
8. Raninen, A., Ahonen, J.J., Sihvonen, H.-M., Savolainen, P., Beecham, S.: LAPPI: A light-weight technique to practical process modeling and improvement target identification. Journal of Software: Evolution and Process (accepted)
9. Ringstad, M.A., Dingsøyr, T., Moe, N.B.: Agile Process Improvement: Diagnosis and Planning to Improve Teamwork. Systems, Software and Service Process Improvement, Vol. 172. Springer Berlin Heidelberg (2011) 167-178
10. Riel, A.: Integrated Design – A Set of Competences and Skills Required by Systems and Product Architects. Systems, Software and Services Process Improvement, Vol. 99. Springer Berlin Heidelberg (2010) 233-244
11. Messnarz, R., Bachmann, O., Ekert, D., Riel, A.: SPICE Level 3 - Experience with Using E-Learning to Coach the Use of Standard System Design Best Practices in Projects. Systems, Software and Services Process Improvement, Vol. 99. Springer Berlin Heidelberg (2010) 213-221
12. Cos, J.A., Toval, R., Toval, A., Fernández-Aleman, J.L., Carrillo-de-Gea, J.M., Nicolas, J.: Internationalization requirements for e-learning audit purposes. Global Engineering Education Conference (EDUCON), 2012 IEEE (2012) 1-6

13. Monasor, M.J., Vizcaíno, A., Piattini, M., Caballero, I.: Preparing students and engineers for Global Software Development: A Systematic Review. International Conference on Global Software Development (ICGSE 2010). IEEE Computer Society, Princeton, NJ, USA (2010) 177-186
14. Carlson, P., Nan, X.: Experience and recommendations for distributed software development. Collaborative Teaching of Globally Distributed Software Development Workshop (CTGDSD), 2012 21-24
15. Monasor, M.J., Vizcaíno, A., Piattini, M.: Cultural and linguistic problems in GSD: a simulator to train engineers in these issues. Journal of Software Maintenance and Evolution: Research and Practice (Special Issue on Global Software Engineering) 24 (2011) 707-717
16. Krosnick, J.A.: Survey research. Annual review of psychology 50 (1999) 537-567
17. Hoyle, R.H., Harris, M.J., Judd, C.M.: Research Methods and Social Relations. Wadsworth Publishing (2009)

Appendix A: Survey

Practitioners were asked the following specific questions:
1. Users will not react in the exactly the same manner when interacting with Virtual Agents as when dealing with real participants. Do you consider this difference negative? Can this difference create a barrier to training?
2. Do you think that the tool could be really useful for training the skills and knowledge required in GSD?
3. Do you think it would be feasible to train members of your company/university by applying this training platform environment? Do you envisage any problems or inconveniences in its application?
4. By considering the example of the Requirements Elicitation training scenario shown, which other training scenarios would you like to be designed?
5. Do you think that it would be worth creating training scenarios for training particular problem recognition or skill development? Which ones?
6. How long would you consider the students could dedicate to these courses in your company? (give time scale)
7. Do you find any weak point in the environment not mentioned previously? What improvements would you suggest?

In the case of the researchers, they were also asked for personal data. Moreover they were asked to give their opinion from the students' point of view:
1. Age, 2. Nationality, 3. University where you obtained your degree.
4. Do you have theoretical knowledge in Global Software Development or Distributed Software Development? How did you get that knowledge?
5. Have you ever practiced GSD in your professional life? For how long? In how many projects? How many different cultures were involved?
6. From the perspective of the student, do you find the environment useful for developing the skills required in GSD?
7. By considering that the student must get as much information as possible and commit as few errors as possible during the simulations, how long would you consider a training scenario should last?