SGLD Vol. 1, No.1 (February 2015), 94-111

Journal of Simulation/Gaming for Learning and Development
ISSN 2158-5539
http://www.thaisim.org/sgld/

Developing Problem-solving and Intercultural Communication: An Online Simulation for Engineering Students

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***Abstract**: In this article we describe ENGINEERS WITHOUT BORDERS, a simulation we created to engage engineering undergraduates in the USA and English language learners pursuing a degree in engineering in Spain in a series of thematically-related activities based on authentic situations, where participants had to work in teams to solve problems and probe complex and relevant issues, thus taking ownership of the outcome. This pilot study seeks to gather findings about the participants' views towards the effects of international classroom simulations on the development of critical thinking and intercultural awareness among engineering students.*

***Keywords**: asynchronous conferencing, collaborative learning, critical thinking skills, EFL/ESL web-based instruction, intercultural communication, learners' attitudes, online role-play, simulations, problem solving, soft skills, students' perceptions, synchronous communication*

We have been using simulations in our graduate English composition courses for international students for many years to promote critical thinking, collaborative learning and intellectual engagement with a topic (Damron, 2008; Halleck, Moder & Damron, 2002; Moder, Seig & Van Den Elzen, 2002; Salies, 2002; Schick, 2007). These simulations provide an excellent structured

series of activities in which students can participate in authentic situations (Demeter, 2007; Fukushima, 2007; Garcia-Carbonell, Rising, Montero & Watts, 2001; Moder et al., Halleck, Coll-Garcia. 2002; Halleck et al., 2002; Salies, 2002). Such simulations can probe complex and sometimes controversial issues (Halleck et al., 2002; Knyshevytska & Hill, 2007; Kovalik & Kovalik, 2007; Moder et al., 2002; Nash, 2007; Schick, 2007) thus taking ownership of the outcome (Halleck et al., 2002; Kovalik & Kovalik, 2002, 2007; Moder et al., 2002; Nash, 2007; Savery, 1998) and fostering autonomous learning of intercultural communication skills (Ho & Crookall, 1995; Crookall & Landis, 1992).

Benefits of Online Communication

In this article we describe a simulation that we developed specifically for undergraduate engineers in the USA and in Spain. Because we had been using simulations successfully in our composition classes for years, and because we had also developed some online simulations for multicultural teams of L2 learners in different locations, we decided that, if we wanted to have multicultural teams working together, we would need an online component for the simulation designed for the engineers. We recognized that an online simulation would have definite advantages over a face-to-face project. Whereas the relatively non-threatening simulation environment in face-to-face simulations often leads to increased motivation (Fukushima, 2007; Halleck et al., 2002; Hull, 2008; Jones, 1982; Knyshevytska & Hill, 2007; Naidu, 2007; Scarcella & Crookall, 1990; Schick, 2008), according to Freiermuth (2002), online simulations have an important advantage: Communicating online tends to reduce inhibitions to a greater extent enabling participants to contribute "to their fullest capacity" (p. 190). The students' comfort with learner-centered technologies is not the only reason to incorporate various electronic collaboration formats into our simulations, however. Bonk & King (1998) suggest that, both synchronous and asynchronous computer conferencing have some advantages over live discussions in terms of student engagement in learning, depth of discussion, time on task, and the promotion of higher order thinking skills (p. 20).

Many authors have begun to incorporate online communication into their class projects. Jarrell and Freiermuth (2005) found that their students prefer online communication because they do not experience the same pressures that exist in face-to-face interaction. The fact that there is no time pressure to answer, enables participants to reread any posts before responding and "to answer at their own pace" (p. 69). This lag time bolsters some students' confidence as they can use a dictionary, or plan what they are going to say, erasing any time pressures that they may experience in face-to-face encounters. Duffy, Dueber & Hawley (1998) point out that such asynchronous environments provide students with "the time for thoughtful analysis, reflection, and composition as their discussion of an issue evolves" (p.74). This has definite advantages for a participant who may not be "fast on his feet" (Croson, 1999, p. 33) since the computer-mediated communication may enable such a participant to proceed at his/her own pace, thus relieving the burden of having to respond immediately, as is required in face-to-face communication.

In addition to increased confidence and motivation, Jarrell and Freiermuth (2005) found that participation online was "more equitable" (p.59) than in face to face communication in the classroom, an observation that led them to conclude that incorporating an online component "encourages the kind of student interaction that constitutes true communication" (p. 70). Croson (1999) agrees that the time lag in electronic communication has definite advantages. After examining the effect that electronic negotiations had on task outcome, she suggests that the use of an electronic medium "levels the playing field" between participants (p. 33). Freiermuth and Jarrell (2006) also found that their students were more willing to communicate when they were involved in online assignments and since these authors acknowledge willingness to communicate as an important part of successful L2 interaction they conclude that "using online chat in the classroom reduces social constraints and reconfigures the way students interact" (p. 207). Hull (2008) also found that the incorporation of an online component in her international composition class elicited positive responses from her students. She observed that their enthusiasm "for sharing their opinions, thoughts, and arguments" (p.207) online was enhanced by the use of chat in an L2 environment.

Changing Criteria in Engineering Education

We designed ENGINEERS WITHOUT BORDERS (EWB) in response to recent trends in engineering education. It has been more than a decade since the Accreditation Board of Engineering and Technology (ABET) issued the new engineering accreditation criteria. These criteria were originally known as Engineering Criteria 2000 (Shuman, Besterfield-Sacre & McGourty, 2005) but are now known as the ABET Engineering Criteria.

In addition to the usual "hard" engineering skills this document introduced such "soft" skills as communication, teamwork and professionalism. The inclusion of such soft skills has created a dramatic change in engineering curricula. As global trends have created major changes in the way the world does business, it has also created similar changes in the way engineering projects are done. Universities are modernizing their curricula to enable their graduates to succeed in the global marketplace that is the reality of the new millennium.

Such globalization has created situations in which professionals must learn to work with colleagues who have similar skills, but who have different values and ideas. Shuman et al. (2005) point out the need for engineers not only to learn to work collaboratively in multicultural teams, but also in teams that are in different places. As a result of this globalization, engineering students are now being trained to work collaboratively on multidisciplinary teams with colleagues from around the world. One benefit of such collaborative teamwork is that

> students work on assignments and projects in teams under conditions that assure (among other things) individual accountability for all the learning supposed to take place" (Felder & Brent, 2004, p. 289).

As Ziemiewski (2009) points out,

> much of the competitiveness of the United States in the future global markets will rely on not simply our math and science skills, but rather on our ability to think critically, creatively and outside the box, and to work in interdisciplinary teams that often include non-engineers" (p.8).

Shuman et al. (2005) point out that this trend for the inclusion of team-based courses reflects industry practice. They

also suggest that within such a team-based approach to teaching, projects with global and humanitarian components have become quite prevalent. The benefits of such approaches, according to Felder and Brent (2004), include "their role in helping students acquire and improve higher-level thinking and problem-solving skills" (p. 289).

In acknowledging that engineering education has changed to reflect the times, Shulman (2005) refers to the juxtaposition between the formal engineering requirements involved in learning mathematics and science with what he calls "the creative challenges that accompany 'messing with the world'" (pp.11-12). He recognizes that today's students must realize

> that all that knowledge and creativity, collaboration and communication, must be accomplished within a matrix of social and environmental responsibility (Shulman, 2005, pp. 11-12).

Methodology

Our ENGINEERS WITHOUT BORDERS (EWB) simulation was designed with these new criteria in mind. Our purpose was to enable the students to participate in an international project.

Tasks

The implementation phase of the simulation lasted two weeks. This project offered them the opportunity to work in teams and to collaborate with students at another university by means of an initial twenty-minute video teleconferencing as well as text-based synchronous and asynchronous means of communication. We decided to pair two groups of students to include the components of both teamwork and multiculturalism. To do this, we involved 42 undergraduate engineering students enrolled in one section of Engineering 2033 at Oklahoma State University, USA, with 56 undergraduate engineering students from Universitat Jaume I, Castellón, Spain. Thus we attempted to meet the needs of both groups of students and to provide opportunities to practice these soft skills. Undergraduate engineering students on the American campus worked with teams of engineering students studying English for Science and Technology on the Spanish campus. The simulation involved a variety of electronic

collaboration formats and these teams met regularly via the internet, interacting through the email and chat tools available from Google Sites to collaborate on this international project. In the rest of this article we will describe the various thematic units that make up the simulation. We assigned students to work together in pairs (3 American students and 4 Spanish students). The EWB simulation required the teams to participate in a virtual humanitarian mission. Their instructions were that, during the two weeks of the simulation, they were to think, speak and act as if they were truly planning this humanitarian mission. They were supposed to make their documents and their conversations with their international partners as realistic as possible. In other words, they were supposed to consider the factors that they would be faced with in the real world, and anticipate the costs, communication

Figure 1. Two of the projects for the humanitarian mission

Talle Batti, Cambodia

There is a lack of clean water in the 3 villages of the Talle Batti community in Cambodia. Due to the use of dirty drinking water, there are a lot of diseases in the village, and there still is a high percentage of child mortality. CDO is searching for alternative solutions to cope with this problem, because previous solutions did not seem to work properly (water pumps and a water filter).

Cameroon

The purpose of this project is to assist orphans and street children in one community in Cameroon with the opportunity to gain life skills through which they can earn incomes. Their incomes will help them to care for their aging parents and family members who are infected with HIV/AIDS. The community needs a new building where they can offer classes and hold meetings. The structure consists of a conference room and three skills-training classrooms. The conference room will serve as an income generating unit while raining goes on in the other 3 classrooms.

problems, possible setbacks, and even consider the possibility that there would be mosquitoes.

Their first task was to choose the project(s) in which they wanted to participate and decide what types of engineering background (i.e., mechanical, chemical, industrial, etc.) they would require. They were given a list of twelve projects (taken from the Engineers Without Borders Website). See two of these projects in Figure 1 above.

After the groups selected the projects, their next task was to select a project leader. They were given a total of eighteen curricula vitae of engineers who might be available. These CVs included civil engineers, chemical engineers, electrical engineers and mechanical engineers with a variety of professional and work experiences. For example, several engineers with PhDs were doing research in academia and some engineers worked in engineering consulting firms. Some engineers had worked with Engineers Without Borders on projects in various parts of the world; others had multicultural experience in South East Asia, and some had participated in internships in Nepal, Sri Lanka, Pakistan, Nigeria and Upper Volta. Some specifically mentioned that they were interested in travel; some mentioned that they were bilingual. Some engineers were trained in the USA, in Spain, in the UK, in China, in Venezuela and in Thailand. The students had to agree on a choice of leader for their mission. This was accomplished first in small face-to-face groups of three to four students, and then in the larger online multicultural groups of seven people. It was their task to find a group leader that was acceptable both to the American group and to the group in Spain.

After choosing the engineer that the team wanted to lead their virtual expedition, their next task was to write a letter inviting this engineer to join them. In the letter they were to explain why they had chosen him or her, and include a brief explanation of the humanitarian mission and what qualities they felt made this person ideally suited for their expedition. The students were reminded that the letter was supposed to persuade the project leader to join their project. After completing the invitation letter, their next task was to seek funding for the mission. To aid them in this aspect of the simulation, they were given a description of a number of international funding sources including Rotary International Humanitarian Grants, UNICEF, ActionAid and the Bill and

Melinda Gates Foundation. Their instructions suggested that they decide which mission statement best matched the goals and benefits of the project they had chosen. In the request for funding, they were to include an overview of the project, and an explanation of how the funds would be used (e.g., for materials, labor, research, equipment etc.).

The next phase of the simulation involved creating an advertisement (in the form of a one-page flyer) that could be placed on bulletin boards or passed out by professors, to recruit college students to join the humanitarian mission. Students were reminded that they should include a number of factors in their flyers, such as the information that would be most important to potential recruits, the aspects that would be most enticing for a prospective volunteer, and also the benefits associated with their project.

After these phases were completed, the students had to hand in a completed project packet. Because a portion of their grade for this project had to do with their communication with other group members, each group had to compile chat records. The chat records were available and could be downloaded and printed. Students were to include all the chats that had taken place between any group members. In addition each group was to hand in a packet that consisted of the following: a letter of invitation, a request for funding, and a sample of the student advertisement.

Data collection

As far as instruments for data collection are concerned, a survey was administered to elicit attitudinal data from participants right after the simulation had taken place. In this survey, students were asked:

- what they expected to learn through their participation in the simulation,
- whether they were concerned about the language and cultural differences between team members,
- whether their teams accomplished the instructional objectives in an efficient manner,
- what improvement(s) to the project they would suggest, and
- what had been actually learnt through their participation in the simulation.

This study constitutes a pilot of new approaches to engineering pedagogy and a part of ongoing study of the development of critical thinking skills and writing skills in undergraduate engineers.

Results

We will deal with the attitudes of the Spanish students towards the international project first, after which we will present the opinions of the American participants.

Spanish responses

When asked what their expectations were when they learned that they would participate in an international project, students from Spain expressed hope that they would improve their English language proficiency by interacting with a group of American students:

> When the teacher told us that we were going to do this simulation, I thought it would be interesting because it would help us to improve our oral English, we would probably learn vocabulary that is useful to us in our working lives. Also thought that such work would be useful to learn the task to organize in groups and in this case have as much to follow students from other site.
> My greatest expectation was to improve my English and learn how to act in that language in a real job related to engineering. Besides, I hoped to learn teamwork and interacting with other students from Oklahoma.

After having analyzed their answers, we inferred that Spanish learners felt that communication with American learners could sometimes be troublesome, as this Spanish student pointed out:

> At the beginning I was concerned because our level of oral English is not good, but like most of the work was done by e-mail this concern disappeared. Cultural differences I am not concerned about.

When a Spanish student was asked whether he was concerned about language and cultural differences between the Spanish team members and the USA team members, he answered:

> No, I was sure that the job would require a major effort from both groups to achieve understanding

> and teamwork between the two, but I was sure that we achieve a good result.

However, in the overall, Spanish students had slightly more positive attitudes towards their experience with the simulation than American learners. They found their participation in the project helped them improve their English, as can be seen in the following opinion:

> […] the experience has been positive. We have learned to organize ourselves as a team and specific language of both the organization and the project itself.

Additionally, Spanish learners were satisfied with the methods of communication used with international teammates, and therefore expressed no wish to change them in future simulations. When asked whether they had any suggestions for improvement, one student from Spain suggested that more time should be devoted to the simulation:

> I think the project is very good and you do not need many changes because we have fun doing it all. Maybe I would add some time to work to deliver better results.

They would have liked to have more videoconferencing sessions with Americans, to practice their oral communication skills. In this line, they suggested that, in the future, using additional teleconferences could be beneficial, especially in the initial stages of the simulation:

> I think that the simulation should be done with more time to improve planning and entire by videoconference.

Although the communication tools provided through Google Sites were user-friendly enough and acceptable for accomplishing the simulation objectives, a few students reported negative perceptions towards Google Sites. They would have liked to work with a more simple platform to be able to navigate in an easier manner.

In response to the question, "What one thing did you learn from this experience?", one of the Spanish students pointed out the positive aspects of the international collaboration:

> I could learn to work with people from other countries and I have learnt to work in teams in a real situation of the working life of an engineer.

American responses

As far as American students are concerned, results show that, on the whole, American learners had positive views towards their experience with the simulation in general. Responses from American students, when asked what their expectations were when they learned that they would participate in an international project, were not very positive:

> I figured there would be language issues. I expected to have to work through the barrier. I thought it would be interesting and a different project than others I have done before. The fake EWB project seemed a little silly though. The project didn't seem to have much to it. There was very little thought required to complete it. I expected the work to be involved with the members from the other country. I didn't really expect to learn a lot other than a feel for how it is to work with people who aren't living in your culture.

As Felder and Brent (2004) point out, course designers who incorporate such soft skills as communication, teamwork and professionalism,

> cannot count on getting a warm and enthusiastic reception from all of the students. While some students respond well to open-ended questions and group work, others express unhappiness or outright hostility toward them. They may grumble that the teacher is supposed to tell them what they're supposed to know rather than making them figure it all out themselves …" (p.286).

American students showed negative perceptions when communicating with Spanish students. They faced numerous problems when completing assignments with Spanish learners due to a poor command of the latter. This resulted in a major increase in the workload on the part of American students – some of them felt they were doing the part of the Spanish students, which turned out to be overwhelming for some of them, as this student points out:

> I became concerned that the Spanish team couldn't write well enough English to be of much value on this project. Everything written had to be rewritten in order for us to get a proper grade.

In spite of this, American students made an effort to integrate the Spanish participants in the group:

> We included the other team from Spain as much as we could, though the three of us separated out tasks pretty well to sort out the work.

When an American participant was asked whether he was concerned about language and cultural differences between the Spanish team member and the USA team members, he answered:

> I was a little concerned because no one in our group spoke Spanish. I didn't worry too much about cultural differences. All of those worries were gone after our videoconference, though, because I realized that our language barrier wouldn't be as great as I thought. I did feel bad though, since we didn't even try to speak Spanish.

American learners did not find their experience with the online role-play simulation relevant to their curriculum. One of the students from the USA complained that the project did not teach them any engineering concepts. He obviously had not heard about the trend in engineering education to stress the importance of international collaboration and problem solving:

> The biggest problem is that there weren't any engineering principles applied during the project. I'm not exactly sure how to fix that other than not using the project in a class where you are supposed to be learning and applying critical thinking and engineering concepts.

Another factor that seems to have affected the attitudinal results of the survey in a negative manner was the time difference between the USA and Spain, which had a negative effect towards a successful completion of group tasks.

In response to the the question asking what one thing had been learnt from the present experience with the simulation, the American students focused more on communication, than on the cross-cultural aspect of the project:

> I learned about communication. I feel that communication is important not only in cross-cultural collaboration but when working on any project. Our ability to talk about the work and divide it up was, in my opinion, our greatest asset. As engineers we need to learn how to explain ourselves concisely, using diction that will allow people to be able to understand clearly. The Spanish group didn't have the best English, so we had to work on what we said to them.

Despite all the difficulties, learners from both nationalities felt that their teams accomplished their tasks efficiently, as can be seen in the two excerpts, by a Spanish and an American student respecively, that follow:

> Yes, absolutely we have managed to work successfully in group. We have all worked and all we have fulfilled our part of the job Yes. We divided our work up well and met all of the deadlines set before us.

Suggestions for Future Implementations of the Simulation

Based on the students' feedback, if this simulation is implemented in the future, the goals of the project need to be clearly explained to American learners. Many American participants were confused when asked to participate in this project. They did not understand what the learning objectives of the simulation were. However, the main learning objective for the Spanish participants was very straightforward (i.e., to enhance their foreign-language proficiency).

Also, American students did not know from the beginning that the Spanish students' learning objectives were to improve their English as well as to enhance their communication skills (i.e., their participation in the project was part of an English-for-engineers course). Had the American students known this, they would have probably acted differently, thus avoiding certain frustrations that occurred when interacting with the international students. Giving them this information beforehand would certainly improve the satisfaction levels on the partof the English-speaking participants.

According to the results of the surveys, it would be positive to schedule at least an additional videoconference, especially in the initial stages of the simulation (i.e., during the phase in which students had to plan out all the work to be done), for learners to establish effective communication. When students used this technology for the first time, they were not familiar with it and, therefore, the interactions between Americans and Spaniards were a bit awkward at times. This means of communication would allow learners to communicate effectively in the future, besides providing the Spanish students with the opportunity to brush up their oral communication skills in the foreign language by interacting face to face with native speakers of English. A second

teleconference would allow participants to learn from the mistakes made in their first interaction through videoconferencing and to organize work in a more efficient way. Finally, a third suggestion would be to come up with a project that suits the academic interests of all the students involved. This project should ideally involve learners in solving problems using skills that they have learned in a specific course. That way, both American and Spanish students would be given the possibility to compare solutions involving technical aspects that focus on one part of a shared course syllabus. Adding a more technical aspect to the project would better simulate the engineering work environment and true international collaboration necessary in the engineering profession.

Conclusion

Perhaps if we run this simulation again we will make sure that we explain in more detail to the American students what we think the benefits of such collaboration might be for them. The students from Spain understood that such an international collaboration would be beneficial to them, at least in terms of improving their oral and written proficiency in the L2. Unfortunately for some of the American students it seemed to be a burden to have to work with people whose English was not as good as theirs. Instead of seeing this as an opportunity to improve their own ability to explain and communicate, they felt that they would just have to do the work by themselves, thus defeating one of the purposes of the project. Despite this (unexpected) outcome, we feel that such a simulated experience should play an important part in an engineering curriculum. However, for students to benefit from such a collaborative experience, they may need to learn more about its purpose. If they are aware that a well-rounded engineering education encompasses more than simply solving problems from a textbook, then they may begin to develop the skills provided by an opportunity to work with colleagues on an intercultural project, one that is similar to the type of work that they are increasingly likely to encounter in their professional lives.

Declaration of Conflicting Interests

The Authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding

The work reported in this paper has been made possible thanks to the funding given to the research project Virtual Engineers-Without-Borders: Fostering communicative and Critical Thinking Skills in the English-As-A-Foreign-Language (EFL) Curriculum Through Online Simulated Learning (PR2009-0532) by the Spanish Ministry of Science and Innovation.

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