ON-LINE ROLE-PLAY AS A TEACHING METHOD IN ENGINEERING STUDIES

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Abstract

In this paper we propose adapting role-play teaching methodology to engineering studies. The role of a maintenance technician, a relevant job profile for engineering graduates is has chosen. The interaction is based on email exchange, with the instructor included in the simulation to help guide the activity and achieve learning objectives. In this paper, we present   experience with this methodology, its implementation, results, and student feedback.

Keywords - Role play, engineering, optical communications.

1   INTRODUCTION

Role playing, as a learning tool**,** may be defined as when students (and perhaps the instructor) are asked to imagine that they are in a particular situation (either as themselves or as another person), and are instructed to behave as they (or their assumed person) would behave in that given situation. A framework for learning diverse competences is therefore created [1]. This teaching method has significant advantages, including:

- Develops generic competences such as oral and written communication, self-motivation, and ability to adapt changing environments, conflict resolution or negotiation [2].

- Provides a positive and secure environment to deal with attitudes and feelings [1].

- Promotes social interaction

- Brings life to descriptive subjects like History, economics, geography…

- Encourages active, student-centred learning

- Provides immediate feedback for students and teacher

- Closes the gap between the academia and real-life scenarios in the working world. Despite these advantages, this teaching method is rarely used at the college level, and is typically reserved to foreign language instruction, [3,4], business [5], law [6] and other studies where social interaction is relevant for the professional. But this methodology is not free of problems, such as [1]:

- Instructor can lose control over of what is learned and which order it is learned.

- It is a time consuming method and requires common resources (people, space and time).

- Results may be distorted, as situations must at times be adapted or simplified.

- Results may depend on what the students already know.

- Some important theoretical aspects or facts may be excluded from the learning process.

- Learning may be considered frivolous and mere entertainment.

In particular, the following obstacles have been cited regarding the use of role playing in engineering studies:

- It is incorrectly associated with role-playing fantasy games, and thus not considered a valid methodology.

- It is not considered a valid method for technical studies due to its focus on generic competences, which have been considered secondary. Those competences specific to the discipline would remain in the background.

- Covering the entire syllabus seems mandatory in these studies, and this method does not guarantee that this will take place.

- It usually requires important social skills, and so is rejected by most of the students and even the instructors.

In this work we propose adapting this methodology to overcome these drawbacks and mitigate the aforementioned causes of rejection. First, we proposed choosing a relevant role related to the professional future of the student. This way, the specific competences to be developed will be derived from a real work situation, and will be perceived as important and motivating for the students. Second, we propose substituting face to face communication with email and instant messaging, as we find today's students far more confident with on-line communication tools. This also reduces the need for a common space and time for students and teachers.

Third, the activity should be carefully designed and "scripted" so that the need to acquire the expected competences or knowledge naturally emerges. This transforms the activity into a relevant learning experience, rather than a simple evaluation or putting into practice of contents previously lectured. Last, the instructor should participate with his/her own role in the simulation. With his/her behaviour and choice of information, the activity should lead to achieving the desired learning objectives.

Based on the three above mentioned ideas, we have designed an activity for three subjects, all related to the field of optical communications in engineering studies. Several innovative teaching methods have been proposed in this field, mainly focused on on-line teaching [7,8] or problem-based learning [9]. In this work, we propose a role-playing activity in which the student takes the role of a maintenance technician in a company operating a large fiber-optic communication network. This job is a typical position for our students after leaving the college, especially for those with a technical engineering degree (3 years degree). For this reason, the experience is relevant to them and is perceived as such.

In the following sections, the design, implementation and evaluation of this experience are detailed.

2   METHODOLOGY

The proposed activity has been designed for and implemented in three courses related to fiber optic transmission technology within telecommunications engineering studies. The specific competences that we wanted to develop were operation of specific instrumentation for the physical layer of the network, and strategies for problem solving in the event of network failure. However, the context for this experience was different in each course.

The first course, "optical communication systems", focuses on the theoretical background of optical communications. While the above described competences are often considered of secondary importance (in the past they were rarely covered during the semester), the activity has a strong motivational purpose as it links the theoretical aspects with the professional practice. For that reason, we believe the activity should include a wide range of instrumentation, measurement procedures and strategies. As the learning material (instrumentation manuals, datasheets, procedures, etc.) is provided on demand, it is an important responsibility of the instructor to guide the progress of the activity to cover the required aspects. Another possibility is to design a comprehensive set of smaller or less ambitious activities and to choose among them for a particular student.

The other two courses, "laboratory of optical communications systems" from two different degrees, focus on experimental work related to optical communications. The competences related to the use of instrumentation and measurement procedures in fiber optic networks are already covered through various assignments performed at the lab. For this reason, the proposed activity is designed in this case with slightly different objectives: integration of the learned skill in real situations and evaluation purposes. This activity allows the teacher to assess whether the student knows what instrumentation is available, what it is intended for, and how to use it. In addition, through this activity the student gains confidence and skills in solving real problems.

The design of the activity begins with the compilation of known data about a real incident of network failure, which are provided in some cases by former students. This includes the architecture and layout of the network, points of presence, transmission equipment or operating parameters. Missing information can be easily surmised on the basis of realistic assumptions. Calculations of important parameters (such as signal levels) are carried out for the cases of failure and correct operation.

A set of real instrumentation typically available for maintenance and repair tasks is then selected. Real instrumentation usually includes an Optical Time Domain Reflectometer (OTDR), an Optical Spectrum Analyzer (OSA), Optical Power Meter (OPM), etc. For each instrument, expected measurements at some points of the networks are generated in the form of printed screens or measured values.

Finally, this is completed with instrumentation manuals, datasheets or commissioning tests, which are provided to the student only on demand. The instructor should monitor which specific information or document is given to the student.

The activity begins, as in most network maintenance companies, when the technician (our student) receives a "trouble ticket" by email from the network operation center (NOC). This document contains only a brief description of the symptoms of the problem. Fig. 1 shows an example of the instructions given to the students to start the activity. In a real-life situation, the technician would collect all the required information, and based on his/her training, perform onsite measurements or remote monitoring procedures to locate the cause of the problem and the failure point in the network. Finally, a corrective action to fix the problem is then performed. (Normally this consists of replacing equipment—be it a piece or the entire machine or mechanism).

Description of the activity

The following situation is considered: the supervision personnel at the NOC of a large network operator detect a failure in one of the fiber optic links. A trouble ticket is sent to the duty maintenance staff (you) asking for help.
The goal is to locate and identify the failure, and to propose a solution to fix the problem. You can request additional information, symptoms, manuals, or specific measurements at any point of the networks to the field technicians or the NOC staff, through this email address: xxxxxx@gmail.com

Fig. 1.: Instructions given to students to start the activity.

In our simulation, we consider a fictitious situation where the technician is unable to perform the measurements by her/himself, but is able to contact NOC staff by email to request onsite measurements, verifications, or all available information at the company. While NOC staff supposedly lack technical knowledge in optical communications, they have experience with past failures and are able to provide information about the network, and request onsite measurements from other technicians. In this activity, the instructor plays the role of the NOC staff, and in this way is able to interact with the student by email. One advantage of communicating via email is that both teacher and student can choose when to reply.

The evaluation of the activity is not only based on the ability of the student to locate the problem and to propose a proper solution in a short time, but also on the relevance of the questions posed and the information requested. The student's questions are used to reveal conceptual flaws and to select the learning material (concepts, procedures, etc.) that should be provided to the student so that he or she may continue with the activity. The replies from the instructor are crafted to take into account both learning objectives and real-life issues, such as missing information or the need for complicated, expensive, and or time consuming measurements**).**

At the end of the activity, the instructor sends students his feedback and comments. The instructor should focus on students´ conceptual flaws and the reading material available to correct them. The instructor performs a final evaluation by using a rubric that considers the following aspects: Completion of the task; information and interaction needed; relevance of student's questions; knowledge of theoretical aspects; choice and use of instrumentation. The rubric is shown in Fig. 2.

The student is finally asked to complete an on-line short survey about his/her learning experience, based on *Google Docs®*. Some of the questions in this survey are the following:

- Has the purpose of this task been stated clearly?

- Were the initial instructions clear?

- How much time has been devoted to this activity?

- Was it necessary to consult additional information (notes, books, Internet)?

- Do you think you have sufficient theoretical background?

- Do you understand the replies of the instructor? If not, specify.

- Do you think that this activity is related to the rest of the course?

- Do you think that this activity is relevant to your professional future?

- Have you learned something new?

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Evaluation of the activity - 2009/2010

Name:

Item	%	1	2	3	4	5
There is promptness in the replies	10	No, more than a week	Several days	Every day	A few hours	Real-time
The questions are relevant	30	No, not relevant and misguided		Partially		Yes, relevant and showing reflection
The right instrumentation is selected and the measurements properly interpreted	20	No, poorly chosen and interpreted		Relevant instrumentation is used		Advanced interpretation and/or use of secondary instrumentation
The theoretical concepts have been acquired	20	No, severe conceptual flaws		Some errors		Yes, solid background
Te task has been successfully completed	20	No, give up early		Reach a reasonable solution		Best solution in fewest possible steps
Conceptual flaws:						
Comments:						

Fig. 2.: Rubric for the evaluation of the activity

In order to reduce the work load for the instructor, the activity has been implemented not only with the students working alone, but also with the students working in groups of two or three people. Students in small groups were instructed to have meetings to analyze and collectively respond to instructor's emails. "Virtual" meetings using instant messaging were allowed. However, the activity, as it is designed, does not seem to be effective for students working in teams because it does not guarantee the necessary positive interdependence and individual accountability for effective collaborative learning [10].

The next section discusses the results obtained after two academic years.

3   RESULTS

This activity has been tested in the aforementioned courses during academic years 2008/2009 and 2009/2010:

1. With students working in groups of two or three in lecture course "Optical Communications Systems", students.

2. With students working individually in lecture course "Optical Communications Systems", working individually.

3. With students working individually in lab course "Laboratory for Optical Communications Systems".

In this activity, students were asked to solve "real-life" problems of varying degrees of difficulty. Several examples of such problems were:

- Pump failure in mid-span optical amplifier for long-distance fiber optic link.

- Optical receiver failure (no spare parts available for the entire receiver and the student must locate the internal faulty part).

- Break at unknown location in fiber optic cable.

- Laser degradation in an optical transmitter (no spares are available for the entire transmitter and student must locate the faulty part).

Fig. 3 shows an example of the trouble ticket sent to the students for the first case.
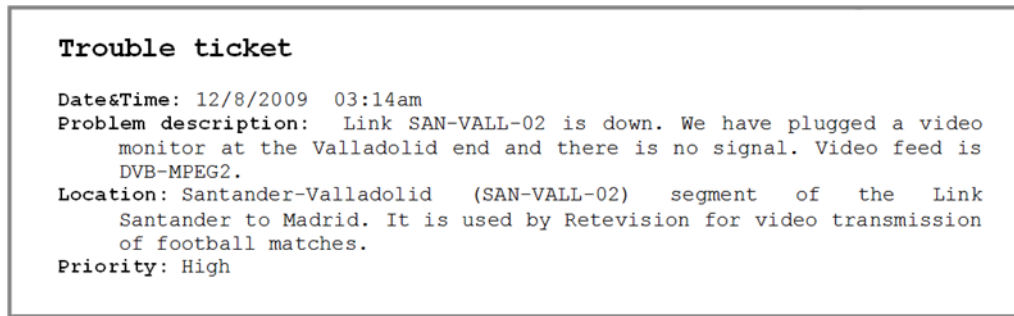
```
Trouble ticket

Date&Time: 12/8/2009  03:14am
Problem description:  Link SAN-VALL-02 is down. We have plugged a video
    monitor at the Valladolid end and there is no signal. Video feed is
    DVB-MPEG2.
Location: Santander-Valladolid  (SAN-VALL-02)  segment  of  the  Link
    Santander to Madrid. It is used by Retevision for video transmission
    of football matches.
Priority: High
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Fig. 3.: Example of trouble ticket sent to the students with a particular problem.

A total of 24 students participated in the activity. All 24 students were able to find and propose a corrective action to the proposed problem in a reasonable time and number of emails. In general, the students seemed motivated to complete the activity, their emails were well elaborated, and the response time was quite short, showing their willingness to participate at almost any time.

The average score for all the participating students was 8.3/10. For the students in the lecture courses, this activity was mandatory and represented 6% of their final grade. For the students in the lab course, this was an optional activity which could raise their final grade by 15%.

As the activities were carried out during a busy part of the semester, and our engineering students have a full weekly schedule, students were not required to reply within a particular period of time. For that reason, a concern of the authors was the number of emails and time required to complete the activity. Table 1 includes the mean number of emails required to complete the activity, and the student mean response time to the instructor's emails.

Table 1: Mean number of emails to complete the activity and mean response time to the instructor's emails.

Course	Number of student's emails	Student mean response time
Optical Communications Systems (working in groups)	5.4	t_{mean} = 2.9 days <1h 1..8h 8..24h >24h
Optical Communications Systems (working individually)	5.2	t_{mean} = 8,5 hours <1h 1..8h 8..24h >24h
Laboratory of Optical Communications Systems (working individually)	6.3	t_{mean} = 14.9 hours <1h 1..8h 8..24h >24h

Our study revealed a much longer response time when the students work in groups, as expected, due to the requirement of providing a common response. In some of the cases, the activity took 23 days in total to complete. Students working alone, on the other hand, were generally able to reply in real time, and only in a few occasions was the reply time greater than 24 hours. It must be noted that at any given time, more than one student shared the same problem to solve. To reduce the possibility of sharing information, an element of competitiveness was introduced: there would be a positive reward in the marks for the student finishing the activity first. This most certainly contributed to reducing response times.

Our study revealed two unexpected results: 1) The number of emails required to complete the activity was not greater when the students worked individually. 2) There was no appreciable difference in the number of emails exchanged by the students in the lab course. A smaller number of emails were anticipated for these students,

due to their previous knowledge of instrumentation and measurement procedures. However, this was not the case. This may be due to the fact that instrumentation in the aforementioned course is taught sequentially, and integration of the acquired skills to solve complex problems is not addressed. This supports the authors´ belief that practical skills should be learned in the context of real situations, and that specific competences-- such as choosing the right instrument or employing a problem-solving strategy-- do not emerge naturally from training in theory, but must be taught expressly.

Fig. 4 is an example of the emails between a student and the instructor, corresponding to the first case mentioned (Trouble ticket in Fig. 3). (As in the other examples, the emails have been has been translated by the authors from Spanish to English).

TECHNICIAN (**STUDENT**): Hi, my first questions are: What are the elements in this link (optical fiber segments, connectors, …); Which instruments do we have?; Do you know what the protective elements of the optical cable are?

STAFF AT NOC (**INSTRUCTOR**): Hi, I will try to answer all your questions: We don't have any documentation about the elements of this link; We have the following instruments: OTDR, OSA, BERT and OPM, but could rent another instruments if necessary; The optical cable seems to be certified for outdoor buried operation and it has been working for several years up to now. Regards.

TECH: Hi, Do we have information about the instruments (manufacturer, operation manual)? Thanks.

NOC: Hi, we have the operation manual of the OTDR, OSA and BERT. Attached to this email you can find them.

TECH: Hi. According to the symptoms, we should check the integrity of the optical fiber cable, maybe the fiber is broken. We would need to capture the trace with the OTDR. I would need the following information: trace from Santander or from Valladolid (better from both ends), with the following configuration: horizontal range of 200km, wavelength at which the link was operating, high pulse width for large distances, and medium averaging. Thanks and regards.

NOC: Hi, we are sorry for the delay but we had to send the field technician to Santander. The OTDR screen is attached to this email. It is measured at 1550nm (we do not have information about the operating wavelength, though). The instrument was configured in "automatic" mode. Waiting for your reply, regards.

TECH: Hi, clearly, the problem is due to a failure in the optical fiber link. There is an attenuation event of 10dB at 160km from Santander, resulting in a drastic reduction of SNR in Valladolid. The causes could be: degradation of the optical cable by a rodent, lightning, terrain movement, nearby works (excavations?) or failure of an optical splice. So, taking into account that, the proposed solution is: send people to the point 160Km away from Santander and have a look. If there is an optical connection, it should be inspected. The optical fiber should be repaired using your established protocols (I could provide basic guidance to do that). Waiting to your reply, regards,

NOC: Ok, I hope that your estimation of the distance 160Km be exact, because locating this point could be difficult (the cable is buried along the N-611 road). However, according to the map we have, there is a point of presence in the city of Osorno, which is 160Km from Santander, we will send people there. (…) One technician is there at this moment, He is telling me that there is a small cabinet with two optical cables (facing north and south), and there is a small rack with some electronic equipment. The card is labeled as "EDFA CRC2000". Any idea on what to do now?

TECH: Hi, I think that the electronic device is an optical amplifier, and, supposing that the optical fiber is not broken inside the cabinet, probably the EDFA have suffered some form of malfunction. There are two solutions: the optimal solution would be to substitute this amplifier for a similar one. If it is not possible, I propose to disconnect the card and to connect both ends of the optical fiber. This way, there will be no gain, but at least we could remove the 10dB losses. Waiting for your reply, regards.

NOC: We have asked to the people at the spare parts workshop and we don't have any at the moment, it must be very old. We could substitute for a new one but we would need to know some parameters, I don't think any amplifier would fit. It is a good idea to remove the card and connect the fibers, we have done that but the link is still down. We have put an optical power meter at Valladolid and read -38dBm. There is light, but the link is still down.

TECH: Hi, taking into account this information, I think that a new EDFA is required, because the optical power of -38dBm is surely below the sensitivity of the receiver. My first doubt is where to put the EDFA: in the cabinet at Osorno we could reuse the connectors. I think that locating the new EDFA in Valladolid is not a good idea, because the extinction ratio is very low and we would not be able to discriminate between the zeros and the ones. Anyway, the parameters of the new EDFA should be: noise figure between 3 and 6db (the lower the better), the gain is given by the following equation: G=S+38 (dB), being S the receiver sensitivity. If the sensitivity is not known, a gain of 30..40dB should be ok. If the cost of an optical amplifier is too much, we could think in an electrical amplifier and I will send its parameters. Regards.

NOC: If we need to insert a new optical amplifier, we would need to know a concrete commercial model, the cost is around 3,000€ and we cannot risk to buy something not appropriate. And I don't think is a good idea to guess the gain, if we damage the receiver, we are fired! :) We don't have the manuals of the receiver, but when the link was commissioned, they performed some tests and we have the results in a document: they tried to reduce with an attenuator the optical power reaching the receiver and they found that it needed -20dBm to work properly. So, if you propose a commercial model and an appropriate gain, we could buy one and try it. Waiting to your reply, regards,

TECH: Hi, I would need a measurement of the optical power levels at the cabinet in Osorno.

NOC: The optical fiber from Santander carries -22dBm.

TECH: Taking into account the last information, I propose to buy this equipment: AEDFA-23 from Amonics. It should be installed in Osorno with a gain of 40dB, this should produce a power level of +2dBm at the receiver. This power is probably too high for the receiver, so I propose to put an attenuator before the optical receiver in Valladolid, with insertion losses of 20dB to reduce the power at the receiver to -18dBm. If this option is too expensive, I propose to increase the power of the transmitter at Santander to +20dBm (I don't know if this is possible, and this could increase the effects of dispersion).

NOC: The transmitter at Santander does not have a configurable optical power output, but we have tried with the proposed equipments and it works! Thanks for your help.

Fig. 4.: Example of one complete conversation between the student (maintenance technician) and the instructor (staff at NOC) regarding the case of a mid-span optical amplifier failure.

Finally, the feedback given by the instructor is shown in Fig. 5. Its main objective is to point out conceptual flaws revealed from the replies and questions posed by the student, and to suggest additional material to solve the conceptual flaws.

After analyzing your conversation in this activity, I would want to point out some conceptual flaws that need a clarification. First, you propose to increase the power level of the transmitter to +20dBm. This is actually too much power for a typical transmitter (see chapter 3.2 of the course's material for typical values for the parameters of a fiber optic transmitter). Besides, increasing the optical power does not affect to the dispersion effect as you say, but could excite non-linear effects that distort the optical signals, pretty much like the dispersion effect (this is discussed at the end of chapter 2 of the course's material; some values of the threshold power for the nonlinear effects are given, it can be lower than +20dBm).

Your suggestion of an EDFA with 40dB gain AND a 20dB attenuator is difficult to justify, it is much easier and cheaper to reduce the gain of the amplifier (most models allows a configuration of the gain by the installer). Finally, you say that the optical level of -38dBm means a low extinction ratio, which is a conceptual error. Extinction ratio is the ratio of the power level of the ones with respect to the power of the zeros. Optical power levels are averaged by the instrument and are mean values. From those averaged measurements, it is impossible to know the extinction ratio, but in a simple optical link it is a magnitude that does not change once defined by the transmitter. A low optical power at the receiver means a high bit error rate (BER), not a low ER. Definition of extinction ratio is available at http://en.wikipedia.org/wiki/Extinction_ratio or chapter 3.2 of the course's material.

Fig. 5.: Example of the feedback sent by the instructor to the students with the conceptual flaws revealed from the exchanged emails.

4   CONCLUSIONS

An experience of online role-playing in engineering studies has been presented. In this proposal the students adopt the role of a maintenance technician in a large fiber optic network. The activity has been designed to maintain the key benefit of role-play teaching methodology--that of simulating a relevant professional situation--, and to circumvent the main obstacle to implementing role-play in engineering studies— the lack of common available time and space for students to interact. The instructor participates in the activity as a supervisor, who is able to provide information and measurements to the student. In this way the activity becomes a learning process rather than an evaluation tool.

Online role-playing has been tested over two consecutive academic years in Telecommunication Engineering studies as a learning activity for developing two specific competences: 1) How to operate specific instrumentation; 2) How to solve concrete problems in the event of a network failure.

According to student evaluations of their experience, students consider the activity of working in a "real-life situation" to be very valuable and relevant to their professional future. Most students feel the activity is closely related to the rest of the course, and that they have the theoretical background to carry out the activity. Students believe the learning objectives have been met. Students also feel they have gained valuable knowledge about instrumentation, available information and/or measurements in real situations, even if they (the students) have not interacted directly with instruments and networks. Another interesting conclusion is that the students are willing to answer the emails at almost any time during the day or night. This contrasts with our previous experiences, in which the students are often reluctant to engage in learning activities that require time outside the classroom. We believe that the requirement of many (but short) periods of time to reply to emails is best suited to the lifestyle of our students.

From the point of view of the instructors, the main problem is the work load, due to the need to reply quickly, and to keep up with students that reply in real time to the emails. However, the time required for the activity gradually decreases, as the same issues tend to crop up again and again with different students. Often with a simple copy, cut, and paste, the instructor can provide the same answer to multiple students with the same question.   Nonetheless, we recognize that this activity is difficult to carry out with more than a few students at a time.

One way to reduce the work load for the instructor would be to have students working in teams. In which case, however, the instructor would have to redesign the activity. We believe that considering more complex problems would allow (and lead to the need for) an explicit distribution of roles and tasks for the students, which should foster effective team work. In addition, periodic meetings with the instructor could help students to better understand the information provided, to acquire learning material, and to pose more effective questions. Another way of improving the activity would be to compile multimedia material illustrating real problems and cases, i.e. photographs of equipment, failures, videos with measurement procedures, etc.

In conclusion, the experience was considered very positive, and an efficient and engaging way of learning competences related to the instrumentation use and problem solving strategies. We think that it could be easily adapted to other contexts in engineering, such as maintenance in industrial scenarios involving electrical, electronic, mechanical or chemical problems, or troubleshooting of communication networks at a higher level (TCP/IP networks, for example).

5   ACKNOWLEDGEMENTS

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