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Communication Problems During Laboratory Work: Interaction Professor-Student and Student-Student

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One of the most basic aspects in laboratory is communication. The way researchers communicate could affect the outcomes of their research. This article will investigate how problems related to communication can hinder the accomplishment of laboratory objectives. Also, we will present what behaviours, actions or measures during communication influence a laboratory practice development. For this research, the laboratories of Yachay University for Experimental Technology and Research were visited to witness different laboratory practices in the fields of biology and chemistry. Communication interactions between professor-student and student-student were recorded and analyzed. We discovered four communication problems that interfere with the normal development of the practices: (1) disrupted communication process, (2) lack of communication, (3) assumptions, and (4) non-verbal communication. Ways of increasing the possibility of success by controlling these problems, as well as factors that affect laboratory research are discussed.

Keywords: laboratory, teamwork, problems, communication, professor-student

L'un des aspects les plus fondamentaux en laboratoire est la communication. La façon dont les chercheurs communiquent pourrait affecter les résultats de leurs recherches. Cet article étudiera comment les problèmes liés à la communication peuvent conduire un laboratoire à atteindre ses objectifs. De plus, nous présenterons quels comportements, actions ou mesures au cours de la communication peuvent influencer le développement d'une pratique de laboratoire. Pour cette recherche, les laboratoires de l'Université Yachay pour la technologie expérimentale et la recherche ont été visités pour observer différentes pratiques de laboratoire dans les domaines de la biologie et de la chimie. Les interactions de communication entre professeur-étudiant et étudiant-étudiant ont été enregistrées et analysées. Nous avons découvert quatre problèmes de communication qui interfèrent avec le développement normal des pratiques: (1) le processus de communication perturbé, (2) le manque de communication, (3) les suppositions et, (4) la communication non verbale. Des moyens d'accroître les chances de réussite en contrôlant ces problèmes, ainsi que les facteurs qui influent sur la recherche en laboratoire sont abordés.

Mots-clés : laboratoire, travail d'équipe, problèmes, communication, professeur-étudiant

This research aims to contribute to establish communication as a crucial factor during the performance of laboratory practices. This will be done by presenting four communication problems found in the analysis of performance during laboratory practices. These problems interfere with the normal development of laboratory practices and thus their success. The goal of this research is to determine the actions and measures that can influence communication as well as to identify solutions that reduce those influences, in order to guarantee or at least facilitate the success of laboratory research.

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Laboratory Work

Laboratory Work (LW) is widely used in different areas related to science and technology development. It is usually viewed as a didactical tool in teaching since it aims to join theoretical knowledge with practical experience in order to develop skills of experimentation. LW can be present in any area where the implementation of scientific knowledge is necessary to solve problems through practical experimentation. LW includes preparing the apparatus, equipment, and substances required for an experiment, planning the experiment, carrying out the experiment itself, and obtaining and analyzing the outcomes.

The outcomes of LW are relevant because they lead to the improvement or development of products, processes or knowledge. In research and development laboratories, for example, the outcomes are indicators of success. To achieve these outcomes in the most efficient and reliable way, people involved in the

laboratory must perform and act in specific ways. These actions play an important role in the success or failure of the LW.

One place to start developing efficiency and reliability is in high level educational laboratory practices, which are primarily based on people's interactions and performances. Moreover, educational laboratory practices have other positives aspects. Teamwork not only helps increase performance and efficiency but also generates an affective experience, which leads to a greater cohesion among team members (Galegher & Kraut, 1994). In the case of laboratory work in teaching settings, all these benefits facilitate the progression of students into highly-skilled workers that perform efficiently in laboratories as members of a team.

Galegher and Kraut's work (1994), based on Hackman's work (1983), stated that success is ordinarily viewed as multidimensional, involving not only instrumental achievements but also individual satisfaction and the maintenance of the group as a performing unit. Thus, a successful laboratory practice can help increase well-being and satisfaction of the people involved in the laboratory. Lang, Wong and Fraser (2005), following the study of positive attitudes (e.g., leadership, understanding, helping/befriend a fellow student), established that they were directly related to the disposition of participating students.

Despite these positive features of LW in education settings, several studies have presented problems related to the use of laboratory practices for teaching purposes. They asserted that the cost of conducting experiments in current laboratories is higher compared to the one of classical lecture (e.g., facilities, materials and staff time; Gordillo, Guerrero, Gurtubay, & Guede, 2008; Reid & Shah, 2007). One solution proposed is the implementation of virtual laboratories. This idea is attractive when considering their accessibility, grade level of security and cost. Nevertheless, these types of laboratories present inconveniences since they are limited by model simplifications, such as the reduction of variables and/ or elements to decrease the level of complexity of an experiment. Calvo, Zulueta, Gangoiti, López, Cartwright, and Valentine (2009) highlight that experimentation in real-life laboratories, even in limited conditions, is a value added to the learning process.

The question hence remains of what can be done to solve the problems of cost without compromising practical experience in education.

Different aspects are present during LW, which can influence its outcomes and potentially lead to its failure due to an accumulation of minor events or errors. Wiegmann, ElBardissi, Dearani, Daly, and Sundt (2007) showed that a proper approach to study errors must consider: 1) environmental factors such as equipment design and/or environmental distractions; 2) social factors such as teamwork and communication; 3) supervisory issues such as training, staffing, and scheduling; and 4) organizational variables such as procedures, policies, and resources.

In our approach, we considered those four characteristics; nonetheless, we focused on social factors as the main aspect. It is necessary to understand teamwork and communication due to their relevance since these factors depend on a proper education development.

Teamwork

According to Kaifi and Noori (2011), teamwork is essential to every daily activity. That's why in the last half century, it has been studied in various contexts. Most modern organizations are multidimensional, including professionals from different areas. It is therefore primordial to understand the role of teamwork in these organizations. The concept of teamwork comprises various elements. Tambe (1997) explained that teamwork cannot be only considered as the union of simultaneous coordinated activities. Thus, it is first necessary to define teamwork to understand its important roles.

Kaifi and Noori (2011, p. 88) treat it as: "a tale of people with different skills coming together with a common purpose. [...] A team is composed of two or more individuals who possess any number of common goals. Exhibiting skill and workflow interdependencies, members combine their differing roles in the completion of a given task." Based on this, we simply define teamwork as the pursuit of common goals by two or more individuals, combining skills, knowledge, and resources; in addition to coordinating activities and interacting with each other in the same physical space.

As it was already expressed, laboratory involves more than just professionals working in the same room. Hoegl and Gemuenden (2001) analyzed several factors such as effort, communication, performance, mutual support and coordination during teamwork. They found a direct relation between teamwork quality and their performance. It should be noted that LW also involves daily interaction between professionals. Indeed, Kaifi and Noori (2011) mentioned that teams include social interactions as its main component. Social interactions are mainly based on communication, especially in LW settings. Kozlowski and Ilgen (2006) state that it is necessary for teams to coordinate and combine skill sets to increase their ability to solve tasks efficiently. To

adequately assess the quality of teamwork, it is imperative to identify behaviours that can affect this partnership (Manser, 2009). These behaviours can negatively influence team performance during LW, leading to unnecessary high cost outcomes or even not obtaining any outcome.

Communication

During teamwork, communication plays the important role of facilitating team coalition and interaction. Therefore, it leads to accomplishing the different objectives. On the other hand, a poor communication process can cause complications that can affect the team's effort to achieve its goals. Indeed, Katz and Tushman (1979) showed that communication and high performance are directly related to problem-solving in R&D laboratories.

Kraut, Egido, & Galegher, (1988) differentiated two types of communication. The first one is interactive communication which involves the ability to exchange information rapidly and adjust message responses to one's communication partners. The second one is expressive communication which requires the capacity to convey ideas considering not only semantic meaning but also contextual meaning (body language, intonation, background, etc.). Both types of communication are present during LW.

Expressive communication is used for project initiation-settling, interpretation of problems, goals definition and work planning (Galegher & Kraut, 1994). It is used to create a common mental model in the group (Leonard, Graham, & Bonacum, 2004). At the beginning of laboratory practices, expressive communication directly helps set objectives, establish how to achieve them and distribute responsibilities and work.

Interactive communication is mainly present during the development of LW. Thus, it can be related to the development and accumulation of errors, which can lead to poor laboratory practices and poor results. Nevertheless, it has not yet been treated in the laboratory setting although other settings have been examined, including aviation and health care, in which teamwork is an inherent element. Leonard, Graham and Bonacum (2004), Manser (2009) and Lingard et al. (2004) showed the importance of effective communication in teamwork to provide appropriate health care. They found a direct relation between communication failures and patient harm. Other studies such as Sexton, Thomas and Helmreich (2000) also examined the repercussions of stress, errors and teamwork in health care and aviation contexts. They found that hierarchy and differences in power between team members negatively affected communication. Nevertheless, to understand the importance of communication in teamwork, it is necessary to see some quantitative examples:

Aviation example. Mosier et al. (2012) analyzed data incidents from June 2009 to October 2011 from the Aviation Safety Reporting System (ASRS) and the National Transportation Safety Board (NTSB). In the ASRS data, communication problem factors appeared in 32% of the reports (out of 116) while in the NSTB's, 20% (out of 60 reports). They concluded that lack of good communication in teamwork might feed into procedural and decision errors. They emphasized the importance of communication in decision making since an inadequate communication process can jeopardize the sharing of critical information.

Health care example. Leonard, Graham and Bonacum (2004) showed that sentinel events (unexpected occurrence involving serious physical harm or death) reported to the Joint Commission for Hospital Accreditation were directly related to communication failures. Most of the occurrences (i.e., 75%) lead to patients' death.

These examples may be perceived as distinct from LW since LW is not directly responsible for people's lives as it is the case with health care. However, they show the importance of communication during teamwork.

Communication can also play an important role in the replication of experiments. Indeed, communication is essential in order to announce findings and methods and assure the possible replication of the research by any other research team. Vegas, Juristo, Moreno, Solari, and Letelier (2006) study the capacity to replicate when communication is limited or eliminated. They concluded that communication is needed to ensure successful replication, even if communication is limited to a couple of meetings.

Lastly, it is necessary to consider another factor such as the hierarchical relationship between students and teachers, and how it impacts LW.

Students and Professors' Relationship

Many researchers have corroborated that the interaction between students can change if they are interacting only with students or with students and professors. Zahn (1991) studied the effects of hierarchical relationships and physical arrangements on face-to-face communication. He emphasized the importance of communication in information processes and decision-making and how proximity, position, and exposure affect them. Two of his hypotheses focused on how status distance due to hierarchy structure was negatively related to exposure and communication time. Since laboratory settings can

also be considered as a hierarchy structure, this negative relation can exist. For example, the interaction time in a laboratory setting is more limited in the case of student-professor interaction than in students' interaction. This is due to fewer interactions between the student-professor since courses and laboratory time are limited. However, the interaction between students is greater because it includes overtime hours due to extracurricular activities.

Lang, Wrong, and Fraser (2005) pointed out the importance of analyzing teachers' behaviour and its influence on students' attitudes, since it has been understudied. Their work indicates that strict professors' behaviour is negatively related to students' attitudes. This strictness could complicate the interaction between students and professors which, in turn, can hinder expressive and interactive communication.

To summarize, teamwork has been studied in several settings showing the importance of communication as an inherent factor. The lack of communication in these settings has been related to hindering workflow, leading to errors and failures. Nonetheless, this analysis has been superficially made in LW, where unlike the health care and aviation settings, there is no qualitative or quantitative data. For this reason, this article focuses on analyzing communication, team work and hierarchical relations, and their relation to error and failures in LW. It also has the objective of considering the factors that can cause theses failures.

Method

This research is part of a bigger ethnographic research with the goal of highlighting what makes a research team successful. This project analyzes nineteen international centers in nine countries to organize innovative strategies transferable to Ecuador's social and cultural context.

During the first semester of 2015, for this research, we visited the laboratories of Yachay University for Experimental Technology and Research. Yachay Tech is a university created with the goal of changing the productive matrix of Ecuador — based on limited resources such as petroleum — to another one — based on unlimited resources like knowledge and technological development. For this reason, its educational program is based on the development of the characteristics of researchers with a vast experience in a laboratory environment.

Participants

The participants are students from the first semester of Yachay Tech University. Their main objectives are introducing and developing the main cognitive and motor skills used in LW (e.g., material use and procedures). Each training course involved thirty students, a head professor and a teaching assistant; and lasted from one and a half hours to two and a half hours. The participants' context information presented in this section was gathered with a survey.

The mean age of the students was 18.90 years (range 17 to 26; *SD* = 1.40). In total, the number of students that participated in the study was 148. Out of the 148 participants, 38.50% (*n* = 57) were females and 61.50% (*n* = 91) were males. The leveling course (optional course where students learn the basics in math, chemistry and physics) was taken by 76.40% (*n* = 113) of the students, 23.60% (*n* = 35) were working for the first time at the university, and 9.50% (*n* = 14) of the students took the first semester for a second time.

In total, 73.60% (*n* = 109) of the students reported that they had prior work experience in real laboratory conditions. Of these 109 students, 40.50% (*n* = 47) reported that they only performed microscope observations; 6% (*n* = 7) exclusively worked with chemical reactions; 50.90% (*n* = 59) had done both and 2.60% (*n* = 3) performed a different type of LW. Finally, 26.40% (*n* = 39) of the students reported to have not worked at all in a laboratory.

Procedure

This research aims to explore different communication problems that may occur during teamwork in laboratory internship. This study was based on ethnographic observations; it included the content analysis and the recording of laboratory internships, interviews with students and professors and the implementation of a survey. It facilitated the discovery of different problems within a context that can help elaborate possible explanations and solutions.

The observations of different laboratory practices were divided into five phases:

(1) Interviews with the head professor and with one or two students before the practical training. In this phase, the main information was obtained through open questions such as what practical trainings were about, what objectives to achieve, what the professor expects from the students' behaviour and performance and what innovative component was included in the practical trainings. There were also questions regarding the summary of the procedure and the importance of the correct use of tools given by the university.

(2) The second phase was the recording of the training courses. In this phase, two or more students pay particular attention to recording the training time while not interfering. The recordings were focused on

the material that was used, the students and professors' participation as well as the communicative interactions between student-student and professor-student.

(3) The third phase was interviews with the professor and two students after the practical training. The reason for the previous interview was to understand what the objectives and goals were. The subsequent focused on confirming achievements and reporting any problem found by either the professor or students.

(4) The fourth phase was the analysis of records to find communication problems and failures.

(5) The fifth phase was the explanation of identified problems. Students filled out a survey in which they explained the possible causes of these communication problems.

The main objective in these phases was to find the common difficulties related to communication that could emerge in any laboratory internships and the way these difficulties are faced by the participants (students and professors). The ethnography approach allowed us to observe different communication and behaviour facets that were common among the various work teams.

Analysis

The program ATLAS.ti (Scientific Software Development GmbH, 2017) was used for analyzing all gathered data. This software allows analysis of qualitative data such as interviews, field notes and audio-visual sources. It enables coding that is used to tag fragments of all collected data. It is also possible to comment on these fragments. Once all documents have been coded, this information can be categorized into qualitative findings based on a *Conventional Content Analysis* because it is best fitting for this type of research (Hsied & Séhannon, 2005).

In a first stage, the analysis of recorded laboratory internships was necessary to eliminate irrelevant data. It was made according to the steps illustrated in Figure 1 as explained below. It also enabled us to come up with the proper codes that were used for this research.

First, we eliminated any non-communicative interactions such as students' preparation for their internships, "logbook" preparation (i.e., a notebook where students wrote about the process, used materials and substances, obtained results and changes or faced problems related to materials and procedure during the laboratory internship), materials arrangement and the setting of used machines.

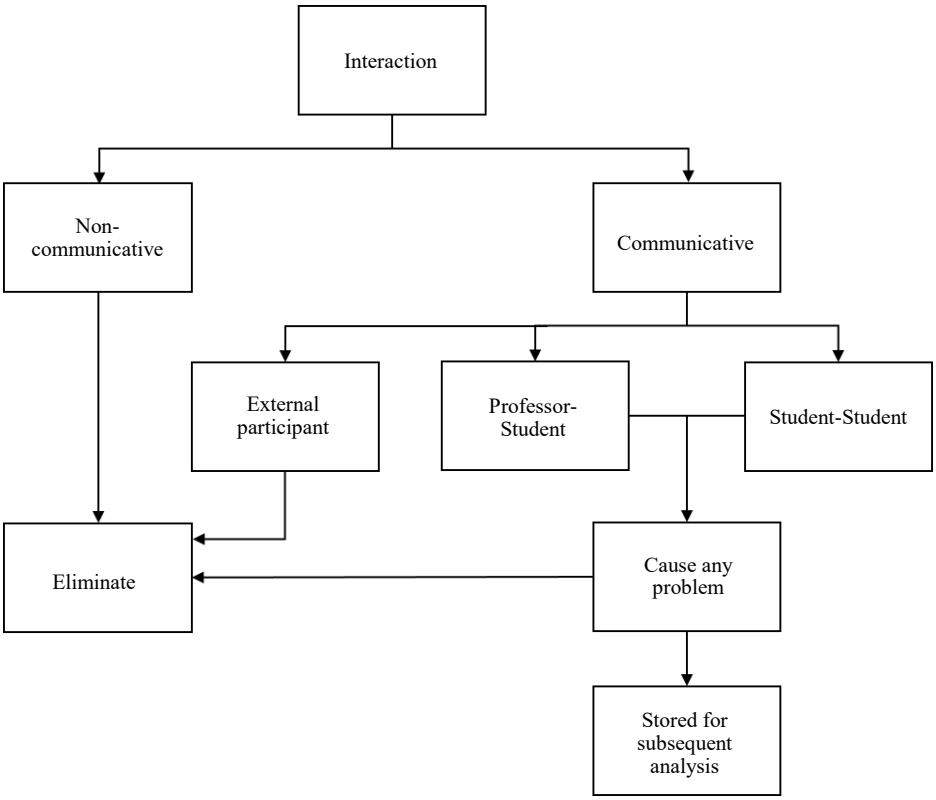

Figure 1. Steps for the analysis of laboratory practices.

Then, we eliminated any communicative interactions with external participants as they were not involved in the practical training. Additionally, any conversations among the students that was not related to the development of the practical training was also eliminated.

Finally, we analyzed the remaining communication interactions between students and professor-students in order to find the ones that interfered with the practical training. For this research, we considered these interferences as situations involving two or more participants performing an activity together, where communication was necessary but its implementation was not included or performed in a proper way, compromising the expressed information and the procedure. For example, a discussion among students on how to proceed once they did not obtain the expected results forces the students to communicate the possible causes or solutions to this problem. This situation illustrates a communication interaction that was not well performed. So, it did not end up in a solution or explanation of the raised problem.

The data was divided into four main categories: (1) disrupted communication process, (2) lack of communication, (3) assumptions and (4) non-verbal communication (see Table 1).

Table 1
Categories and Codes Used in Content Analysis

Categories	Codes
Disrupted communication process	Unfinished ideas
	Distraction
	Silence
Lack of communication	Lack of attention
	Disinterest
	Noise
Assumptions	Doubts
	Solutions
	Inquiring
Non-verbal communication	Meaningless sounds
	Hand signs
	Exchange glances

Based on this analysis, these communication problems were identified and named as the categories shown in the *Results* section. Nevertheless, until this point, there was not any possible causes suggesting an explanation of these findings. Thus, a survey was made to gather the students' opinion on the laboratory context since a laboratory is a dynamic environment with a hierarchical structure. It was filled anonymously to avoid any bias.

The survey consisted of fourteen questions, including open and closed questions. The first five questions were related to background information (age, sex, semester, exoneration and repeaters). The next two questions were related to previous laboratory experiences and the type of performed practicals (microscopy, chemical reactions or another type of LW). The last seven questions asked the students' opinion on laboratory hierarchy, trust development, expressiveness, communication and the possible causes of found problems depending on the involved participants (students, professors or both).

Since some of the questions were open-ended questions, a content analysis technique was employed. We used a *Content Analysis Technique* (Yildririm, & Simsek, 2005) as it is considered a proper tool to analyze qualitative information (Dikmenli, 2009; Kaleli-Yilmaz, 2015). This technique enables the separation of the information into its components, and then it analyzes its components for similarities or common factors. Dikmenli (2009) also showed that this data analysis technique provides reliable results in many studies (Hirvonen & Viiri, 2002; Kaleli-Yilmaz, 2015; Pekmez et al., 2005).

Data

At the end of the laboratory internships, over 140 forty minutes of video, 200 pictures and 148 surveys were collected. This data were saved into an online database that can be accessed by any student with the authorization of the head professor. It made the analyzing, commenting and sharing of information easier. Through the database, other documents were shared such as requests for visitation, papers regarding similar studies, encryption codes and timetables.

To organize the data obtained, an intuitive encryption code was presented and implemented. It took into consideration the initial type of data (images, videos or audio), type of laboratory (chemistry or biology) and type of information source (preliminary professor interview, preliminary student interview, practices development, latter professor interview or latter student interview).

The contribution of the data collected can be divided into three main groups. First, interviews (videos and audio) helped the contextualization of the laboratory internship. Second, the laboratory practice recordings were the main source of qualitative data related to the real-life interaction of the participants (students and professors) in a laboratory condition; thus, they helped to find the communicative behaviour and problems that could be recognized. Lastly, the survey filled out after the laboratory internships was about the students' background information and their ideas related to hierarchy, trust and communication development. This qualitative and quantitative information gathered in the survey helped explain the problems that emerged.

Results

Once the analyzing process finished, four different communication aspects that could influence the laboratory internship were determined: (1) disrupted communication process, (2) lack of communication, (3) assumptions and (4) non-verbal communication.

Disrupted Communication Process

Disrupted communication process was defined as any aspect causing the communication process to end or causing an interference with its normal flow. Students and professors demonstrated this when they tried to perform the practical training. In the survey, students reported many causes of hindrance in communication between professors and students (see Table 2 for an exhaustive list).

The main responses from the students were: fear of being wrong or mocked (19.60%, $n = 29$), lack of trust with the professor or other students (15.50%, $n = 23$), lack of organization and equipment (14.90%, $n = 22$), professor's attitude (13.50%, $n = 20$) and lack of knowledge or topic misunderstanding (10.80%, $n = 16$). They also reported that the number of students is related to the lack of organization and equipment (13.50%, $n = 23$).

For example, during a laboratory internship, the professor tried to explain to a group why they were using a specific material (i.e., powder to absorb moisture). During the explanation period, the professor visited another group (group B) in order to obtain more material to give to group A, perceiving lack of organization in that group. She then proceeded to distribute the material. During the time the first group of students was without her supervision, they started talking among themselves. When the professor came back, she had to repeat her explanation.

Lack of Communication

Lack of communication is defined as a problem in the transmission of a message to a recipient. Lack of communication can be caused, for instance, when one seeks the attention of another person or simply because one feels unable to express an idea. In fact, 55.40% ($n = 82$) of students reported to have experienced trying to express an idea, but they felt not being heard.

Among the most significant responses are distractions (21.70%, $n = 32$), unimportance and disinterest from their colleagues (22.30%, $n = 33$) as well as not expressing concerns in a proper way (16.90%, $n = 25$). Distraction, in this case, is also linked to the number of students per internship. Students reported that they did listen to some concerns, but did not answer them because they were considered insignificant or unimportant. Among others reasons, one reported that students ignored the concern when it was not clearly expressed.

An example of distraction was found during the performance of a reactive-product laboratory internship. In this internship, students had to manipulate some substances required in a precise amount. Students were unsure about having the right information although they had received it at the beginning of the internship. A first possible reason for their uncertainty was that during their different tasks, students became immersed and did not pay attention to the professor's speech. A second possible reason was that the professor would have had to assist every student, which was impossible due to lack of time. A third possible source of this problem could be observed when several students tried to find a solution when an issue occurred. Consequently, they started to share their ideas and did not pay attention to what others were saying.

An example of a concern not properly expressed along disinterest from colleagues was evident in internships where students expected certain results. Some students reported, in the survey, that they do not express themselves due to fear of derision or to being intimidated by their colleagues and other figures of authority. In fact, as it is shown in Table 2, 57.40% ($n = 85$) of students reported this situation as being caused by lack of trust among classmates and 31.80% ($n = 47$) reported that the cause could be fear of derision.

In the case of students-professor students reported in the survey that they did not pay attention to the professor's directions due to distractions (39.20%, $n = 58$) or to disorganization (12.20%, $n = 18$). In addition, 19.60% ($n = 29$) did not understand the professor's instructions. For instance, disorganization was caused when students did not pay attention to a classmate's speech in which he was trying to communicate a problem and give possible explanations.

Nevertheless, once these barriers were removed, students started to set aside these problems and began to express their concerns. This situation was illustrated when one student decided to ask a common question that the majority of classmates also had regarding the setting of a machine. Once he asked his question, the others continued with theirs.

Assumptions

The third aspect is a result of the two previous problems (disrupted communication process and lack of communication). When the students did not ask, nor express any problems, they tried to keep the

Table 2
Frequencies (and Percentages) of Answers to the Survey Questions

Answer	*n* (%)
What can hinder communication between students and professors?	
Fear of being wrong or mocked	29 (19.60)
Lack of trust in the professor or other students	23 (15.50)
Lack of organization and equipment	22 (14.90)
Professor's attitude	20 (13.50)
Lack of knowledge and comprehension about the topic	16 (10.80)
Other	15 (10.10)
No reason	11 (7.40)
Eloquence	8 (5.40)
Distraction/Disinterest for the class	4 (2.70)
Did you ever express a concern and nobody else listened/answered you?	
Yes	82 (55.40)
No	66 (44.60)
Why would someone not listen/answer someone else's concerns?	
Distractions	32 (21.70)
Other reasons	31 (20.90)
Unimportance and disinterest	33 (22.30)
Not clearly expressing the concern	25 (16.90)
Noise	13 (8.80)
Inopportune moment	8 (5.40)
Fear of being wrong or derision	5 (3.40)
Not knowing the answer	1 (0.70)
What can cause students not to express their concerns to their classmates?	
Lack of trust	85 (57.40)
Fear of derision	47 (31.80)
Other reasons	16 (10.80)
Why would you not pay attention to your professor's instructions?	
Distraction	58 (39.20)
Do not understand	29 (19.60)
Disorganization	18 (12.20)
Others	16 (10.80)
Boredom	14 (9.50)
Fatigue	11 (7.40)
Disinterest	2 (1.40)
Do you think there is any distance created by power differences between students and professors that can hinder students from expressing their concerns?	
Yes	26 (17.60)
No	122 (82.40)
With whom do you tend to develop trust, your classmates or professor?	
Classmates	129 (87.20)
Professor	19 (12.80)

Note. $N = 148$.

internship going on. The problem gets worse when the assumptions are accepted by the group. This becomes an issue as students are more likely to trust their classmates than the professor.

In fact, the majority of students reported that they preferred expressing their doubts among themselves before expressing them to the professor. Nevertheless, 82.40% (n = 122) of students think that communication between them and professors is not affected by the hierarchical structure and the difference in power (see Table 2). So, why do students prefer to express their doubts to other students?

This was explained in the survey where 87.20% (n = 129) of students reported to be likely to develop more trust with their classmates than with their professor (see Table 2).

This is an example of this problem: the students were unsure if they had the correct amounts of reactive products, so one of them assumed that the measurement A was wrong. If the rest of the group had agreed with the student, they would have obtained wrong results. This time, the group did not agree with her, and they verified every measurement leading them to realize that she was wrong and that it was actually measurement B that was wrong.

Non-verbal communication

In the present research, non-verbal communication is defined as any way to express an idea among participants without being stated literally. This definition thus includes cases where incomplete sentences communicate an idea.

During their LW, some students asked questions to the professor. During these specific verbal communications, three different examples of non-verbal communication were observed: (1) a student completed a professor's sentence before the professor did; (2) a student understood a professor's request without being completely stated; and (3) communication between the professor and students involved only affirmative statements to express an idea. Even if these three cases are a consequence of a verbal communication process, the information transmitted was unclear.

In the first example, the professor explained what material was necessary to use. The student relied on context to understand what the professor was about to say. She acted accordingly before the professor finished his explanation. Then, the professor confirmed what the student had already assumed. In the second example, the professor asked a student to go to a certain page. Nevertheless, she did not finish her request nor did she state the page number. However, the student understood what the professor was referring to. As for the third example, the professor explained to the student what he was supposed to do. However, after a certain period, both the student and professor stopped talking and did not mention what the task was; they simply began to make affirmative statements.

Discussion

Our study supports the finding that failure of teamwork communication is one factor that contributes significantly to errors and team performance degradation (Wiegmann, ElBardissi, Dearani, Daly, & Sundt, 2007; Tambe, 1997). The results of the current study established a parallel between communication problems found during teamwork in LW and other well studied settings, such as aviation and health care, where analyses of reports of sentinel events indicate that teamwork failure are caused by communication problems (Leonard et al., 2004; Manser, 2009; Sexton et al., 2000; Mosier et al., 2012). The current work also supports Vegas et al.'s (2006) conclusion of communication as a necessary and indispensable element for experiment replication. The problems found in the current work ended in changes in process, which are not reported and leading to lower chance of experiment replication.

At last, the following problems were found: (1) disrupted communication process, (2) lack of communication, (3) assumptions, and (4) non-verbal communication.

Why Are They Problematic?

The problems found in the current work can be linked to Lingard et al.'s (2004) work, which explained why communication failures are problematic during teamwork in the operating room. These problems are summarized in Table 3.

In the case of disrupted communication process, students' loss of attention can lead to delays and inefficiency problems since the professor has to resume the activities and repeat information already stated. Another problem is the students' lack of attention resulting in a loss of interest in achieving the task and, in turn, affecting the internship flow. Moreover, the time lost was unnecessarily increased due to these problems and pushed students to accomplish the laboratory internship in less time than the one originally assigned, thus increasing their chances of failure.

Table 3
Problems Found by Lingard et al. (2004) During Teamwork

Problem	Consequences
Inefficiency	Communication failure requires team members to redo or undo a procedural step; step requires more action or discourse than usual
Tension	Emotional responses to a communication failure; may ripple to other members/ environments

The problem related to lack of communication is that relevant information is not expressed since some students do not express their doubts or they prefer to do it away from the group, which is not beneficial for the internship. The amount of shared information in a group has shown to be related to the success of such group (Orasanu & Fischer, 1992). This unexpressed information can lead to procedural errors, inefficiency, tension and inconvenience. In this case, inconvenience may affect students, which can make them feel despised. Some causes of this problem, according to students, are linked to the attitude of other students or professors, short duration of the internship, lack of organization, great number of students, lack of interest, external noise, and lack of other people's attention.

The realization of assumptions leads the laboratory internship to obtain different unreliable results due to the possible changes made during the process. These changes are not usually reported because students think either they are right or they do not want to be exposed to possible repercussions from other students or the professor. The source of this mistrust comes from the lack of trust and the fear of derision. It reduces the reliability of the obtained results and the possible replication of the experiment causing procedural error and resource waste. It can cause a workaround problem since students may accept these practices of making assumptions as a standard practice.

Non-verbal communication involves information that is not explicitly stated, leading to assumptions. For example, a professor and a student do not express which substance should be changed. Lingard et al. (2004) found a similar communication failure named as a content failure. These problems mainly included cases where relevant information was missing, or inaccurate information was exchanged, which led to inefficiency and resource waste.

Non-verbal communication can be also related to a strong relation among people and often facilitates the communication process as shown in the next section. However, in a sensitive and changing environment as a laboratory, it is necessary to express and record any interaction that can lead to a change in procedure.

Are They Always Problematic?

Some problems allowed students to improve and reaffirm their knowledge because they could also be used as indicators of other problems as it was shown in Lingard et al. (2004). These problems forced the students to go over the procedure and material in order to find what was wrong, which led to finding other problems that had not been considered until that point of the procedure.

For example, a problem resulting from lack of communication led a student to make an assumption regarding the right measurement of a substance. Even though the student was wrong in her assumption, she decided to go over all the measurements, leading her to find another problem. This demonstrates that problems or concerns that are stated worked as a useful tool in finding other errors and reassert the right information since a problem was noticed during the procedure.

Another similar beneficial situation can be seen when doubts are expressed to the whole group: they allow the students to clarify those doubts. It also encourages other students to discuss other problems with the professor. In that way, it improves their knowledge in addition to the laboratory internship. Being said, an important aspect that can help the laboratory internship to be successful is to express, correct and reaffirm information in front of the whole group involved.

Finally, there is a behaviour that has not been yet discussed in any field even though it can be seen in various contexts besides laboratory internships. In this case, the student completed beforehand the professor's sentences. This was beneficial since it obliged the professor to confirm whether or not the information was correct. In this situation, the student was right and the professor confirmed the information by repeating it. However, if the student had been wrong, the professor would have had to correct her and thus understanding would have been ensured.

Possible Solutions

Wiegmann, ElBardissi, Dearani, Daly, and Sundt (2007) pointed out that errors captured immediately are more likely to be detected by the same person who committed the error. Nonetheless, when these errors are not immediately captured, they are more likely to be recognized by someone else. In both of these cases, it is necessary that involved people feel free to speak up. Leonard, Graham and Bonacum (2004) state that hierarchy, power distance, lack of psychological safety, and cultural norms frequently inhibit people from speaking up. Thus, it is necessary to improve the relation between student- and professor-student.

As it was shown in the results section, students tend to develop trust more easily with other students than with their professors. Thus, it is necessary to focus more on the latter. As a result of developing trust with the professor in charge, students would feel more comfortable in expressing concerns that would have felt embarrassed to communicate before. Additionally, it can also increase cooperation and promote higher performance and competitive advantages (Jones & George, 1998).

It is also important to monitor team performance to avoid teamwork failures in order to reorganize and reallocate resources to meet any contingencies (Tambe, 1997). LW students and professor should go over and confirm information several times during the procedure to make sure it is right. This is common in health settings where standard protocols are used in order to verify the correct development of procedure.

As it was shown in the lack of communication example, the appropriate assertion was not used, which resulted in no one realizing the problem they were having. Leonard, Graham and Bonacum (2004) showed a useful figure that illustrates a model to guide and improve assertion in the interest of patient safety that can be extrapolated to LW. The first step of this model directs the attention to the person that tries to express a concern — attention that is often not given as demonstrated in our results. This is the way for assuring that the information is correctly emitted and received.

In the internship, we saw that if the information needed for everyone was given to the entire group in an understandable manner, there would be no need to repeat it. Thus, it is required that the presentation of necessary information be done during less critical times, where students are more available in order to reach more students.

Another thing to focus on is the necessary material for research internship. It should be prepared and distributed correctly on time. Lack of preparation and incorrect distribution of material caused professors to lose students' attention. To avoid this, it could be suggested to create a previous request/delivery register process. This process must include information about the material needed and used, its quantity, people or groups of people who require it as well as the dates it will be needed. This process ensures that the material would be on time and correctly distributed.

Assumptions can be avoided by giving the necessary information for the internship and allowing participants to have access to it during work time. Students in laboratory internships did have this kind of resource, but the frequency of its usage was negligible. It is therefore necessary to develop a different form of this particular resource. It could be, for instance, writing information easily seen from any point, such as a board. Hence, any change made could be noticed by anyone. Nevertheless, this must be checked from time to time to ensure that the information is correct.

Finally, another possible solution is the implementation of pre-laboratory exercises. These exercises aim to reduce information load for students. They must be able to stimulate the students' thinking, encourage students to express themselves, verify that procedures have been read and understood, link procedure and concepts with the knowledge taught, offer experiences in planning as well as reducing the gap among LW, lecture experiment, and application (Reid & Shah, 2007).

Different Backgrounds

Up to now, it has been shown that it is necessary to avoid communication problems during any laboratory internship or research because they are detrimental to time and resource management. However, this can be contrasted with different cases; one of them is practices focused on knowledge dissemination.

Practices performed to instruct and acquire new knowledge or even to encourage people for science usually do not care about these problems. It is because in order to teach something, professors give greater freedom during performance of practices. It allows students to become more aware of LW. It could not be possible if practices just consisted on tracing predetermined steps. In research practices, it is different due to the protocols researchers have to follow to standardize the obtained outcomes. Another reason for giving this freedom is because materials typically used in these laboratory internships are not so expensive. One of the main reasons to allow students to make mistakes during internship is to let them repeat the experiment until the expected result is observed; they become more experienced and confident. This kind of practice is focused on calling the attention of students' curiosity. However, once the students got to a higher position in their career, the cost of materials and substances increases, thus the freedom given to them is reduced.

Another laboratory field that is not affected by these communication problems is medical LW for the analysis of medical samples. In these laboratories, people must follow strict protocols that have been established beforehand. Then, communication does not play an important role in the development of analysis, but it is important in sample collections and in the result report. Problems that arise in this type of laboratory are related to material management.

Limitation of the Research

In the previous part, different communication problems that affected the performance in the laboratory internships at Yachay Tech were presented. This data from various groups in similar laboratory internships helped describe, in a superficial way, problems that appear during the development of each practice. In order to obtain more data to improve and reaffirm the results of this research, it is necessary to have a larger frame that includes participation of

university laboratories from other fields and other socio-cultural contexts. Nevertheless, the data collected in this particular study can serve as a stepping-stone to improve the way laboratory internships function.

It is necessary to mention that this is a qualitative research; thus, it has inherent limitations due to its nature. The information gathered in this research depends on the conditions of the setting and the participants. Therefore, it is difficult to extrapolate produced knowledge to other contexts. Rigor is harder to maintain, measure, and demonstrate despite the researchers' proximity to the subject of study. It is not easy to ensure validity of obtained results unless there is a large enough data from a disparate group of subjects. Additionally, the results may have been influenced by researchers and participants' personal biases and idiosyncrasies. These limitations can be reduced by replicating the research with larger groups and different conditions. By doing so, it could help generalize the obtained results.

Conclusion and Future Work

Four different communication problems were found: (1) disrupted communication process, (2) lack of communication, (3) assumptions, and (4) non-verbal communication. To solve these problems, we suggest the establishment of rules before any internship in order to create an organized environment as well as to encourage researchers' participation.

This research was limited to the short sample of laboratory researches we had access to due to the development of Yachay Tech. Another problem was the lack of literature related to this topic. On the other hand, this research gives a basic idea of present communication problems in different field practices. In the future, as part of a bigger ethnographic research, we wish to analyze a more significant data supplied by witnesses in different laboratory internships for research groups in various universities.

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