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ANALYSIS OF COMMUNICATION MANAGEMENT IN A DISCRETE EVENT SIMULATION PROJECT IN AN HIGH-TECH MANUFACTURING COMPANY

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ABSTRACT

There are many projects using discrete event simulation as a decision-making tool. However, it was found in the literature that these articles are related to improving the execution of projects, not studying issues related to the management of simulation projects. From this perspective, this paper used concepts proposed by the PMBOK® to drive the management of communication between members of a simulation project and stakeholders. To achieve this goal, a real simulation case in a manufacturing company was studied. The steps of communication structure were followed and an Action Plan was elaborated and applied in this project. One of the outcomes of this effort is a communication model that was proposed for simulation projects. A questionnaire was applied to evaluate the proposal, results showed that simulation analysts judge communication aspects in their projects to be very important, and is related to the success.

1 INTRODUCTION

Discrete Event Simulation (DES) is a powerful tool applied to study dynamic and complex systems (Robinson, 2005). White and Ingalls (2016) say DES is an experimentation with a model, the model imitates some salient aspect of the behavior of the system under study and the user experiments with the model to infer this behavior.

Montevechi et al. (2015) affirm that there are some systematics presented in literature which aid analysts in the development of simulation projects such as Mitroff et al. (1974), Banks et al. (1998), Carson II (2005), Law (2006), Sargent (2010), and Balci (2011). This systematics have the objective to aid simulation specialists in developing their projects showing a structure that they may use to construct their model. For example, a three stage structure was proposed by Montevechi et al. (2010) that enabled dividing a simulation project into three stages. The first stage is the conceptual, which is responsible for defining the objectives of the simulation and construction of the conceptual model. The second phase is the implementation in which the conceptual model is converted into a computational model using a simulator. Finally, the third stage is the analysis, where the results of the analysis are being performed.

This systematics are very helpful to simulation specialists by helping them avoid some mistakes and reworks. On the other hand, there is a dearth of research studies in the literature on managing simulation projects. The authors could not find any studies related to comprehensively managing simulation projects considering aspects such as scope, time, people, costs, interested parts, procurements, risk, quality, human resources, and communications.

According to Sturrock (2014), development of a simulation project goes further than just building a computational model. It requires the ability to go beyond the knowledge of a specific simulation tool to develop a comprehensive model. Balci (2011) claims the key to success in a simulation study relies on following a structured, complete, and well organized methodology. Rabechini Jr. (2001) says the success of a project also depends on meeting deadlines and budget, meeting end customer needs, and better understanding the organization's environment. The same author points out that it is important to have clear goals, good communication, organized task planning, adequate and motivated human resources, appropriate monitoring and leadership.

Langnon (2009) mentions that the success of a project is related to failure because there is no consensus about the definition of success and failure. In this sense, Keelling (2002) and Sotomonte (2012) point out some aspects that lead to failure, such as incorrect estimates and unrealistic plans, poor scope definition, incomplete communications, and little integration between time, cost and quality.

According to PMBOK® (2013) the ability to communicate is essential to ensure the understanding of information throughout the lifecycle of a project. It is clear that all aspects (scope, time, people, etc.) are important for the success of a project. Of these, the communication aspect is considered a vital aspect, which can assure synergy between the stakeholder's needs and development team because an entire project cannot be properly executed without communication. The effectiveness of communication and the consequential success of projects considering the communication factor has been described in several papers, such as Carvalho and Mirandola (2007), Chaves (2015), and Sotomonte (2012).

Using this as a context, the objective of this paper is to present an analysis of communication management between development team and stakeholder in a real case of simulation project executed in a manufacturing company. To achieve this goal, the action research method was followed and the communication process was developed in this project.

This article is divided into six sections. The first section contextualizes the research topic. The second section presents basic concepts of Discrete Event Simulation, Project Management, and Communication. The third section shows the research method. The fourth section explains the application of the research method. The fifth shows the results. The final section presents the conclusions.

2 LITERATURE REVIEW

2.1 Discrete Event Simulation

According to Burse et al. (2015), simulation is a powerful tool that can be adapted to business context to help manage production and other operations. Siebers et al. (2010) state that in recent decades, the use of discrete event simulation was the most applied tool in operational research.

Wagner (2014) points out that the simulation of discrete events is applied to simulating real-world systems. According to Rutberg et al. (2015), DES is a computer modeling tool which replicates complex systems, allowing interventions that can be studied without compromising the real world with changes without knowing the effects of the changes.

Banks et al. (1998) state that simulation is the imitation of a process or system in the real world over time. This involves creating an artificial history and reviewing of this history to make inferences about the characteristics of the system operation. For Balci (2011), simulation is the act of experiencing or running a model under some aspects trying to achieve a predetermined goal.

Harrel, Gosh and Bowden (2000) define each component that is part of a system, Entities, which are items that are processed throughout the system, such as products, customers, and documents. Banks et al.

(2009) define entity as an object of interest within a system, such as parts and/or clients. Activities are the tasks that are being executed in the system, involved directly or indirectly in the processing of entities. For Banks et al. (2009), an activity corresponds to the specified period of time for which an entity undergoes some operation or processing. Resources are the elements that are used to execute the activities. They provide the support facilities, equipment and personnel to perform the activities. Controls are considered the parameters that indicate how, when, and where the activities are performed, and they specify the rules of the system.

2.2 Project Management

Project Management (PM) can be defined as a disciplined application of knowledge, abilities, tools, and techniques in order to attain the requirements of a project (PMBOK, 2013; Turner and Müller, 2005). According to Larson and Gray (2016), PM is a powerful set of tools which helps in the planning, implementation, and management of activities to achieve some specific organizational objectives.

In this context, it is important to define what is a project. A project is defined as "a temporary endeavor undertaken to create a unique product, service, or result" (PMBOK®, 2013). Andersen (2016) claims that a project can be seen as a way of making a unique product where the main focus is delivering on time, within budget, and with specified quality. Additionally, projects can also be looked upon as a temporary organization working in close interaction with a permanent organization, where the main focus is supporting the value creation of the receiving organization. Shenhar and Dvir (2007) have shown that projects are managed, planned, organized, and controlled in different ways. It is also very fundamental to capture empirically all the activities required to achieve success in a project (Pinto and Winch 2016).

According to Kerzner (2016) and Nasir et al. (2015), there is a structure of Project Management called PMBOK® Guide, which is important and internationally known. According to Dinsmore and Cabanis-Brewin (2009) PMBOK® is the first and entirely new set of knowledge in Project Management published by the Project Management Institute. Patah and Carvalho affirm that this Guide is one of the complete set of methods which presents content related to projects, value, project office, and strategic aspects of Project Management. PMBOK® has established a standard for the practice of PM. It unfolds into ten areas of knowledge in a project. These are integration, scope, procurement, time, human resource, interested parts, communication, cost, risk, and quality. The same author affirms that the study of these areas improve the management process and contribute to the success of a project.

2.2.1 Communication Management

Communication Management (CM) includes the processes required to ensure that information related to a project is planned, collected, created, distributed, stored, retrieved, managed, controlled, monitored, and finally arranged in a timely and appropriate form. An effective communication creates a bridge between the different stakeholders of the project, connecting various cultural and organizational contexts, different levels of experience, perspectives and interests in the implementation of the outcomes (PMBOK®, 2013).

According to Chaves (2015), communication is the relationship established by the transmission of stimulus and the responses provided. It is a voluntary process, where two agents transmit and/or receive messages, and may involve unconscious elements.Projects are carried out by people, who use communication to understand how they should develop tasks and fulfill the established objectives. Thus, communication uses exchange and sharing of resources capable of promoting mutual understanding, essential element in the management of any enterprise (Chaves, 2015). According to PMBOK® (2013), most communication skills are common for overall management and project management. So understanding and using the communication process correctly is fundamental to good project management.

There are communication models, techniques, and tools that may be applied to project management in order to aid the interaction and synergy among members. The utilization of these communication

concepts helps with the management process and contributes to the success of the project.

3 RESEARCH METHOD

A wide range of complementary methods has been employed to study communication management over time. In this paper, we utilize the communication methodology provided by PMBOK® (2013), which presents three main stages that can be used to aid the communication process.

1. Plan communication management which is the process of developing an appropriate approach and a communication project plan based on the information needs, requirements of stakeholders, and organizational assets available.
2. Manage communication consists of the process to create, collect, distribute, store, retrieve, and provide information about the project according to the communication management plan.
3. Monitor communication is the process of monitoring and control of communication throughout the entire project lifecycle to ensure that the information needs of the stakeholders are met.

4 APPLICATION OF RESEARCH METHOD

4.1 Object of study

The object of study is a simulation project which was developed in a manufacturing company with an external team of simulation analysts. The project was named Neotropic, with the purpose of developing computational models of two production lines, proposing and executing improvement actions from the application of the techniques of Discrete Event Simulation and Value Stream Mapping. The company studied is located in Itajubá, Brazil, and produces electronic products composed of scanners, collectors, and tags of the brands "Sem Parar®" and "ConectCar®".

4.2 Plan Communication Management

The Neotropic project started in January, 2015 when the partnership between the manufacturing company and NEAAD - Advanced Studies Center for Decision Aid was formed. Initially, a diagnosis of the study was conducted to understand the system, production lines, objectives of the simulation, people involved in the process, and stakeholders and their expectations. There were scheduled weekly meetings between the leadership of the company and NEAAD members to understand the project needs, to establish the methodology, and to define the project scope.

Through the synergy and agreement among members, it was possible to clearly define the project objectives, tools to be used, and some additional information on the project. From this, an Action Plan was created. This plan addressed the management of project communication. The plan involved establishing important tasks that should be followed to achieve a good communication of the project. The Action Plan is showed in Table 1.

Table 1: Action Plan for communication management of the Neotropic project.

#	Actions Tasks
1	Identify the stakeholders
2	Consider environmental factors
3	Analyze requirements for communication
4	Define communication technologies
5	Highlight communication models
6	Identify communication methods

7	Define information management systems
8	Establish meetings
9	Report performance
10	Analyze expert judgment/ brainstorm

4.3 Manage Communication

In this step, the communication plan is executed and managed by developing all the action tasks established in Table 1. The tasks highlighted in Table 1 were performed based on PMBOK®'s concepts and they are described in this paper.

The first action task consists of identifying the stakeholders. According to PMBOK® (2013), the identification of stakeholders is the process in which we recognize people, groups, and organizations that can impact or be impacted by a decision or task of a project. This process also consists of analyzing and documenting relevant information related to interests, the level of engagement, influence, and potential impact on project success from the associated members.

In the beginning of the project, the main associated members involved in the system were identified. The Project Manager opted for this team's structure based on the required abilities for the development of the tasks. Table 2 shows associated members, covering the development team and stakeholders.

Table 2: Associated members of the project.

Development Team		
Position	**Function/Responsibility**	**Quantity**
Project Manager	Coordinate all activities of the project	1
Tutors	Guide the implementation of activities	2
Information Technology Professionals	Develop/implement the information technology tools to conduct the project as information systems	3
Trainees	Execute the activities and collect the data	2
Stakeholders		
Position	**Function/Responsibility**	**Quantity**
Coordinator	Coordinate all activities of the project in parallel with the Project Manager	1
Production leaders	Answer questions necessary for the development team	3
Professionals from national purchases, human resources, sales, and inventory	Provide information requested by the development team	Based on requirement
Staff from production lines	Provide information on the process	Based on requirement

The second action task is related to the consideration of environmental factors. These factors are linked to the conditions and aspects outside of the control of the project team that may influence, restrict or direct the project. The enterprise environmental factors vary greatly in type and nature depending on the project. Thus, this information was agreed in defining the scope, with the leadership of the company.

The third action task consists of analyzing the requirements for communication. According to PMBOK® (2013), this part determines the information needs of the associated members. These requirements are defined using the combination of the type and format, and analyzing the value of this information. As a result, a fundamental component of planning the actual project communications is determined and limitations are placed on who will communicate with whom and who will receive what

information.

Data sources used to identify and define the communication requirements include organizational charts, an organization of responsibilities, relationship among people, departments, courses, and specialists involved in the project. Figure 1 identifies the communication structure utilized among associated members. The arrows in Figure 1 represents the direction of the information and communication flow during the project.

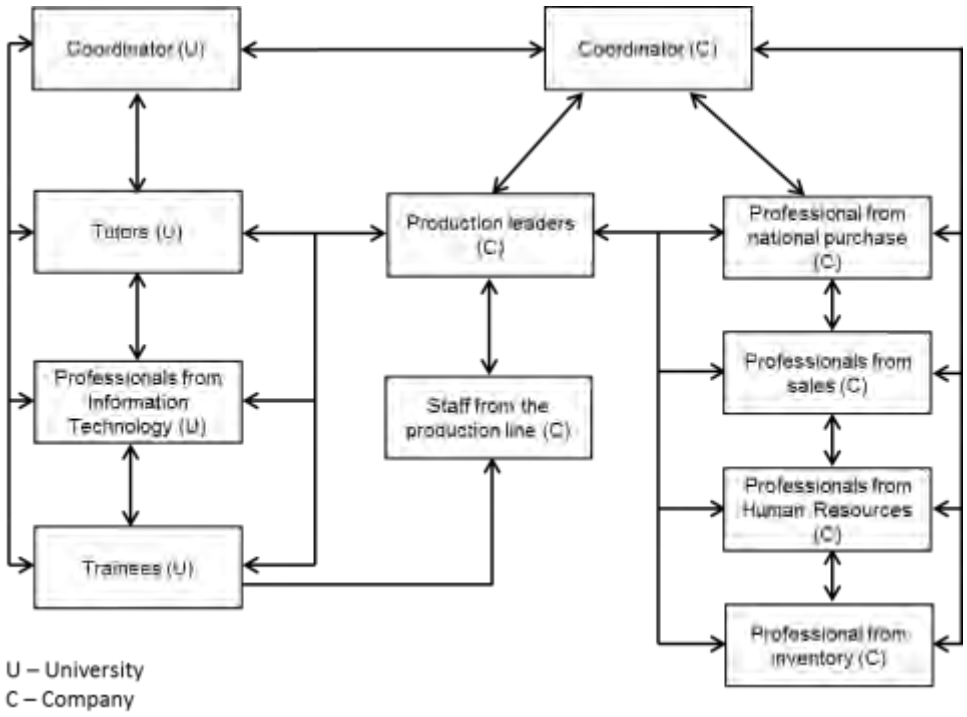

Figure 1: Communication flow among associated members.

The next action task is the definition of the communication technologies. Methods used to transfer information among associated members may vary significantly, thus these methods can be selected considering aspects such as information urgency, technology availability, ease of access, and project environmental, and confidentiality of information (PMBOK®, 2013). Observing these aspects, the main communication technologies utilized here were tools such as e-mails, an information management system, and a web-based management system for project tasks.

The fifth and sixth actions refer to the study of communications models and methods. PMBOK® (2013) claims that communication models may vary depending on the project. The basic communication model that was adopted in this study consists of two parts, defined as the sender and receiver. The communication model is illustrated in Figure 2. The basic model was used along with the interactive communication model, which is based on communication between two parts. These parts are performing a multidirectional exchange. It is considered the most efficient way to ensure a common understanding of all associated members on specific topics.

The seventh action consists of defining the information management system. As mentioned earlier in the fourth action, there were two systems to manage the communication. The first system used to manage the communication of the Neotropic project was called GC_Simula®. This system works with the management of files and is the principal communication tool to access the information from the project. The second system is a web interface which is called Redmine®. This system manages the tasks and

deadlines of the project, and also has a management focus with specific tools for a Project Manager such as Gantt chart and task execution reminder.

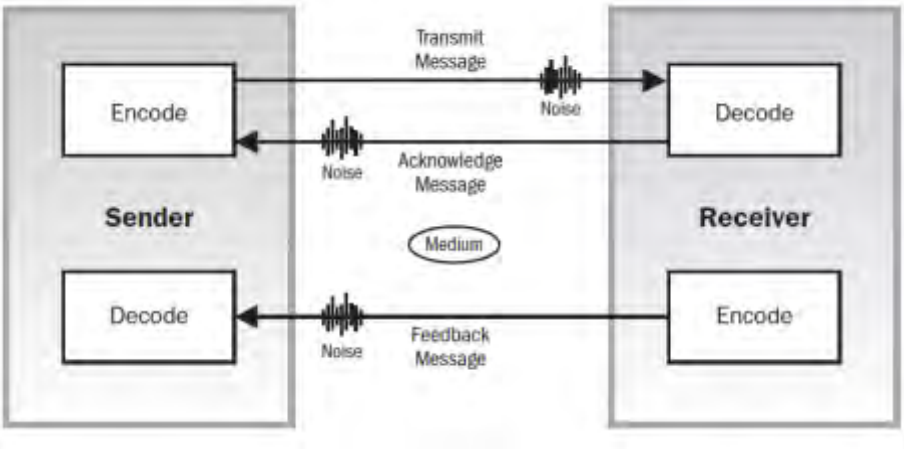

Figure 2: Communication basic model. Source: PMBOK® (2013).

4.4 Monitor communication

This stage corresponds to the process of monitoring and control of communication throughout the entire project lifecycle to ensure that the information needs of the project stakeholders are met. From this point of view, the monitoring conducted in this project was performed by meetings, which is the eighth task.

Meetings are part of the project communication control. It facilitates discussion and dialogue with the project team to determine the most appropriate way to communicate performance and respond to information requests from stakeholders (PMBOK®, 2013). Meetings are considered the strong point of this project. It was decided that there should be weekly meetings between the associated members of the development team in order to present the progress of the project, determine the next steps, and evaluate the performance. The meetings enabled scheduling of monthly meetings with the stakeholders to show the current results at the end of each month. As a way of formalizing these meetings, minutes are written about the points discussed during the meetings and, also, the next steps that should be performed along with their respective responsible persons. These minutes are stored in the Redmine® system for future reference. The last two actions, performance reports and expert judgment/brainstorm, were developed in the next section where evaluation of communication could be qualitatively measured.

5 RESULTS

From all the discussion and application of the concepts of communication management in this project and as a result of this study, it is possible to propose a structure for the process of management of the communication of Discrete Event Simulation projects. All this contextualization is summarized in Figure 3, which presents the communication model developed for this project.

This structure is divided into two parts. On the left side, there are members from the University who are responsible for developing the project. They are called Senders. On the right side, there are members from the Company who are expecting the results of the project. They are called Receivers. Senders encode the message and transfer it to the receivers. The receivers decode the message and confirm the receipt to the senders. Then, receivers read the message and send the feedback about the message to the senders. The lower part of the figure shows the communication tools used by the members. On the left side, there are formal and informal communication tools used among members from the University. On the right side, there are formal and informal communication tools used among members of the Company.

In the middle, there are formal and informal communication tools used among members from the University and Company.

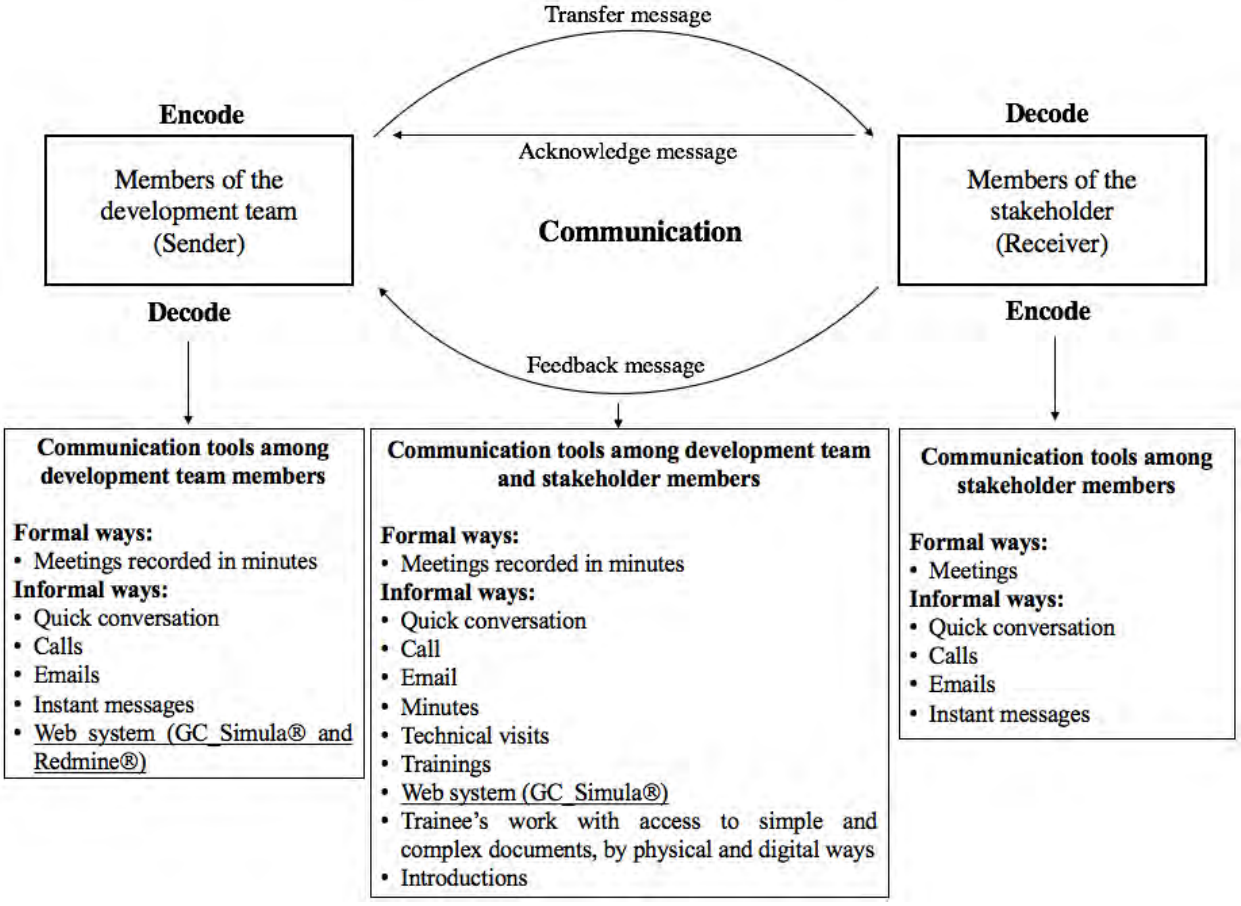

Figure 3: Communication structure among associated members.

The management of project communication is part of project management field. It cannot be considered that all the results obtained from the execution of this project were due to the improvement of the communication process. It is difficult to measure the specific contributions of communication management. Here, in order to perform a qualitative evaluation, a questionnaire was developed with the objective of identifying the main contributions of this communication process. The questionnaire also addressed other issues that are not the primary focus of this paper. The answers provided by the respondents are presented considering the factor of communication in the Neotropic project.

There were four questions where the respondents could choose among five options (Extremely important, Very important, Important, Little important and It is not important). The questions were related to the importance of the communication process. The first question is about the importance of the definition of members of the project. The second investigates the identification of the communication model. The third question intends to establish communication tools. The fourth one studies the control and monitor of the relationship among members. The fifth question asks about improvements of the communication process. A totally of seven responses were obtained. All the questions and responses are presented in Figure 4.

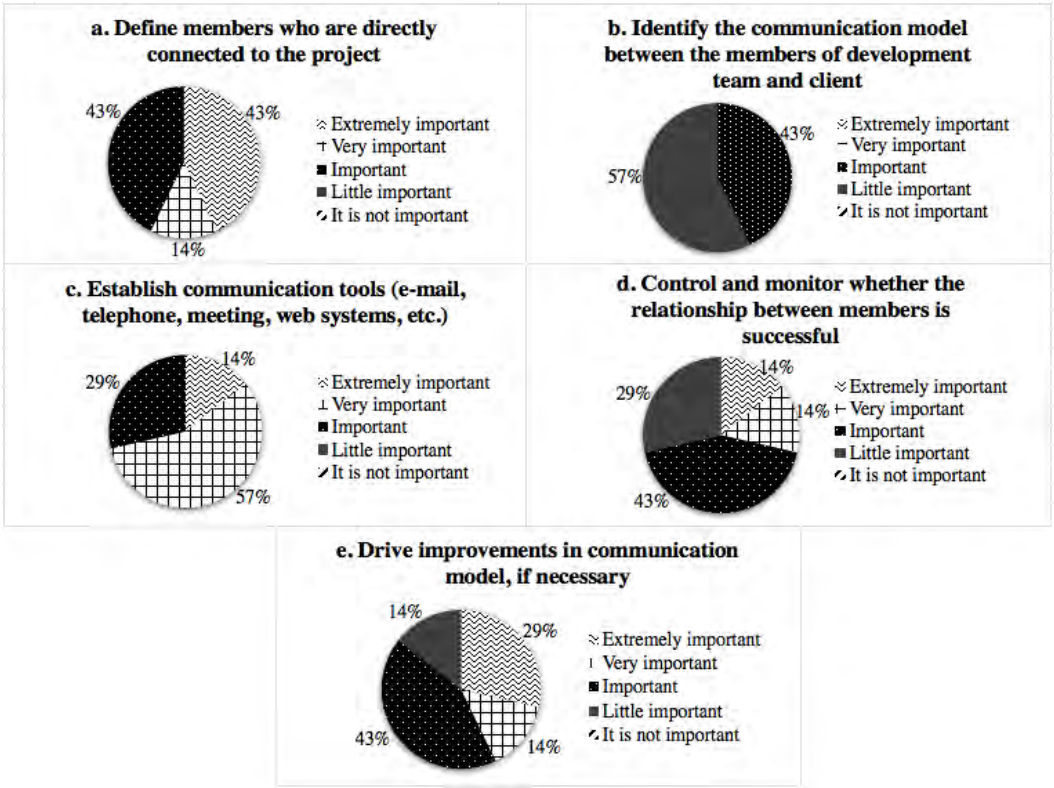

Figure 4: Responses of the communication process.

From the analysis of the graphs in Figure 4, it can be observed that respondents consider important communication issues within project management. Questions a and c, which define people involved in the project and establish the communication tools, all the respondents judge them extremely important, very important and important. For questions, b, d, and e, some respondents judge as little important questions on the communication model, control and monitoring of the relationship, and application of improvements of the communication aspect. There are others respondents that judge them as important aspects. Despite some respondents judging them as little important aspects, the proposal to include the communication factor within this simulation project is an important point to consider and to study.

Finally, a descriptive question was added into the questionnaire. The question was "How do you describe the communication aspect within Neotropic project?". The responses were summarized in just one paragraph. "Members of the Neotropic project had no problems with communication aspect. GC_Simula® allowed the files to be shared from a single location which had improved the communication process. Members also used an informal social network to facilitate (streamline) the communication. Meetings allowed all members to follow the tasks, to present problems, to define solutions, and to establish new tasks to be executed. Information systems and email could facilitate the interaction among members of the University and Company. Redmine® aided the Project Manager to follow the execution and deadline of the tasks".

6 CONCLUSIONS

This paper studied a real simulation project which had the objective to apply Discrete Event Simulation and Lean Manufacturing techniques in order to improve the production process in a manufacturing company located in Itajubá. This paper proposed to analyze the management process of this project, focusing on the communication aspect, which is considered one of the most important points for the success of a project.

To achieve this goal, the steps of communication structure proposed by PMBOK (2013) was followed. These steps were plan communication management, manage communication, and monitor communication. Initially, the object of study was analyzed and a first diagnostic was prepared. Subsequently an Action Plan was performed. This Action Plan had ten action tasks which were developed for the execution of the project.

Action tasks of the plan consisted of identifying the stakeholders, considering environmental factors, analyzing requirements for communication, defining communication technologies, highlighting the communication models, identifying the communication methods, defining the information management systems, establishing meetings, reporting the performance, and analyzing expert judgment/brainstorm. All these action tasks were executed.

By the execution of the communication steps, a communication structure summarizing all the communication process executed in this project was proposed. This communication structure was divided into two parts, senders are members of the University and receivers are members of the Company. To manage the communication among all members, some tools were used in order to facilitate and improve this process. In this case, two web systems were utilized during the project, and others tools, such as emails, meetings, and instant message also contributed to the communication process.

A questionnaire was prepared and deployed to the members of the University and Company to collect the feedback of this proposal. This questionnaire focused on the communication aspect within this simulation project. From the responses obtained from this questionnaire, it was identified that respondents believe that the study of the communication can help the management process and help achieve success in any project.

Finally, this paper could contribute to Discrete Event Simulation and Project Management fields, showing an application of these two concepts in a real simulation case. As discussed earlier, there were no papers addressing this issue until now. From this perspective, this paper can be considered as a first discussion including the study of these areas and it is also a contribution for simulation analysts who wish to make improvements and create successful projects.

As a future work it is suggested that the communication structure might be replicated in other projects in order to evaluate its applicability and practicability. We also suggest that further information about the complexity and the validation processes of the model can be discussed, as the results found in other related papers on communication aspect.

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