COBEM UBERLÂNDIA 2019

ABCM Associação Brasileira de Engenharia e Ciências Mecânicas

25th ABCM International Congress of Mechanical Engineering
October 20-25, 2019, Uberlândia, MG, Brazil

COB-2019-0927 - USE OF ACTIVE LEARNING AS A TOOL IN RELIABILITY-CENTERED MAINTENANCE DISCIPLINE

Wildson Santana de Melo[1]
Fernando Diógenes Bezerra Batista[2]
Universidade Federal Rural de Pernambuco – Unidade Acadêmica do Cabo de Santo Agostinho – Rua. Cento e Sessenta e Três, 300 – Garapu – Cabo de Santo Agostinho – PE[1,2]
wildson.melo@ufrpe.br[1] nandodiogenes03@gmail.com[2]

Adriano da Silva Marques[3]
Universidade Federal Rural de Pernambuco – Unidade Acadêmica do Cabo de Santo Agostinho – Rua. Cento e Sessenta e Três, 300 – Garapu – Cabo de Santo Agostinho – PE[3]
adriano.marques@ufrpe.br[3]

Abstract. *Lately it has been discussed how Engineering education could evolve. Some teaching techniques have emerged in order to improve the teaching-learning experience within the Engineering courses, in addition to developing technical and social skills in the students. The present work aims at presenting a interactive classroom activity that made use of active methodologies to facilitate the understanding of subjects such as the Exponential distribution of the discipline of Centered-Reliability Maintenance in the undergraduate course in Mechanical Engineering at Universidade Federal Rural de Pernambuco Campus UACSA¹. To accomplish the interactive activity, the students were divided into groups where they simulated a production line of a candy. After the simulation, the obtained data were collected, analyzed and discussed in the room, using concepts of reliability systems. The concepts of exponential distribution were used as the basis for the analysis of the results. In addition to the analyses carried out, a growing interest and understanding of the concepts addressed in the lecture were observed, when the students themselves were able to relate the theory to its practical meaning. It is worth emphasizing that the interactive activity can be applied in other subjects related to the discipline, covering the entire discipline, and can be replicated to others. It was also observed the improvement of students' transversal skills, such as: teamwork, sense of organization, verbal and written communication, leadership and management practices.*

Keywords: *Engineering Teaching, active learning, maintenance, reliability, exponential distribution.*

1. INTRODUCTION

In Brazil, the demand for engineers grows every day, the more time goes by, the more companies look for newly graduated professionals with specific skills that can be both technical and social. These include leadership, communication, analysis and problem solving as well as decision making (PEREIRA-GUIZZO and NOGUEIRA, 2015; Carraro et al., 2016). In this context, it is important that the engineering course stimulates the student to develop these skills, and the best environment for this is the classroom, where you should simulate situations close to reality. Even with good technical training, students need other stimuli to develop the cognitive skills needed to meet the demands of the labor market. The development of these skills is directly related to the teaching method used in the courses (BARBOSA and MOURA, 2013).

Among the teaching methods, two stand out: the traditional method (lecture) and the active teaching method. The conventional method, centered on the teacher as the content holder, is still used by many education professionals, and despite its importance has raised discussions about the results obtained. Blinkstein (2010) suggested that it is harmful to know that students are harmed and led to believe that they are incapable when the problem is in the system and not in the students.

On the other hand, the active teaching method is centered on the student who learns from problems and develops knowledge with the help of the teacher. The active methodology is based on developing the process of learning from simulations or real experiences, giving conditions to successfully solve the activities (BERBEL, 2011). As a benefit, teachers can use alternative methodologies to reduce student insecurity (MORAES, 2018). In addition, Parreira (2018), speaking about learning efficiency, cited: students who share their experiences, reflections and interact with colleagues and teachers, tend to promote better evolution. Thus, the application of the active method combined with the conventional method can lead to improvements in the teaching-learning system and make the classroom experience more enjoyable and effective.

Among the techniques used to apply the active method, Problem-Based Learning (PBL) is a strategy that aims at producing individual and group knowledge, which cooperatively uses techniques for understanding and solving problems under the guidance of a Tutor teacher. The student must acquire the ability to manage self-learning and develop a sense of criticism and reflection of knowledge, which is not memorized and / or imposed, to reach the process of understanding (SOUZA and DOURADO, 2015). The use of the active teaching method seeks to bring students closer to real situations by stimulating critical thinking and physical and cognitive skills (PONCIANO, GOMES and MORAIS, 2017).

In this paper we present active teaching tools to enhance the Reliability-Centered Maintenance (RCM) learning, besides evaluating the qualitative results of the process, discussing how it was useful to add this method to the course. Siqueira (2005) defines reliability as the probability that an item will survive in a certain period of time. In addition, Leemis (1995) says that the reliability of an object is equal to the probability of performing the task for which it was efficiently performed. designed. Fogliatto (2009) draws attention to how the concept of reliability is directly linked to probability. Therefore, the reliability of a system or item will always have values between 0 and 1, it also states that the classic probability axioms can be used in reliability calculations.

One of the issues addressed by RCM is the use of reliability probability distributions to estimate parameters and times to failure. The method selected for this work was the exponential distribution model, known within the area as a practical model of working because of its simpler equations and having a constant risk rate, i.e. the risk of failure does not vary with time.

Other applications of this distribution can be seen in other areas. Pereira and Dantas (2017) use the exponential distribution to assist in the modeling of queues. Exponential modeling for fault distribution represents the behavior of many real applications, albeit at a constant failure rate (KUO and ZUO, 2003). Other works also use the exponential model as a reliability tool for the manufacturing process of electronic components involving shear stress testing (MENDONÇA and CAMPOS, 2013). The present article aims to present a interactive classroom activity in order to maximize the understanding of the theories and tools of the Reliability Centered Maintenance discipline, especially what involves the concepts of Exponential Distribution. The work was developed and performed in the mechanical engineering course of the Universidade Federal Rural de Pernambuco - Campus UACSA. One of the most pleasant surprises was the ability to practice and develop cognitive skills in students, because it was possible to simulate a factory environment, simulating a production line with its problems and conflicts. The use of active methodology transforms traditional teaching, making it more attractive through a interactive activity with playful tools to detect and analyze a gummy candy production problem.

2. METHODOLOGY

The interactive activity was planned in order to respect the time of a 50-minute class. For each stage of the activity a time for execution was stipulated, as described in Tab. 1.

Table 1. schedule of activity to methodology of active learning.

Steps of activity	Time (minutes)
Theoretical basement and Exponential distribution	10
Groups division	5
Material distribution and Problem contextualization	5
Time to execution of the practice	10
Analyses and obtained data discussion	20

Source: Elaborated by the authors.

Table 2. Characteristic equations of the exponential distribution used to generate the activity graphics.

Characteristic equations of the exponential distribution	
Mean time to failure	$MTTF= 1/\lambda$
Hazard function	$h(t) = \lambda$
Reliability function	$R(t) = \varepsilon^{-\lambda t}$
Probability density function	$f(t) = \lambda * \varepsilon^{\lambda t}$

Source: Adapted from Fogliatto, 2009

The students received a brief explanation with concepts and equations about the Exponential distribution to develop the interactive activity. The equations used for data processing are presented in Table 2.

After introducing the concepts, the following problem was suggested: A gummy candy Packaging machine is programmed to pack single-flavored candies, eventually a failure occurs and the established flavor changes to the package. When this occurs, the machine restarts and the process return to normal. Your job is to map machine activity and provide data using the exponential distribution model.

To develop the interactive activity and simulate the gummy candy manufacturing process the class was divided into five groups with four students. The classroom represented the production line and the student groups the machines. The materials assigned to each group were: three empty plastic bags, a bowl and a form for entering the raw data. The form contained the name of the group members, amount of correct gummy candy placed in the bag before the first error, amount of correct gummy candy after the first error and before the second, amount of correct gummy candy after the second error and before the third, thus establishing the values for the bag filling cycles. In addition to the lambda value (λ) that was previously defined.

In total about 250 two-color gummy candy mixed in a 10: 1 ratio were used and randomly distributed in the bowls of each group.

After the materials were distributed, the students simulated the work of a machine by randomly removing the candy from the bowl and filling the bags. Each gummy candy (or jelly beans) of the predominant color meant a machine success, and each gummy candy of the other color in addition to an error defined the end of a cycle. The intervals between a success and an error were measured and recorded on the form. The entire procedure was performed randomly and was completed by filling in the three bags given to each group.

The forms were collected and one of them was randomly chosen to have their data processed in a program developed in Python language for this purpose. The graphs generated were analyzed with all teams using the exponential distribution concepts previously exposed.

After the completion of the course, a survey was conducted among the students who participated in the dynamics in order to quantify and qualify the influence of the teaching method used. This research was conducted through an online form containing simple information about the student optimizing the response time and facilitating data collection.

The questions were formulated from the KISS ("keep it short and simple") principle, where what is important should be brief and effective. This principle is little used in academia although widely used in satisfaction and agreement research in companies from various sectors. The “principle was developed” by Kelly Johnson who sought to develop simple, quick ways to solve technical problems. At first KISS is recommended to use simple sentences, omit unnecessary details and use paragraphs for each idea.

In satisfaction surveys, the intention is to understand the consumer what really matters to him. Using this principle in satisfaction surveys, it is recommended to ask the following question: Can a 150 character question be asked with 75? If the answer is yes, do so, as it will favor a better understanding of the phenomenon under study.

Simple questions may not be fully understood. Therefore, some decisions have been made about the format of the answers. In general, there are three types of response format: open, multiple choice and dichotomous. In open answers, the respondent is not limited to a list of alternatives and is free to answer in his own words. In multiple choice questions respondents should choose one or a group of them. Dichotomous have a bipolar character.

In closed questionnaires, such as the last two types, there is no possibility of measuring opinions without using a scale. The Likert scale presents a series of five propositions, from which the respondent must select one, which can be: totally agree, agree, indifferent, disagree, totally disagree. The numerical satisfaction grade scale uses scores from 1 to 5, where 1 is the highest degree of satisfaction and 5 is the lowest. These two scales were used in the questionnaire. They are widely used in closed-ended questionnaires and satisfaction surveys, being more limited and oriented towards directly understanding the respondent's opinion. For these scales to be used the questions must be straightforward, which relates to the KISS method used in formulating the questions.

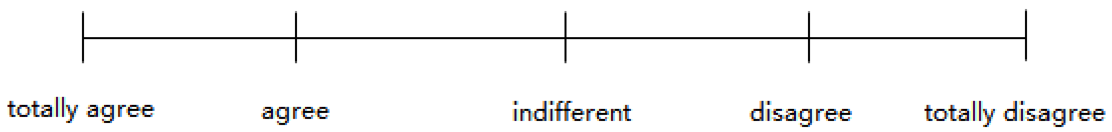


Figure 1. Likert scalet. Source: Elaborated by the authors.

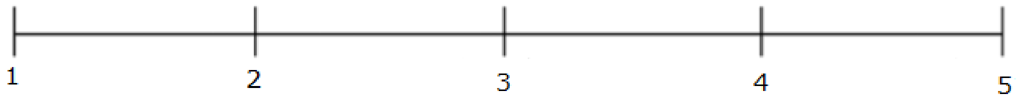


Figure 2. Numerical scale of satisfaction. Source: Elaborated by the authors.

The questionnaire was divided into two parts, with 4 questions each and multiple choice answers using the Likert scale. The first part with numerical answers related to the degree of satisfaction and the second part related to the agreement or disagreement of the question.

The questionnaire used was as follows:

Part A

1. Has the information about the content been passed on clearly?
2. Was it possible to establish a relationship with a real situation from the interactive activity?
3. Did the simulation of a production line make the subject easier to understand?
4. Have your content questions been resolved as expected?

Part B

5. Do you agree with the time it took for the application of dynamics?
6. Does the use of gummy candy in the interactive activity facilitate the exposure of the content?
7. Do you agree with the repetition of this interactive activity in the next classes of the discipline?
8. Do you agree to the use of interactive activities in engineering education?

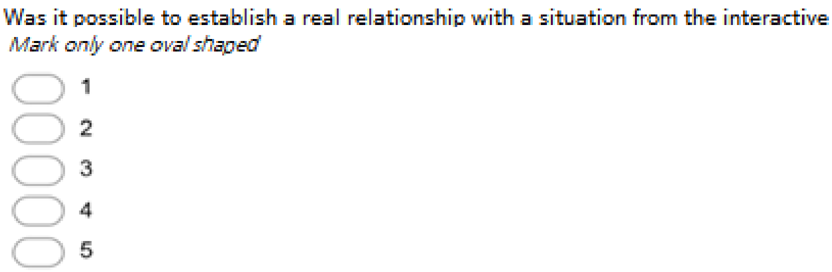
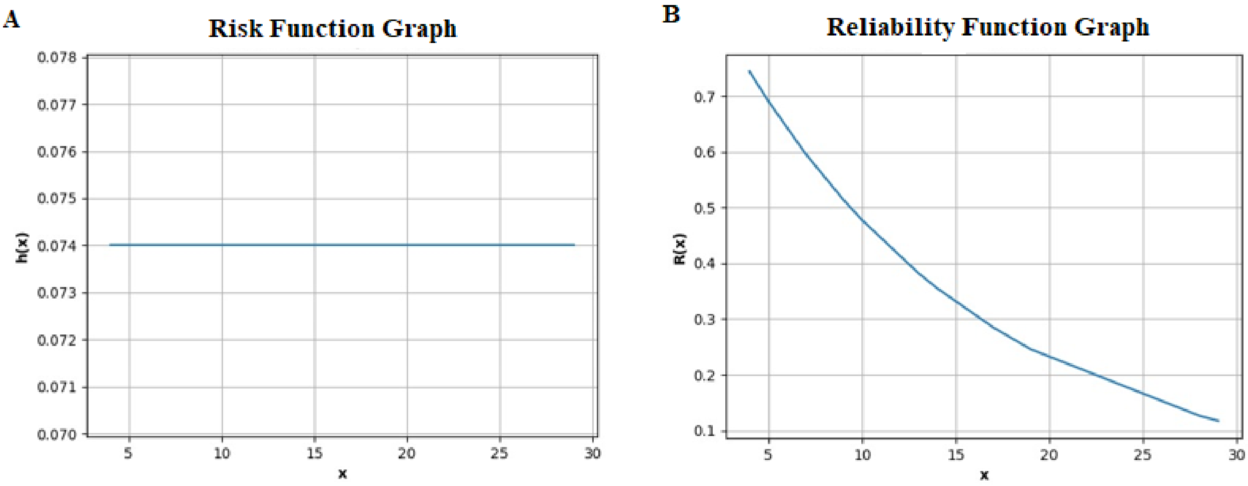


Figure 3.Examples of the questionnaire Part A.
Source: Elaborated by the authors.

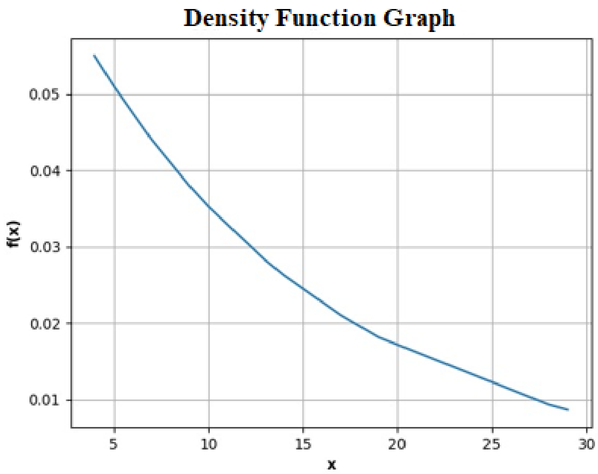
The questionnaires were collected, saved in a datasheet and then graphed for analysis and discussion of the results.

3. RESULTS AND DISCUSSION

The graphs presented were debated, the students came to a conclusion about each graph and its meaning. It is important to start thinking about how to make this model more frequent in engineering disciplines. The graphs generated from the data obtained in the dynamics are presented below.



Graph 1. A: Risk of failure of the candy machine (jujubes – jelly beans) in relation to the time of use; B: Graph 2. the reliability function of the candy machine (jujubes – jelly beans).



Graph 3. Probability Density Function of the candy machine (Jujubes – jelly beans).

Graph 1 represents the Risk Function h (t) showing that the risk rate does not change over the cycles, and that the distribution chosen was appropriate to the situation. Although the risk ratio is always the same as 0.074%, the R (t) Reliability Function shown in graph 2 showed that the more cycles the machine performs the less reliable it will be. It was observed that at the beginning of the process the reliability was above 70%, but over X Cycles it declined to approximately 12%. The Probability Density Function shows the probability of the event happening as the number of samples increases, we can see that from the 30th cycle, this chance is below 1%. Finally, we can estimate the MTTF, which is a direct result of applying the formula seen in table 2 and results in approximately 13.51 cycles.

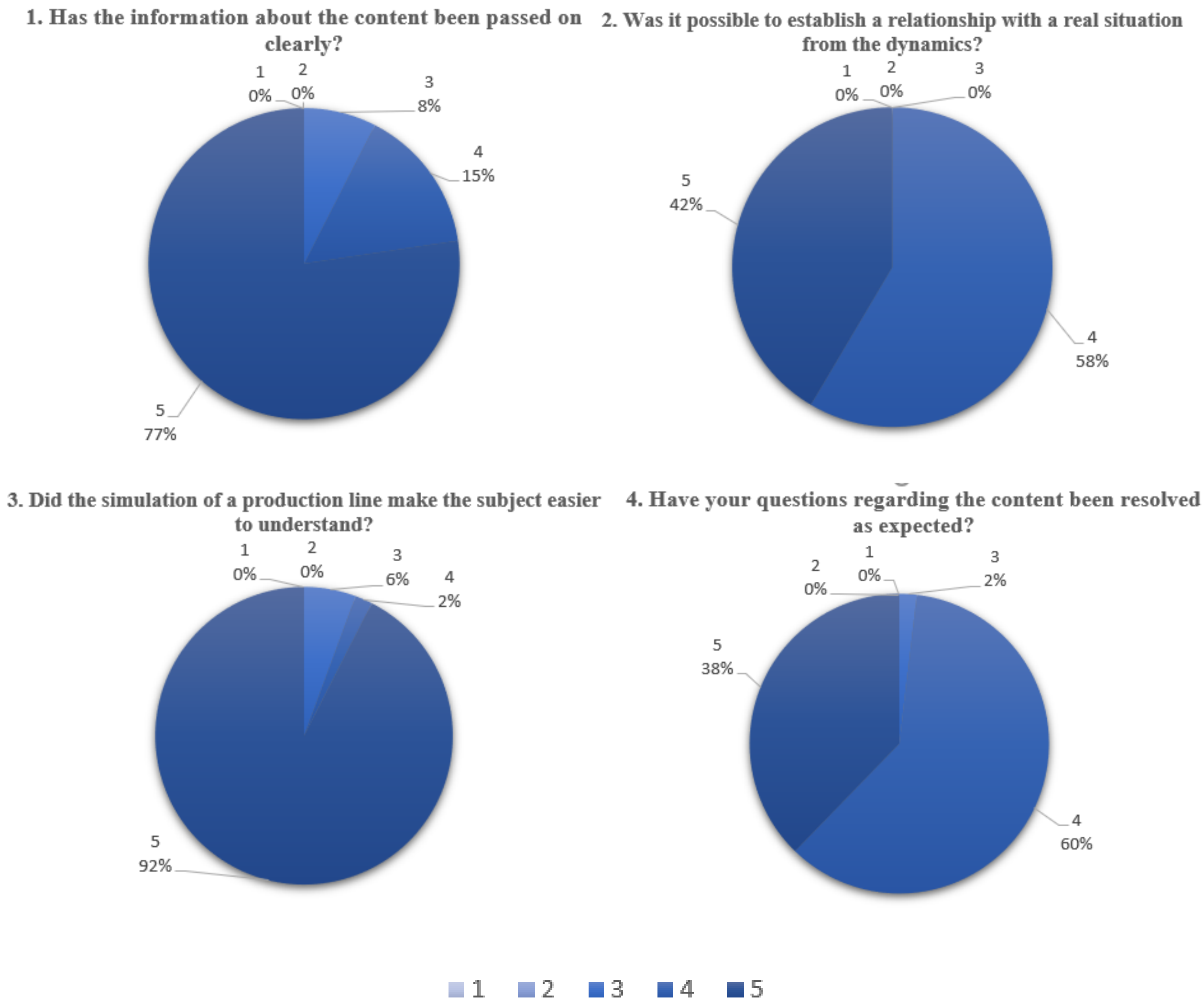


Figure 4. Results of part A of the questionnaire.
Source: Elaborated by the authors.

The scale on the graphics ranges from 1 to 5, where 5 is the maximum satisfaction. Thus, it is observed that the dynamics were very well received by the students, since 92% vote for the top grade. It is noted that 77% of participants indicate that the information about the content was passed clearly.

In Graph 2, Fig.1, 42% voted for maximum satisfaction and more than half chose score 4 on this scale, which we can conclude was successful at this point. Still in graph 2, we observed that we had no score for scales smaller than 4, reiterating the previous statement about the success of the simulation. Ponciano (2017).

Ninety-two percent of the votes indicated that the momentum was successful in facilitating understanding of the issue. In the fourth question, it should be noted that 38% of the evaluators stated that the doubts were completely clarified while the sum of the votes on scale 3 and 4 stated that there were still doubts. One more step in the methodology for doubts after the simulation may be suggested. However, the results of this first part of the questionnaire were positive.

The success of these results is linked to Parreira's (2018) statement about the efficiency of learning with classroom simulations that can reduce student insecurity in contact with problems in a less decisive environment, where mistakes such as the classroom are tolerated. (MORAES, 2018).

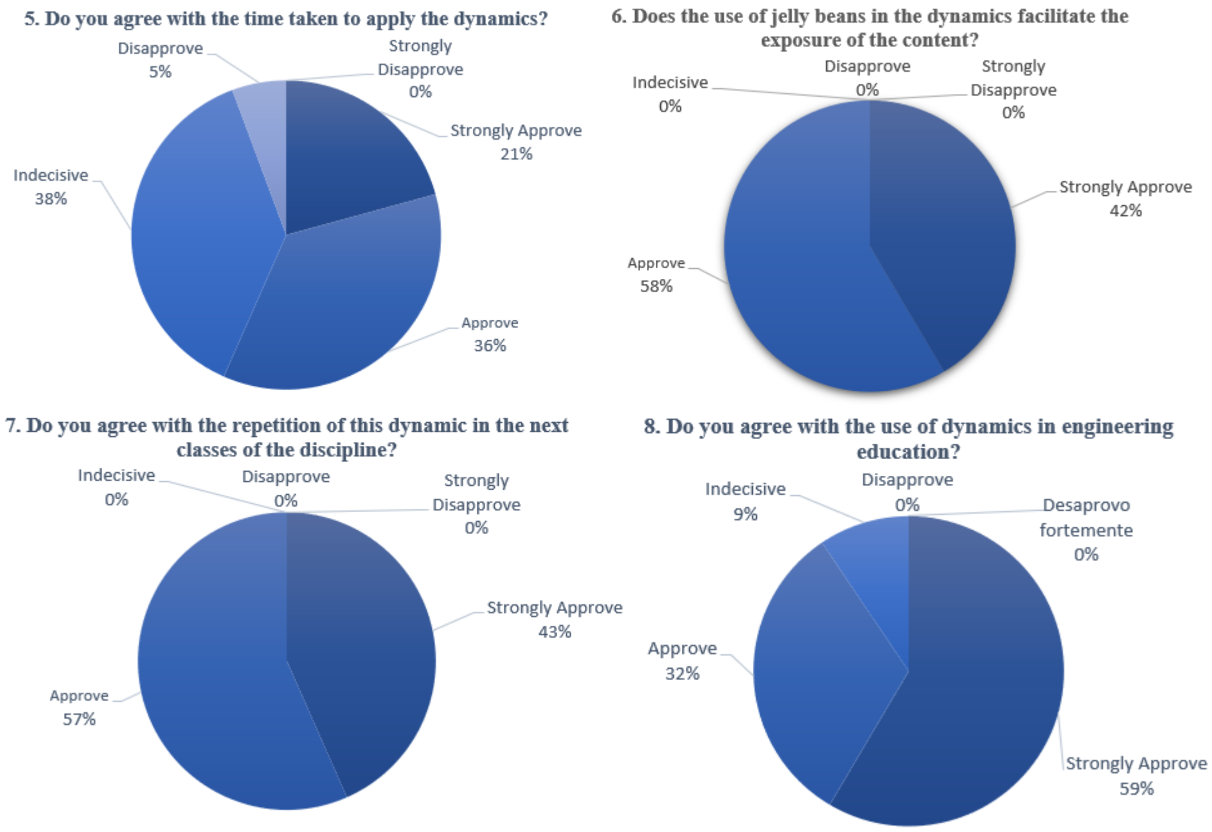


Figure 5. Results of part B of the questionnaire.
Source: Elaborated by the authors.

In the second part of the questionnaire the participants answered the approval or disapproval of the question. For the fifth question the results fluctuated, but more than half of the participants approved on one of the two levels the application time of the dynamics, 38% voted on the undecided option and only 5% disapprove the application time. As the result of the questionnaire A was positive, it is concluded that the students liked the dynamics, a longer time to apply the dynamics would result in a better result in the questioning 5.

All votes for question 5 were positive, 42% strongly approving and 58% approving the use of a gummy candy, which could be easily replaced by numerous types of products produced in the industry. The result is similar to question 7. All votes were for approvals, 57% in approval and 43% in strong approval. Students who participated in the activity believe that the repetition in the following classes is valid. In the last question, even presenting some undecided (9%), 59% of the respondents strongly approve and 32% approve the use of dynamics in engineering education.

Although other courses use similar models, such as those in the health field where the use of simulations to bring students closer to professional practice is constantly seen, there is still a long way to build a predominantly active learning course within the discipline. This type of situation is still little used in engineering, but similar methods gain more space every day and have had positive responses, as is the case of BPA briefly mentioned in this paper. To this end, this paper brings to the reader ideas that can be used within other issues regarding Reliability Centered Maintenance.

4. CONCLUSION

The active learning method as the basis for the class generated a greater appeal for students, using playful tools and interactive activities applied to the teaching of Exponential Distribution in the field of mechanical engineering, improving understanding and stimulating teamwork, communication and leadership.

It was noted that when the protagonist of teaching is the student and the class is developed aiming at the best use of their skills with interactive activities and practical examples, academic achievement tends to increase. This is because activities that bring reality and play closer inspire students to interact with each other, generating a better understanding of the subject and building knowledge more dynamically. This is based on Ribeiro (2016), who obtained similar results from the use of active teaching methodologies, easy content assimilation and good student engagement.

It can be said that in addition to improving the effectiveness of the class, students were more willing and excited about classes in the same model. After the event, we took testimonials from the participating students and their written opinions are mentioned below (the acronym S refers to the word student and the numbering refers to the anonymous quotation of the students):

> S1: The dynamics were good, the content was developed and well explained. Interactive activities really help develop the skills of the engineer.
>
> S2: It is important to look at this content with the simulation of the work environment, it stimulates and opens our eyes to what awaits us in the daily life of the profession. Certainly, it came out of this dynamic with academic gains, and not in the same way that I entered.
>
> S3: I found the simulation very consistent with the possibilities we can find in our profession. The use of jelly beans can easily be replaced by any other part or product on a production line.
>
> S4: Daily we are overloaded with technical information that needs time for assimilation and study both before class and after class. The information obtained through dynamics and simulations fix the content more deeply and I will hardly forget it.
>
> S5: I found the dynamic use to explain reliability content very interesting. I can already see the application of this theoretical content, a difficulty I have.

The testimony of the five students confirms the whole study present in this article, starting with the theoretical study, use of playful tools, application of dynamics and the answers of the questionnaire. Therefore, a better investment in research with teaching methods improves the training of such professionals, so that they complete their courses being better prepared for the job market. As presented by Araújo and Ilha (2019).

Engineering teaching should accompany the advancement of teaching techniques. Currently we have techniques focused on learning through practical situations, the philosopher Confucius made this direct relationship with active learning when he quoted: “What I hear, I forget; what I see, I remember; What I do, I understand.” So, we can understand that the use of interactive activities and playful methods in conjunction with lectures brings students qualitative and quantitative academic gain, helping them understand and develop the skills needed by an engineer.

5. REFERENCES

ARAÚJO, L.S.M.; ILHA, M.S.O. Ensino de projeto dos sistemas prediais hidráulicos e sanitários: abordagem baseada em problemas. Ambiente Construído, Porto Alegre, v. 19, n. 2, p. 203-217, abr./jun. 2019

Barbosa, E.F., Moura, D.G. Metodologias ativas de aprendizagem na Educação Profissional e Tecnológica. *B. Tec. Senac*, Rio de Janeiro, v. 39, n.2, p.48-67, may/aug. 2013.

Berbel, N. A. N. As metodologias ativas e a promoção da autonomia de estudantes. *Semina: Ciências Sociais e Humanas*, Londrina, v. 32, n. 1, p. 25 – 40, jan./jun. 2011.

Blikstein, P. *O mito do mau aluno e porque o Brasil pode ser o líder mundial de uma revolução educacional.* 25 jul. 2010. Disponível em: < http://www.blikstein.com/paulo/documents/books/ Blikstein-Brasil_pode_ser_lider_mundial_em_educacao.pdf>. Acesso em 15/01/2019.

Carraro, C.R. et al. Habilidades sociais profissionais presentes em engenheiros alunos de MBA de uma universidade no interior de São Paulo. *LAJBM*. Taubaté, SP. v. 7, n. 2, p. 298-312, jul./dez. 2016.

Fogliatto, F. S.; Ribeiro, J. L. D. *Confiabilidade e Manutenção Industrial.* 1. ed. São Paulo: Campus-Elsevier, 2009. v. 1.

Guizzo, C. S., Nogueira, T. B. R. Habilidades sociais na formação de engenheiros inovadores: possibilidades e desafios para instituições de ensino. In: DEL PRETTE, Z.A.P. et al. Habilidades sociais: diálogos e intercâmbios sobre pesquisa e prática. Novo Hamburgo: Sinopsys, 2015. Cap.17, p.445-461

Lemis, L. Reability: probabilistc models and estatistical methods. New York: Prentice Hall, 1995

Likert, R. A technique for the measurement of attitudes. Archives of Psychology, 1932.

Mendonça, A. F; Campos, M. A. Confiabilidade auto validável de sistemas com processo exponencial de falhas. São Carlos, v.14, n. 3, p. 383-398. 2013. Disponível em <http://www.scielo.br/scielo.php?script=sci_arttext&pid=S2179-84512013000300010&lng=en&nrm=iso>. Acesso em 01 de março de 2019. http://dx.doi.org/10.5540/tema.2013.014.03.0383.

Moraes, M. M., Cardoso, P. A. Jogos para ensino em engenharia e desenvolvimento de habilidades. *Inovação científica e tecnológica IFPB*, João Pessoa, n°39. 2018.

Parreira, J. E. Aplicação e avaliação de uma metodologia de aprendizagem ativa (tipo ISLE) em aulas de Mecânica, em cursos de Engenharia. *Revista Brasileira de Ensino de Física*, vol. 40, n°1, e1401, 2018.

Pereira, M.M; Dantas, P.J.M. Aplicação da modelagem e simulação nos sistemas de filas M/M/S – Entendendo a natureza da simulação. In: Anais do Encontro Nacional de Engenharia de Produção,2015.

Ponciano, T. M.; Gomes, F. C. D. V.; Morais, I. C. D. Metodologia ativa na engenharia: verificação da abp em uma disciplina de engenharia de produção e um modelo passo a passo. Revista Principia - Divulgação Científica e Tecnológica do IFPB, v. 34, p. 32-39, junho 2017. ISSN ISSN 1517-0306. Disponível em: <http://periodicos.ifpb.edu.br/index.php/principia/article/view/1309>. Acesso em: 03 março de 2019.

Ribeiro, Alexandro. Aplicação e benefícios da metodologia ativa (abp) em disciplina gamificada de uma pós-graduação em engenharia de produção. Artigo (MBE). Unisinos. São Leopoldo. 2016. Disponível em: <http://www.repositorio.jesuita.org.br/bitstream/handle/UNISINOS/6060/Alexandro%20Ribeiro_.pdf?sequence=1&isAllowed=y>. Acesso em: 20 dezembro de 2019.

Siqueira, I. P. Manutenção centrada na confiabilidade: manual de implantação. 1. ed. Rio de Janeiro: Qualitymark, 2005

Souza, S. C., Dourado, L. Aprendizagem baseada em problemas (ABP): Um método de aprendizagem inovador para o ensino educativo. Holos. v. 5, p. 182 - 200. out. 2015.

Kuo, W., Zuo, M. J. Optimal Reliability Modeling: Principles and Applications. John Wiley & Sons. 2003.

6. RESPONSIBILITY NOTICE

The authors are the only responsible for the printed material included in this paper.