

FOSTERING SCIENTIFIC VOCATION IN 1ST YEAR UNIVERSITY STUDENTS OF TECHNICAL DEGREES

Miguel Galiana Martínez¹, Ana M. Gutiérrez Campo², Lucía Seguí

¹*Departamento STEAM, Escuela de Ciencias, Ingeniería y Diseño, Universidad Europea de Valencia (SPAIN)*

²*Photonics Research Labs, Universitat Politècnica de València, Valencia (SPAIN)*

³*Departamento de Tecnología de Alimentos. Escuela Técnica Superior de Ingeniería Agronómica y del Medio Natural, Universitat Politècnica de Valencia (SPAIN)*

Abstract

In some STEM degrees (Science, Technology, Engineering and Mathematics), the interest for developing a PhD or scientific career starts at the end of 4th year course, or even during Master specialization. However, authors believe that research vocations can be encouraged since the very first university steps, but specific activities need to be designed in order to successfully accomplish this goal. Therefore, the present work aims to foster scientific attitude in students of 1st year of technical degrees (Physics, Data Science and Industrial Engineering) by means of a challenge-based learning activity, in the context of the subject Mathematical Analysis.

The activity was carried out with three different groups of 37, 35 and 7 students. In the first step, the students were given a questionnaire in order to check their knowledge and interests on scientific research. In other session, the professors explained to them the basics of the scientific method, the structure of a scientific paper and a scientific congress. Afterwards, the students were arranged in groups of three people to work on a specific paper, which they had to deeply understand in order to answer a set of questions. In the last stage, the groups were asked to work on a review paper about Mathematics applied to different fields of study. To this aim, they were provided information on available data bases. This paper was then evaluated by the professors through a specifically designed rubric, and it contributed to the final mark of the students.

After the activity, all the students were given a new questionnaire to test how their perception about scientific research had been modified, as well as to check their level of understanding about scientific investigation.

The close and permanent contact with the students along the activity is crucial to carry on this study. Therefore, several sessions during 1st semester of the present academic year are being used to work on this activity with the students in the classroom.

Keywords: scientific research, scientific paper, 1st year, technical degree.

1 INTRODUCTION

Is A PhD Degree Worth It? Is a PhD a benefit in today's job market? Is a PhD helpful for a science career? Is academia career a competitive option in comparing with others? Many papers and online articles have been published addressing these issues and thousands of data, obtained from a huge number of studies based on surveys of graduate students, have been provided. In general, the responses are well-optimistic about academia careers and tilt the balance in favour of having a PhD [1, 2]. However not so many works have been carried out about fostering the interest of students in obtaining a PhD and pursuing academia careers during the university degree, and beyond that, about the influence of doing that at the 1st degree year. We agree with Ruchina et al [3] on that research experiences and skills are crucial for students at any level of education and can benefit them in their different personal and labour perspectives.

In [4], authors claim that there is increasing evidence that science & engineering PhD students lose interest in an academic career over the course of graduate training. Also, the same authors in [5], previously claimed that even though academic research is often viewed as the preferred career path for PhD trained scientists, most U.S. graduates enter careers in industry, government, or "alternative careers." Could be an early information about academic job market the solution for this interest leakage?

In a recent study based on nursing degree [7], authors present strategies to promote and sustain interest in PhD in nursing among baccalaureate nursing students and discusses the importance of meaningful engagement in research and engaged faculty mentorship. The conclusion of this work was that it is important to incorporate research into undergraduate experiences, promote engaged mentorship during undergraduate level and beyond, and provide a conducive environment for undergraduate students to address their fears, misconceptions, and myths about PhD.

The benefits and the importance of mentored research programs and research-based teaching methods are also highlighted in [7-9], where they agree with the fact that undergraduate research is touted as a high-impact educational practice yielding important benefits such as increased retention and notable learning gains. In the former, they make an overview of the three factors that shape undergraduates' attitudes towards research: the research training environment, the research support from university and faculty mentoring in the research training environment. Their study results showed that faculty mentoring in the research training environment has the strongest influence on undergraduates' attitudes towards research and suggests the strengthening of faculty mentoring to enhance not only students' confidence in conducting research but also promote students' research experiential learning. Apart from These all conclusions are totally aligned with our perception and it is indeed what we want to demonstrate with our study in STEM degrees at Universidad Europea de Valencia.

2 METHODOLOGY

The research was conducted in 3 groups of different degrees having a technical profile: Degree in Data Science, Degree in Industrial Organization, Physics Degree. The number of students involved in each experience was of 30, 12 and 37, respectively. This activity was developed in the context of the course Mathematical Analysis, which is part of the three degrees mentioned previously, in the academic year 2021/2022. The activity was planned in 5 different steps which consisted of a preliminary questionnaire, three onsite sessions of guided work, and a final questionnaire. These steps are explained next.

Students were given a preliminary questionnaire which was formulated with the aim of evaluating their knowledge on research issues. The questionnaire was prepared and shared with students through Google Forms, and they were given some time in classroom to answer the questionnaire online. The survey included the following questions:

★ *Preliminary questionnaire:*

- 1 To which extent do you think research is valued by society, in Spain?
 - a) Very little
 - b) A little
 - c) Neutral
 - d) Quite
 - e) Very much
- 2 Would you be able to explain what a scientific congress consists of?
 - a) Not much
 - b) A little
 - c) Neutral
 - d) Quite
 - e) Very much
- 3 Do you see yourself participating in a Scientific Congress, in the future?
 - a) Yes
 - b) No
- 4 Have you ever read a scientific paper? (Research, not informational or educational)
 - a) Yes
 - b) No

- 5 Do you know what the impact factor of a scientific journal is?
- Yes
 - No
- 6 In a 1 to 5 scale, do you believe that writing a scientific paper is:
- Very easy
 - Easy
 - Neutral
 - Difficult
 - Very difficult
- 7 Are you aware of any scholarship or research contract which is given in Spain?
- Yes
 - No
- In case you have answered positively to the previous question, specify which one:
- _____
- 8 Do you know what an internship consists of?
- Not much
 - A little
 - Neutral
 - Quite
 - Very much
- 9 In a 1 to 5 scale, value the sentence "I would consider completing a PhD after finishing my studies".
- Totally disagree
 - Disagree
 - Neutral
 - Agree
 - Totally agree
- 10 Considering developing a career in research, which sentence do you feel more identified with?
- I would like to develop a research career to contribute to society
 - I would like to develop a research career since I would like to continue learning
 - I wouldn't develop a research career since I don't see a direct application
 - I wouldn't develop a career in research because of economic reasons (income).
 - Other: _____

In the following weeks, a **first onsite session** was programmed to introduce students some concepts and issues related to research such as: scientific paper (what it consists of, which structure it has...), scientific journals, scientific congresses (modalities, types of presentations...), etc.

A **second onsite session** was scheduled to develop an activity to work in pairs. During this session, students were provided 5 different scientific papers (in English) which contents were related to the course (Mathematics). In particular:

PAPER 1_A New Long Proof of the Pythagorean Theorem [10]

PAPER 2_Connecting Mathematics To Real Life Problems [11]

PAPER 3_Influence of mathematics in our daily lives [12]

PAPER 4_Is Maths everywhere Our students responds [13]

PAPER 5_Mathematics importance in our life [14]

The goal of this second session was to get students familiar with the structure and contents which are characteristic of a scientific paper. Thus, each pair of students were asked to choose one of the previous papers, read it and answer to the following questions:

- 1 Please, briefly summarize the topic of the paper.
- 2 Which is the specific objective of the work?
- 3 Which is the methodology employed to demonstrate the objective of the work?
- 4 Which is/are the most relevant result/s obtained from the experiment/study?
- 5 Which are the conclusions of the work?
- 6 Do you think that the conclusions are relevant for the field of study? Do they support the aim of the work?
- 7 Do you believe this is an interesting work/paper? Why?

This activity was proposed in English to develop the generic competence “oral and written communication in a foreign language”. Besides, it was part of the course mark, for which performance in the activity was assessed through the following rubric (Table 1):

Table 1. Rubric used to evaluate the answers to the questionnaire about structure and contents of a particular scientific paper (2nd onsite session).

ITEM	1	2	3	4
ANSWERS TO THE QUESTIONNAIRE	Less than 30% of the answers are right	At least 50% of the answers are right	Between 50% and 80% of the answers are right	Between 80% and 100% of the answers are right
OPINION ANSWERS	Opinion answers are literally copied from the paper	Opinion answers are partially copied from the paper	Opinion answers are mostly based on the student's opinion	Opinion answers are original and they are completely based on the student's opinion
LANGUAGE	All answers to the questionnaire are written in Spanish	At least 50% of the answers of the questionnaire are written in English	Between 50% and 80% of the answers of the questionnaire are written in English	Between 80% and 100% of the answers of the questionnaire are written in English
STRUCTURE AND CLARITY	The activity delivered is disorganized and it does not present a proper structure	The activity delivered is organized in general, but the structure can be improved	The activity delivered is clear, well organized and the structure is correct	The activity delivered is presented in a very clear way and it is very well organized; following a proper structure

On a **third onsite session**, students worked in groups of 3. Students needed to perform their own search of scientific papers in which the role of Mathematics in other fields (music, sports, health, economy, mathematical demonstrations, etc) was studied. Students were introduced different data bases to perform their search: Redalyc, Research gate, Academia, Dialnet, Google Scholar, Scielo, ERIC. Then, they were asked to choose at least three scientific papers related to the topic of interest to perform a short review, so that they needed to read, analyze and synthesize the information in order to write a review report. Students were given instructions to write the paper following the structure of a scientific paper and prepare a 10-min presentation to be recorded in video in order to simulate an oral presentation in a scientific congress.

Students were given two months to complete the work and deliver the review paper and the video. Both deliveries were evaluated by the professor and contributed to the 15% of the final mark. The video was also co-evaluated by the other groups, it contributing to a 5% of the final mark. Video presentations were evaluated by means of the following rubric by means of both professor and students, in which all items have a similar weight.

Table 2. Rubric used to evaluate the video (oral presentation) by professors and students (co-evaluation)

ITEM	1	2	3	4
SUITABILITY OF THE TOPIC AND INTEREST (20%)	The chosen topic does not fit the scope of the activity	The chosen topic fits the scope of the activity, but it is not interesting	The chosen topic fits the scope of the activity and it is interesting	The chosen topic perfectly fits the scope of the activity, it is interesting and it stimulates curiosity to get a deeper knowledge about the subject
CONTEXTUALIZATION AND INTRODUCTION OF THE TOPIC (20%)	The student does not contextualize the topic and he/she does not introduce the contents to be presented in a clear way	The student contextualizes the topic, but the introduction of the contents present some weaknesses	The student contextualizes the topic and he/she introduces the contents to be presented in a proper way	The student perfectly contextualizes the topic and he/she introduces the contents to be presented in a very clear way
ORDER AND CLARITY OF THE CONTENTS (20%)	Contents are presented in a confusing way and they are loosely organized	Presentation of contents is difficult to follow but, in general, it can be understood	Presentation of contents is mostly clear but it can still be improved	Presentation of contents is totally clear and well organized, so that the work is easy to understand
STRUCTURE AND PAPER SECTIONS (20%)	The work does not follow the structure of a scientific paper at all	The work presents at least 50% of the sections of a scientific paper	The majority of the work follows the structure of a scientific paper, and it includes most of the sections	The whole work perfectly follows the structure of a scientific paper, including all the sections
VISUAL RESOURCES AND QUALITY OF THE VIDEO (20%)	The video is poor quality and it does not allow to follow the explanation properly	The video is medium quality and it allows to follow the explanation moderately	The video is high quality and it allows to follow the explanation properly	The video is excellent and it allows to follow the explanation perfectly
BODY LANGUAGE AND EYE CONTACT (20%)	The student does not use body language at all and he/she does not keep eye contact with the audience	The student barely uses body language and he/she barely keeps eye contact with the audience	The student uses body language and eye contact properly	The student perfectly uses body language to emphasize the presentation; as well as he/she maintains eye contact with the audience catching their attention

Finally, students answered a **final questionnaire**, which is shown next:

★ Final Questionnaire

- 1 In a 1 to 5 scale, indicate if you have enjoyed the activity proposed.
 - a) Very little
 - b) A little
 - c) Neutral
 - d) Quite
 - e) Very much
- 2 In a 1 to 5 scale, say if you are satisfied with the final result of the paper you have prepared.
 - a) Very little
 - b) A little
 - c) Neutral
 - d) Quite
 - e) Very much
- 3 In a 1 to 5 scale, indicate the difficulty of preparing and writing the paper:
 - a) Very easy
 - b) Easy
 - c) Neutral
 - d) Difficult
 - e) Very difficult
- 4 Would you like to develop similar activities, related to research issues, during the degree?
 - a) Yes
 - b) No

- 5 In a 1 to 5 scale, value the amount of new information learned during this course, with respect to developing a research career.
 - a) Very little
 - b) A little
 - c) Neutral
 - d) Quite
 - e) Very much
- 6 Would you like to have received more information?
 - a) Yes
 - b) No
- 7 If the school/university schedules seminars or workshops to learn about research career issues, would you participate?
 - a) Yes
 - b) No
- 8 In a 1 to 5 scale, value the sentence "The activity has increased my interest in research and developing a research career".
 - a) Totally disagree
 - b) Disagree
 - c) Neutral
 - d) Agree
 - e) Totally agree
- 9 In a 1 to 5 scale, value the sentence "I would consider completing a PhD after finishing my studies".
 - a) Totally disagree
 - b) Disagree
 - c) Neutral
 - d) Agree
 - e) Totally agree
- 10 Considering developing a career in research, with which sentence do you feel more identified?
 - a) I would like to develop a research career to contribute to society
 - b) I would like to develop a research career since I would like to continue learning
 - c) I wouldn't develop a research career since I don't see a direct application
 - d) I wouldn't develop a career in research because of economic reasons (income).

3 RESULTS

Results of the present research are based on the answers to the preliminary questionnaire. A further analysis on the impact of the activity on students' opinion towards research issues will be completed in the near future when answers to the final questionnaire will be available and conveniently analyzed.

The preliminary questionnaire was answered by 49 of the 79 students surveyed, which implies a 60% of participation. Authors believe this response may be improved, but in any case, the number of questionnaires answered are considered satisfactory for the purpose of this paper. One possible reason for a rather reduced participation was that due to COVID pandemic, a part of the students were participating in online mode, and they were not that engaged to answer the survey as those students which were participating onsite. On the other hand, no group distinction was made during the surveying period, for which answers are all analyzed in a unique pool. For further research, the group/degree in which subjects are enrolled will be included in the questionnaire to discriminate differences among degrees, if any.

Summary of answers to the preliminary questionnaire are shown in the figure below (Figure 1), in which pie graphs showing percentages of answers for each question raised (1-10) are presented.

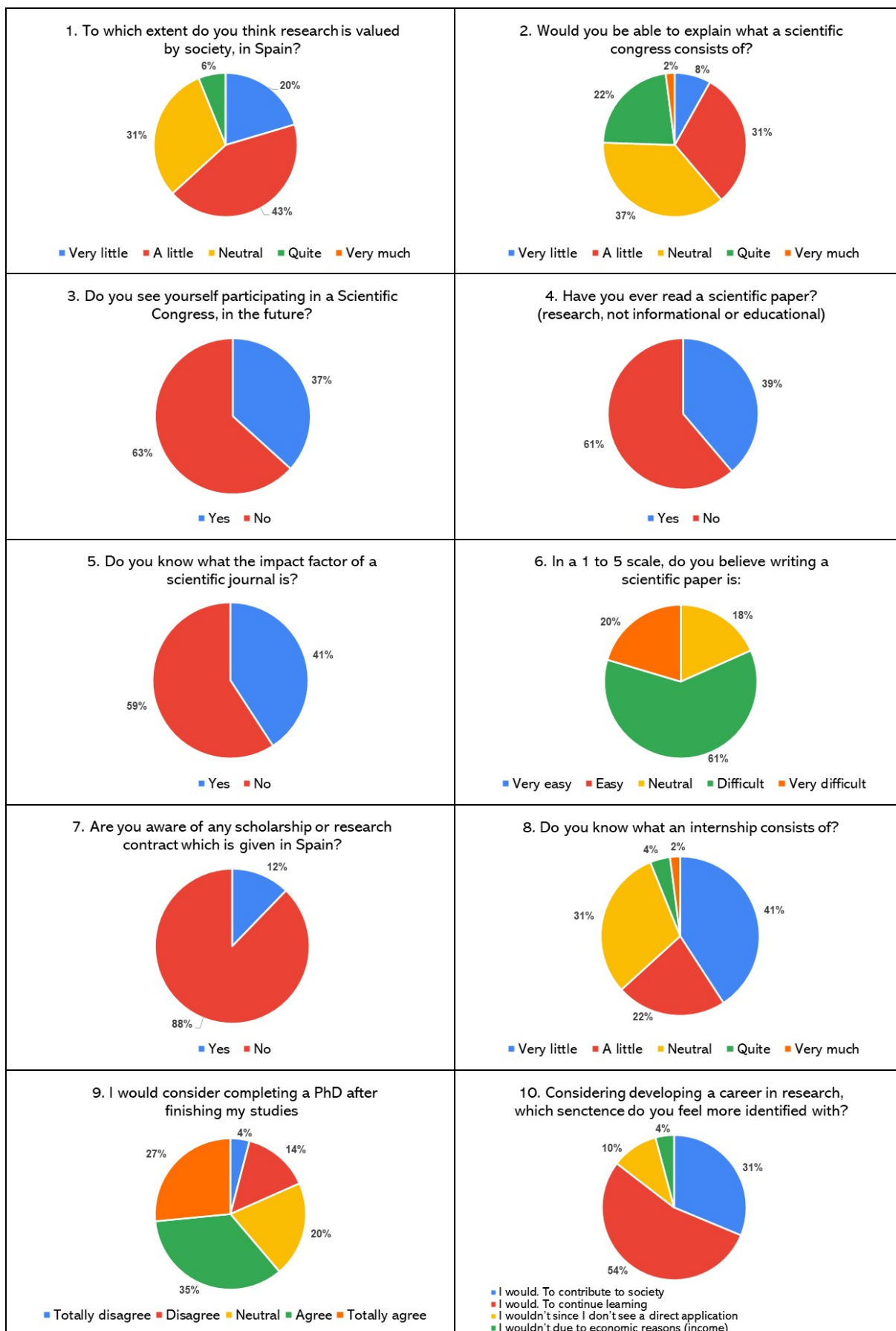


Figure 1. Answers to the preliminary questionnaire. Values are given in percentage of students over a total of 49 subjects.

As it can be observed in the Pie Charts of Figure 1, several remarkable results can be pointed out:

- 1 More than half of the respondents (63%) think that research is very little or little valued by society in Spain.
- 2 Only 24% of the students consider that they are able to explain what a scientific congress is.
- 3 63% of the subjects believe that they will not participate in a scientific congress in the future.
- 4 Only 39% of the respondents claim that they have read some scientific paper.
- 5 59% of the students do not know about the impact factor of a scientific journal
- 6 81% of respondents believe that writing a scientific paper is difficult or very difficult (answers combined)
- 7 88% of the students do not know about any scholarship or research contract in Spain. Among those students who answered positively, they knew about Marie Curie and Severo Ochoa grants.
- 8 More than half of respondents (62%) do not know what an internship consists of.
- 9 62% of the students consider the possibility of doing a PhD when finishing graduate studies.
- 10 54% of the students say that they would develop a career in research to continue learning; while 31% claim that they would do it to contribute to society.

In the light of these results, it can be stated that most of the students showed a lack of knowledge about research issues (Items 2 to 8). Moreover, more than the half of them (63%) think that research is not very well considered in Spain. However, in spite of these facts, a large proportion of them (62%) are interested in developing a scientific career in the future (item 9) and 85% would develop a scientific career in research to contribute to society and for lifelong learning. These results are very inspiring for the authors since we think that the attitude of the students towards scientific research is very good. Our task is to provide them with the proper tools to understand and be familiar with research related issues. Therefore, it is important to provide students the proper knowledge along the degree and, particularly, engaged them since the very beginning so that this potential good attitude is fostered, and they do not get discouraged throughout.

4 CONCLUSIONS

Results of the preliminary questionnaire showed that although most of the students of 1st year ignored about essential aspects of research; more 50% consider the possibility of carrying on a PhD after their studies. A large proportion of them (85%) also considered the possibility of developing a career in research to help society progress and continue learning. The purpose of this activity was not only to foster scientific vocation in 1st year students, but also to provide them with the essential concepts to start understanding the basics of research. Attitude and proper tools combined will help students develop a scientific vocation as they complete their studies.

On the other hand, the answers of the final questionnaire will be very useful for the authors to test whether the students acquired the main ideas to start understanding the scientific field. These results are expected to be available in late January, for which are not included in the present results and conclusion sections; nevertheless, authors are very confident about the experience evidenced that students were very involved with this activity. Moreover, authors are planning to continue this activity during the second semester, so that the itinerary continues.

Authors agree that scientific research is essential to help society develop. That is why the final aim is that students get familiar with the basics of research and acquire certain expertise by the time they finish their graduate studies; so that they can face master and, eventually, PhD studies with guarantees, this contributing to society.

REFERENCES

- [1] J. Hughes, "Why Earning a PhD is a Benefit in Today's Job Market," *Keyston PHDSTUDIES*, 2020. Retrieved from <https://www.phdstudies.com/article/why-earning-a-phd-is-a-benefit-in-todays-job-market/>.
- [2] C. Woolston, "PhD career paths hold promise," *Nature*, vol. 555, pp. 277, 2018.

- [3] A. V. Ruchina, M. V. Kuimova, D. A. Polyushko, A. E. Sentsov, Z. X. Jin, "The Role of Research Work in the Training of Master Students Studying at Technical University," *Procedia-Social and Behavioral Sciences*, vol. 215, pp. 98-101, 2015.
- [4] M. Roach, H. Sauermann, "The declining interest in an academic career," *PLOS ONE*, vol. 12, no. 9, pp. 1-23, 2017.
- [5] H. Sauermann, M. Roach, "Science PhD Career Preferences: Levels, Changes, and Advisor Encouragement," *PLOS ONE*, vol. 7, no. 5, pp. 1-9, 2012.
- [6] A. Ayoola, K. Kamp, Y. J. Adams, J. R. Granner, L. DeGroot, H. Lee, G. Zandee, M. M. Doornbos, "Strategies to promote and sustain baccalaureate students' interest in pursuing a PhD degree in nursing," *Journal of Professional Nursing*, vol. 37, no. 5, pp. 935-941, 2021.
- [7] J. S. Stanford, S. E. Rocheleau, K. P.W. Smith, J. Mohan, "Early undergraduate research experiences lead to similar learning gains for STEM and Non-STEM undergraduates," *Studies in Higher Education*, vol. 42, no. 1, pp. 115-119, 2017.
- [8] L. L. Echiverri, W. Chen, X. Wang, "Factors That Shape University Students' Attitudes Towards Academic Research," *6th International Conference on Higher Education Advances (HEAd'20)*, Universitat Politècnica de València, 2020. DOI: <http://dx.doi.org/10.4995/HEAd20.2020.11175>.
- [9] N. V. Kozlova, I. V. Atamanova, "The development of undergraduates motivation for research work," *Procedia - Social and Behavioral Sciences*, vol. 93, pp. 498-502, 2013.
- [10] S. Mahmud. "A New Long Proof of the Pythagorean Theorem," *International Journal of Scientific and Innovative Mathematical Research (IJSIMR)*, vol. 7, no. 9, pp. 3-7, 2019.
- [11] Y. Dissou Arthur, E. Kofi Owusu, S. Asiedu-Addo, A. Kwamina Arhin. "Connecting Mathematics To Real Life Problems: A Teaching Quality That Improves Students' Mathematics Interest," *Journal of Research & Method in Education (IOSR-JRME)*, vol. 8, no. 4, pp.65-71, 2018.
- [12] S. Bin Sami Khan, R. Salman. "Influence of mathematics in our daily lives," *Arts & Humanities Open Access Journal*, vol 4, no. 2, pp. 50-52, 2020.
- [13] J. Mulero, L. Segura, J.M. "Sepulcre. Is maths everywhere?," Our students respond. *Proceedings of INTED2013 Conference 4th-6th March 2013*, Valencia, Spain. IATED, 2013.
- [14] J. Hodaňová, D. Nocar Palacký. "Mathematics importance in our life," *Proceedings of INTED2016, Conference 7th-9th March 2016*, Valencia, Spain. IATED, 2016.