

A STUDY REGARDING LEARNING AND INNOVATION SKILLS (4Cs) IN A PORTUGUESE HIGHER EDUCATION INSTITUTION

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Abstract

Doctoral education is the pinnacle of the education system but is also the link between the education system and the research area. To work, as a researcher, in a 21st-century society, learning and innovation skills, like critical thinking, creativity, collaboration, and communication are important. In Portuguese law to have a PhD degree, is necessary that students among others must have scientific skills, critical thinking, and communications skills. Creativity and collaboration skills are not mentioned. But these skills are very important as scientific research usually occurs in research teams where collaboration and cooperation are crucial to concretize the research project. Also, creativity is important once it can drive to new areas of knowledge or new solutions to the research problem. In this context, it is important to know what PhD students fill about these four skills that are among the 21st-century skills. This research work is a study case, with the characteristics of quantitative research, which aims to perceive the doctoral students' perception regarding critical thinking, creativity, collaboration, and communication (understanding and development). The data were collected, through a questionnaire applied in Jun 2022, via institutional email to the Population of the Science and technology school at NOVA Lisbon university. This survey was based on others, already published, but adapted to the Doctoral population. Among other things, it captured the students' perception regarding their trust in their capabilities regarding critical thinking, collaboration, communication skills, and creativity. The meaning of creativity, how to develop it, regarding doctoral supervision practices, research environments, and development were explored, and PhD students' perceptions were collected. Data analysis revealed that students are very confident regarding their ability to use critical thinking (77%), work collaboratively (84%), communicate with peers or with society (81%), and be creative (73%). Considering the supervision practice (and teaching practice at this level) that promotes them, there is a lower agreement regarding it. The meaning of creativity that emerges in this research implies thinking out of the box, seeing the world in different ways/perspectives, creating new things/concepts/ideas, and making unusual connections between things/concepts/ideas. The personal characteristic associated with creativity is curiosity. In the view of doctoral students, the practices that promote the development of creativity are to participate in seminars/ debates or cycles of study (80%), followed by research work in a research group (79%). It is possible with the research results to conclude that these four important skills are being developed and deepened in doctoral education at this institution.

Keywords: *Doctoral education, critical thinking, creativity, collaboration, communication.*

1. Introduction

Doctoral education is the highest level of education in the education system around the world. It is linked to the research area and is the "pool" and resource of researchers and the backbone of research and innovation. Innovation is one requisite to a developed society and needs highly qualified people but also innovative and fearless. Doctoral education must prepare doctors to be not only qualified people in a certain area, but also innovators, fearless, accurate, critical thinkers, communicators and responsible.

At the end of the twenty century and the beginning of the 21st century, some work groups, with persons from different areas of knowledge, started to think about what should be the most important skills for people in the 21st century. The traditional 3Rs (Reading, writing and arithmetic) proposed in the 20 century were misfit, unsuitable, and restricted in the face of the challenges of the new century, where artificial intelligence is emerging and evolving and will be deeply developed. Networking, decision-making skills, Project, time and stress management, attention to detail, teamwork, and adaptability/flexibility, were some skills that were proposed. In this research, the framework used, as the starting point was the P21 framework for 21st-century learning (from the P21 group a coalition of the US different organizations related to education and development). (Demystifying Learning Frameworks:

The P21 Framework | Remake Learning). In this frame (<http://www.p21.org/about-us/p21-framework>), the bases are standards and assessments, curriculum and instruction, professional development, and learning environments, and the learning and innovation skills for the 21st century presented are critical thinking, creativity, collaboration, and communication (<https://files.eric.ed.gov/fulltext/ED519462.pdf>). The P21 framework document challenge students not only to learn content knowledge but also to learn how to use it to engage in critical thinking, problem-solving and analysis, to make informed and reasoned decisions, this is, be literate people. But it also appeals to the development of learning and innovation skills, which they define as critical thinking, creativity, collaboration, and communication. As they are the key to interacting with others (skills of communication and collaboration are needed), but also promote innovation (and critical thinking and creativity play an important role).

In the context of higher education, these skills may be the difference between being a qualified worker or a researcher. A qualified worker may have a master's or doctoral degree, but it is the person who follows the leader(boss) and, do what the "boss" propose. A researcher can be a leader, but he is a project constructor who proposes solutions, do innovations, and have a critical but creative mind. Constructing a researcher is not an essay job, it implies knowing how to supervise PhD students, having as a goal develop not only scientific and research skills, but also soft skills like critical thinking, creativity, collaboration, and communication. And this implies putting the PhD student in specific environments that are appropriate for it. Supervision practices are important, as strategies to allow the development of the academic self by the student, to help it to fit into the research environment, and to create a sense of belonging to the research team and the academy (Ribau, 2019, 2020a, 2020b, 2020c, 2021a, 2021b). In this sense, looking to practice and the degree of confidence of the students regarding a task can give information regarding the development of the skill.

Why these 4 learning and innovation skills are so important in a doctorate? First, it is necessary to understand what they mean and what are the implications of each one. It should be underscored that, on one hand, critical thinking and creativity are related to the construction of the self and can be related to the social and educational environment where people where a person is inserted. On the other hand, collaboration and communication are related to the socialization process.

Critical thinking is the ability to analyze in detail and with accuracy something (idea, solution, process, product, fact, and so on) in particular circumstances, and make an interpretation or make conclusions regarding the thing that was been analyzed. It implies the use of an analytical mindset and putting the right questions and, seeking correct information to do the analytical dissect of the problem/thing that is being viewed critically. As Kivunja refer (2015), citing the California National Council for Excellence, critical thinking is "the intellectually disciplined process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and/or evaluating information gathered from, or generated by, observation, experience, reflection, reasoning, or communication, as a guide to belief and action" (Kivunja, 2015). To have the critical thinking, a person must know deeply the area of analysis, be aware of the field frames and be assertive. This skill is relevant to be an independent, autonomous person.

Creativity was defined by Guilford as a multipurpose cognitive ability that implies fluency, flexibility, accuracy, and originality. Other researchers such as Torrance, Maslow, Csikszentmihalyi, Roger or Simonton among others, also gave meaning to creativity by looking at it from different perspectives. As Hallmann (1963), cited by Matraeva and collaborators (2020), states in their paper entitled "The necessary and sufficient conditions of creativity. (Journal of Humanistic Psychology, 1963)" " Creativity is a fusion of perceptions implemented in a new way (McCullar), the ability to find new connections (Cubie), the emergence of new relationships (Rogers), the predisposition to make and recognize innovations (Lassuelle), the activity of the mind, leading to new insights (Gerard), transformation experience in a new organization, the imagination of new constellations of meanings (Giselin)". (Matraeva, Rybakova, Vinichenko, Oseev & Ljapunova, 2020). Creativity also depends on the area being context-dependent (Hu & Adey, 2002; Wiyanto, Saptono & Hidayah, 2019). Creative thinking is the ability to, based on the same permission, think differently from most of the persons, switching perspectives and seeing an idea, solution, process, product or fact in different ways. It implies having flexible and adaptable frames of mind, to achieve a goal (<https://files.eric.ed.gov/fulltext/ED519462.pdf>). A creative-thinking person must know deeply the field, be resilient (as others may not easily accept the proposed solutions) and be able to adopt different solutions in a different context. This skill is important in a society that wants to be developed and innovative. This is what makes the difference between a deep-thinking machine (that works based on algorithms) or artificial intelligence (that works based on algorithms but can create its own) and humans.

Communicating consisted of someone sending a message and someone understanding it. First, it is essential to know what is to communicate (the message's aims) and how to do a clear and concise message. Secondly, have clear goals, and targets to achieve. The message can be written, or oral, and the targets can be specialists in the field or ordinary people. This skill is relevant in a developed society,

where communication via networks is essential. Communication skills walk hand in hand with collaboration (<https://files.eric.ed.gov/fulltext/ED519462.pdf>).

Collaboration is the art of working with others, pursuing some goals, and having common outcomes but being different. Often collaboration requires negotiations, flexibility, adaptability, and compromises. This skill is very important in teamwork, as communication with the different partners in the team group. Other skills related to collaboration are social, leadership skills and conflict management. (<https://files.eric.ed.gov/fulltext/ED519462.pdf>)

In Portuguese law, regarding the doctorate, creativity or collaboration skills are not explicitly referred to. In the Decree Law n.º 216/92 (13 October) CHAPTER III, Article 17, states in the first point that “The doctor's degree proves the achievement of an innovative and original contribution to the progress of knowledge, a high cultural level in a given area of knowledge and the ability to perform independent scientific work.” Due to the implementation of the Bologna process, the Decree-Law No. 74/2006 of March 24, of the Portuguese Republic was published. This Decree-Law (No. 74/2006, 24 March) that present the legal regime of academic degrees and diplomas of higher education under the Bologna process, in chapter IV, article 28, regarding the Doctor's Degree in point 1 states that "1 - The doctor's degree is conferred on those who demonstrate: a) ability to understand systematically in a scientific field of study; (b) Competencies, skills and research methods associated with a scientific field; (c) the ability to conceive, design, adapt and carry out meaningful research in compliance with the requirements imposed by academic quality and integrity standards; (d) have carried out a significant set of original research work which has contributed to the widening of the frontiers of knowledge, part of which merits national or international dissemination in publications with a selection committee; (e) be able to critically analyse, evaluate and synthesize new and complex ideas; (f) be able to communicate with their peers, the rest of the academic community and society in general about the area in which they are specialised; (g) be able, in a knowledge-based society, to promote, in an academic and/or professional context, technological, social or cultural progress (translation of the author). The most recent decree-law regarding higher education, the Decree-Law No. 65/2018, of 16 August, intended to accept the recommendations of the Organization for Economic Cooperation and Development (OECD) on Portuguese higher education and science, technology, and innovation systems, continues not to refer clearly to creativity or collaboration skills. In this context, it is important to know if these skills are being developed during the doctorate as, critical thinking and communication (explicitly refer in the decree-law), as they are essential nowadays.

The present research work is part of a project that aims to characterize the doctoral supervision practices and the doctoral education process at NOVA Lisbon University. Research results had already been published, regarding the supervisors' lens (Ribau, 2020b, 2021a) and PhD students' perception (Ribau, 2019, 2020a, 2021b). This research work intends to bring light to the practices used to develop and empower students regarding creativity, critical thinking, collaboration and communication during the doctorates. It also intends to reduce the gap in knowledge about the development of creativity, critical thinking, collaboration and communication, during doctoral research.

2. Methods

This project aimed to evaluate the degree of development of four skills: collaboration, communication, creativity, and critical thinking. This data was reflected in the confidence of the PhD Student regarding tasks related to the skill. It is a study case, with the characteristics of quantitative research, which aims to perceive the doctoral students' perception regarding critical thinking, creativity, collaboration, and communication (understanding and development). To collect data, a survey was applied and disseminated, via institutional email, similar to others (Kelley, Knowles, Han & Sung, 2019; Matraeva, Rybakova, Vinichenko, Oseev & Ljapunova, 2020) already applied to higher education institutions in another country. Some changes have been made in the survey to adequate it for doctoral education. The survey had two parts, the first one had close questions regarding the sample characterization the second part, had close questions, aimed to collect data regarding creativity, communication, collaboration, and critical thinking. A four-point Likert scale ranging from strongly disagree to strongly agree was used to measure confidence in skills regarding creativity, communication, collaboration, and critical thinking. The survey was applied in Portuguese, to PhD students at NOVA School of Science and Technology | FCT NOVA, NOVA Lisbon University, in June 2022.

3. Discussion

All the respondents were doing a PhD at NOVA School of Science and Technology, 52% of the respondent population was female and 48% male. 75% of the respondent population had between 25 and 35 years old, and the rest, of the respondents, had between 36 years to more than 56 years old.

To collect data from collaboration, doctoral students must reflect on their confidence regarding their ability to do tasks/activities related to the skills being evaluated. PhD students had to apply a Linkert scale on 14 statements concerning collaboration. Regarding communication skills doctorate had to evaluate 10 sentences, and to perceive the use of critical thinking had to analyze 18 statements finally, they had to examine 10 sentences using.

Table 1. Doctoral perception regarding their confidence in the ability to use the 4C skills.

| Dimension | Average | frequency (%) |
|-------------------|----------------|----------------------|
| Collaboration | 3,4 | 84% |
| Communication | 3,2 | 81% |
| Critical thinking | 3,1 | 77% |
| Creativity | 2,9 | 73% |

It makes sense for collaboration, and communication to be the skills doctoral students feel competent in using since these competencies are usually inserted in a research group and many of them have seminars where they see presentations and/or make presentations, of the work that they are developing. In the data collected in this research students assign that in meetings with their supervisor, they are encouraged to express their ideas (more than half of the respondents appoint) and to seek new pathways for their research work, if something is not well in the research project.

The meaning of creativity skill was investigated, as this concept can differ from person to person and may differ from the knowledge area. So, in the survey, a close question was proposed, to perceive the significance of creativity in this population. The students had fifteen options and could choose 5 options. The options that had more assigns, are presented in Table 2.

Table 2. Dimension evaluated in the survey.

| Creativity means... | Percentage of respondents (%) |
|--|--------------------------------------|
| think "outside the box". | 70% |
| see unusual links/connections between existing concepts, ideas, or things. | 69% |
| seeing the world in different ways. | 66% |
| being curious. | 56% |
| generate new ideas. | 54% |
| inventing, innovating, and producing new things. | 54% |

The most chosen option to complete the sentence "Creativity means..." was "Thinking "outside the box" and the second option was "seeing unusual links/connections between existing concepts, ideas, or things". Interestingly, the two personal characteristics that are in these top five means of creativity are "seeing the world in different ways" and "Being curious". All the others are related to the process ("think "outside the box".; "...see unusual links/connections between existing concepts, ideas, or things") or product ("...generate new ideas.", "...inventing, innovating, and producing new things). In conclusion, for the survey respondents, the process is the best form to define creativity.

To understand what practices could be used, to develop creativity during the doctorate, a close question was presented: "What forms of work at the university are most conducive to the development of creativity?". The students had twenty options and had to choose 7 options. The options assigned for more than 50% of the respondents are presented in Table 3.

Table 3. Percentage of doctorates that choose the option to answer the question "What forms of work at the university are most conducive to the development of creativity?".

| What forms of work at the university are most conducive to the development of creativity?" | Percentage of respondents (%) |
|---|--------------------------------------|
| Participate in seminars, round tables, plenaries, and debates. | 80% |
| Carry out research activities (laboratory or not) in a research group. | 79% |
| Participate in meetings between PhD students and teachers/supervisors. | 64% |
| Develop projects throughout the course (project activities in master and doctorate) | 62% |
| Conduct laboratory work within the course (project activities)/study cycles. | 51% |

It should be stressed that taking part in seminars, round tables, plenaries and debates in university are forms of work that, for the respondents (PhD students), may conduct the development of creativity, but also "Carry out research activities (laboratory or not) in a research group". These activities also promote the development of communication, collaboration, and critical thinking, as "be an active participant" in seminars, round tables, plenaries, and debates, which implies that all participants know how to expose, explain, and exchange ideas - have communication skills. Collaboration skills are implicit

in research teamwork so conducting research activities (laboratory or not) in a research group is a basic skill. These activities may also promote the scientific skills developed by researchers, and open new horizons for others as they exchange ideas with others. “Participate in meetings between PhD students and teachers/supervisors” can be very useful if techniques like “Brainstorm” are used to discuss the data or the research process. So, what happens during the meetings can influence positively creativity or kill it, if the supervisor doesn’t allow a true discussion of data or research process or doesn’t promote autonomy and critical thinking and teach students to deal with uncertainty and failure.

4. Conclusions

From the data collected in this research, it is possible to conclude that, the learning and innovation skills for the 21st century proposed in the P21 framework, critical thinking, creativity, collaboration, and communication are, from the PhD students' point of view, being developed in doctoral education at this institution.

It should be underscored that research that has been taken since 2017, in this institution regarding doctoral education, allows a view through doctoral supervision practices and their change in time. If in the beginning, the data indicated that generally supervision practices were not open to soft skills development and were focused on scientific skills. In the present data, PhD students present a new image, as they fill comfortable with soft skills. A hypothesis that emerges, is that the doctoral school at NOVA Lisbon University (a structure that offers different short courses regarding soft skills, for the PhD students and supervisors), is changing the profile of a doctorate and may be a crucial institutional support to develop soft skills. Although this study has a sample limitation, a new pathway of research was opened, to perceive the change that is occurring in the PhD students' and supervisors' profiles.

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