How many roads? Critical Thinking and Creativity in Higher Education and Mathematics

Maria M. Nascimento[1,2][0000-0002-3913-4845] and Paula Catarino[1,2][0000-0001-6917-5093]

[1] University of Trás-os-Montes e Alto Douro, Vila Real, Portugal
[2] LabDCT-UTAD/Research Centre on Didactics and Technology in the Education of Trainers, University of Aveiro, Portugal
mmsn@utad.pt

Abstract. We present a decade's work in higher education and teaching subjects in Mathematics in what refers to critical and creative thinking (CCT) at a Portuguese University. Thus, this study aims to summarize and interconnect the contributions of cooperative work among teachers interested in fostering more systematic and intending to foster critical and creative thinking in Portuguese and in parallel with reflecting on their pedagogical practice. The research question: How have CCT practices in the authors' courses changed, driven by their participation in the cooperative work of their research group? The analysis was 3-folded 1) the learning methodologies, 2) the exploratory studies, and 3) the results of the projects. We did a narrative literature review of 17 papers and a book chapter using the three groups analyzing the theme in which (at least) one of the authors appeared. The results revealed that integrating into the cooperative group allowed the two teachers to transform aspects of their practices and contribute to training the students, preparing them for the changes in this century's daily life and labor market. Teaching using active learning strategies does not necessarily promote CCT development, but the change is still in progress. Professional learning communities are drivers for education.

Keywords: Critical and creative thinking, Pedagogical practice, Higher education, Mathematics.

1 Introduction and context

The authors began their higher education (HE) career at the University of Trás-os-Montes and Alto Douro (UTAD) in the Department of Mathematics at the School of Science and Technology. They have been teaching several disciplines in the area of Mathematics. Their involvement in teaching Mathematics and their students' success remains today.

However, following the Bologna process, we began a path involving critical (CT) and creative thinking about ten years ago. The Bologna process intended that, at the end of the course, the graduate will be able to mobilize the necessary skills to face the challenges of the labor market. So, the study programs must provide the development of entrepreneurship, innovation, creativity, and critical thinking [1]. So, the HE

organization model is accomplished through a) moving from teaching based on the transmission of knowledge to teaching based on the development of competencies; b) orientation of the training given towards the specific objectives that must be ensured by the study cycles of the subsystem, university, or polytechnic in which it is inserted; c) determination of the work that the student must develop in each curricular unit - including, namely, when applicable, teaching sessions of a collective nature, personal guidance sessions of a tutorial type, internships, projects, fieldwork, study, and assessment - and their expression in credits according to the European Credit Transfer and Accumulation System, ECTS, based on student work [2]. Following the Bologna Process, student learning should be active and have a strong self-learning component. This self-learning should involve developing analysis, problem-solving, argumentation, group work, and communication skills, reinforcing the potential for lifelong learning [3].

Furthermore, "[a] *student-centred teaching environment fosters students' proactive engagement, which generally translates, in its simplest form, in students asking frequent more challenging questions. Teaching in such settings requires increased confidence, flexibility, and resilience*" [4].

At the same time, the role of teachers should change, leaving their centrality and becoming the moderator/supervisor/coordinator of students. In this way, modifying teaching practices in higher education and "weaning" students from passive audience practices, involving them in the active construction of their knowledge, will be able to enable them to exercise citizenship in a more intervening and participatory way in all aspects, including that of being competent professionals.

To UNESCO, "(…) *professional teaching knowledge has intuitive, practical, and relational dimensions. Collaborative teaching work naturally integrates a dimension of reflection and sharing among peers. Increasingly, this research can be translated into writing, with teachers assuming authorship*." [5, pp. 89-90].

Therefore, working on critical and creative thinking, and because of current developments in the world, will prepare students to (i) resist the imponderables of their lives with resilience and solid skills, both individually and collectively; (ii) work in jobs that have not yet been created; (iii) make new learnings along their paths; (iv) interact with intelligent machines; (v) meet the complexity of problems that require highly specialized knowledge [3].

For this work, we formulated the research question: How have critical and creative thinking practices in the authors' courses changed, driven by their participation in the cooperative work of their research group? A narrative literature review of 17 papers and a book chapter using three focuses for their analysis is presented: 1) the implemented learning methodologies, 2) the exploratory studies, and 3) the results of the projects we participated in.

2 Methodology

Usually, a literature review involves identifying materials for potential inclusion - whether or not a formal literature search is required - to select included materials, synthesize them in textual, tabular, or graphical form, and analyze their contribution or

value [6]. Grant and Booth [6] characterize a literature review by the generic term and from published materials that examine recent or current literature on a range of subjects at various levels and may or may not include an assessment of the quality of the articles. It may or may not be exhaustive and is typically narrative. The analysis of this literature review may be chronological, conceptual, and thematic, among others.

The study of literature published in books and journal articles in the author's interpretation and personal critical analysis [7], in this case, from the authors.

In this work, the literature review was carried out to describe the path of the two authors - the 1st author will be designated by A and the 2nd by B - regarding their critical and creative thinking publications in the last ten years. The narrative of the aspects detected is described.

This work started from the chronological analysis of 17 papers and a book chapter on the theme in which at least one of the authors figured. The final list of references will have an asterisk (*).

Fig. 1 summarizes the articles to be analyzed. The analysis of the papers began with their systematic re-reading carried out by the two authors simultaneously to organize the elements of the three following aspects: 1) the implemented learning methodologies, 2) the exploratory studies, and 3) the results of the projects in which we participated.

Paper n.º [Reference]	Participating author	Year	Original Title [English title]
1 [8]	A	2013	Insights on web-based peer review: a case study with energy engineering students
2 [9]	A	2014	Estratégias de reforço das capacidades de pensamento crítico: um caso na UTAD [Strategies to reinforce critical thinking skills: a case at UTAD]
3 [10]	A	2014	Come Together: Peer Review with Energy Engineering Students
4 [11]	A	2014	Peer review and critical thinking: Path towards a transversal methodology
5 [12]	A	2015	Learn to cooperate and cooperate to learn: Empowering critical thinking skills through cooperative peer review.
6 [13]	A	2015	Adding value to the learning process by online peer review activities: towards the elaboration of a methodology to promote critical thinking in future engineers
7 [14]	A	2016	Fostering critical thinking through peer review between cooperative learning groups
8 [15]	A, B	2016	Mathematical creativity's understanding in engineering students of a Portuguese university
9 [16]	A, B	2016	Take this Waltz on Creativity- The Engineering Students' Conceptions
10 [17]	A, B	2017	Breaking the habit: engineering students' understanding of mathematical creativity.
11 [18]	A, B	2019	Com Um Brilhozinho nos Olhos: Três experiências promotoras de ensino do pensamento crítico na área da Matemática [With a Twinkle in the Eye: Three experiences promoting the teaching of critical thinking in the area of Mathematics]
12 [19]	B	2019	Cooperative Learning on Promoting Creative Thinking and Mathematical Creativity in Higher Education
13 [20]	A	2019	With a little help from my peers: professional development of higher education teachers to teach critical thinking.
14 [21]	A	2019	Stairway to the Stars: Comparing Health and Tourism Professionals' Views About Critical Thinking
15 [22]	A	2019	Perceptions of Portuguese University Teachers about Critical Thinking Educational Practices
16 [23]	A	2020	The Show Must Go On II: Statistics In (Engineering) Higher Education
17 [24]	B	2021	Teaching Linear Algebra in Engineering Courses Using Critical Thinking
18 [25]	A, B	2018	The Views of Engineering Students on Creativity

Fig. 1. Papers (1-17) and a book chapter (18) in this review.

3 Data Collection and Analysis

3.1 Implemented learning methodologies

Mitchell et al. [26] "define active learning as one-time or ongoing student exercises introduced in the classroom to encourage student thinking and participation to engage students in the learning process."

Of the papers in Fig. 1, 12 (66.7%) involve reports of methodologies implemented in teaching practices by at least one of their authors.

At the beginning of the journey from 2013 to 2016, author A began working cooperatively with other teachers interested in fostering critical and creative thinking more systematically and intentionally at UTAD and, simultaneously, reflecting on their pedagogical practice, resulting in the papers referenced from papers 1 to 7 [8, 9, 10, 11, 12, 13, 14]. Methodologies were also addressed in paper 11 involving the two authors. Papers 16 and 17 are works in each author's specific teaching area. From 2013 to 2016, in Papers 1 to 7 [8, 9, 10, 11, 12, 13, 14], author A joined the analysis and implementation of a web-based peer review task or tasks at the degree (bachelor) level in a Portuguese Higher Education Institution.

In that time frame, the task was described, developed, and the different results were peer-reviewed and published to disseminate the results. The methodology involves students reviewing and providing constructive feedback on each other's work, facilitating the development of critical thinking skills. Each student or each group of students (in courses with many students) "produced a written document, containing a synthesis and an analysis of the paper (…) using Ennis' six dimensions FRISCO guideline (…) in a Google Drive Doc (digital) template designed by the teacher" [14, p. 35].

Later this task was also referred to by Nascimento et al. in case 3 [18, p. 199]: "The FRISCO guideline allowed students to develop critical thinking skills: identification of reasons, inferences, and credibility of information, among others. The grid was 1st presented in class through an example of the analyses of a newspaper piece".

Paper 11 [18] also refers to other strategies in the classroom, namely: Discovery of the Linear Algebra definitions using images (case 1), explaining the choices in true/false questions in tests (case 1), think-pair-share strategy (cases 2 and 3), class surveys with discussion (cases 2 and 3), and project work (case 3).

Catarino et al. [19] report a quasi-experimental study where the experimental group carried out "(…) *the Trade Questions cooperative method consisted of the analysis by the different cooperative groups of an image related to the contents of Linear Algebra on which they had to elaborate the greatest possible number of questions during four minutes*". In the discussion, the authors mentioned an intervention to promote creative thinking in a Communication and Multimedia degree in a Linear Algebra course. The authors found that cooperative learning activities enhanced experimental group students' creativity.

Active teaching strategies were implemented during the COVID-19 pandemic also by Nascimento and Morais [23]: motivational video reading quizzes, think-pair-share tasks in the theoretical classes, and for the theoretical-practical classes, the use of Padlet as a mural to schedule and follow the pairs/group peer-review activity cycle with

feedback from students and the teacher, concept maps, and project work. Catarino and Vasco also reported the think-pair-share strategy [24].

From Paper 1 [8]: "*These lines of research will be carried out by a critical thinking research group which was created in the current school year (2012/2013) by several teachers at the [UTAD]. After the analysis and presentation of previous experiences in the engineering courses* (…)*, their benefits and difficulties, teachers from other scientific areas such as Veterinary, Linguistics, Education, Statistics, Agriculture, and Second Languages teaching showed interest* (…)*. Therefore, this group is working on* (…) *using a similar global methodology*."

In Paper 4 [11], based on the description of the path of a group of professors at UTAD (webPACT) in the use online peer review environment, some constraints to the development of communication and critical thinking development of communication and CT skills in students. Some initial adjustments were made to the methodology used between theory and practice, making it completer and more refined. The interventions were carried out in bachelor's and master's courses, including Engineering Degrees, Veterinary Medicine, Basic Education, Communication Sciences, and Mathematics.

3.2 Exploratory Studies

Singh writes, "*Exploratory research is the initial research which forms the basis of more conclusive research*" [27, p. 63]. Similarly, it "*allows researchers to explore issues in detail in order to familiarize themselves with the problem or concept to be studied*" [27, pp. 63-64].

Of the papers in Fig.1, 4 (22.2%) report exploratory studies from both authors regarding students' creativity and mathematical creativity understandings and concepts. Based on surveys done with engineering students, the open-ended questions about their understanding of creativity and mathematical creativity. The answers' content analysis was done and reported in those four papers.

In Paper 8 [15]: "*This exploratory study leaves clues on the connection that needs to be made between mathematical creativity and 'solving problems', maybe it is a way to foster it in Mathematics courses in engineering degrees*" [15, p. 4].

In Paper 9 [16], "(…) *the exploratory analysis of students' definitions* (…) *showed that definitions were affected neither by gender nor by the original area of study, and* (…) *showed the predominance* (…) *of grouped implicit categories (creation, imagination, and originality)*" [16, p. 5].

In Paper 10 [17], the exploratory study also indicated, "[d]*ifferent tasks may encourage mathematical creativity, hence creativity. Following this study for engineering degrees* (…) *in their mathematics courses, for instance, exploring problem-solving and problem-posing in other mathematical subjects such as Statistics*" [17, p. 10].

Finally, in the book chapter [25], the final remarks suggested that "(…) *the use of problem-solving or project-based learning* (…) *would foster students' confidence* (…) *by triggering their curiosity for new approaches toward common problems and challenging their ability to propose and select the most suitable solution*" [25, p. 154].

3.3 Project results

The project was

"(…) *an 'Erasmus+ Programme, the 'Critical Thinking Across the European Higher Education Curricula – CRITHINKEDU' project arises from the background and experience of European Higher Education Institutions, business corporations and Non-Governmental Organisations, and their ongoing concern to improve the quality of learning in universities and across different sectors, which converge in a common need on how to better support the development of Critical Thinking (CT) according to labour market needs and social challenges*" [28]

Their main results were:

"*Higher awareness of the need for CT education; Improvement of curricula design and classroom educational practices; Enlargement of academics and researchers' network; Engagement of all institutional levels in supporting CT education; Closer University-Business Cooperation for CT education; Empowerment of teachers' professional development and students' CT; Implementation of activities and teaching strategies that prompt and support CT; Creation of CT scenarios in diverse higher education fields*" [28].

Of the papers in Fig.1, 7 (38.9%) refer to project results as implemented learning methodologies in Papers 11 [18], 12 [19], 16 [23], and 17 [24] and referred to in paragraph 3.1. The project reports work in CRITHINKEDU resulted in Papers 13 [20], 14 [21], and 15 [22].

The methodologies were "(…) *implemented in a European training course on CT education for university teachers in Rome, Italy. This course aimed to engage participants with CT teaching practices, preparing them with the required pedagogical knowledge and tools suitable for this purpose*" [20, p. 143]. The course was "*drawn upon the proposals of the 'European inventory of critical thinking skills and dispositions for the 21st century' and the 'Preliminary guidelines for quality in critical thinking education'* (…)" [20, p.143]. The course topics for each day are in Fig. 2.

The changes reported in Papers 11 [18], 12 [19], 15 [22], 16 [23], and 17 [24] were done during the Rome course and began their implementation in the 2nd semester of 2017/18 after it and subsequently.

Course days	Topics for each day	Course days	Topics for each day
Day 1	What do we want to achieve in our course? 1.1.An introduction on the 4C/ID model 1.2.Heuristic bias and CT 1.3.Characterization of CT: a proposal	Day 3	How can we support students in CT development? 3.1.CT lesson planning, classroom environment, questioning, and cooperative learning techniques 3.2.Methods and strategies of Problem-Based Learning (PBL) supporting CT development, creative thinking, and visual literacy 3.3.Using Values and Knowledge Education (VAKE) for enhancing CT
Day 2	What do students have to do? 2.1.Task analysis 2.2.The design of teaching sequences integrating CT 2.3.Tips for designing supportive &procedural information to deal with an intuitive mental model	Day 4	How can we measure the achievement? 4.1.Tools to assess CT levels of students
		Day 5	Are we all ready to go? 5.1.Expectations after the CRITHINKEDU course

Fig. 2. CRITHINKEDU course topics for each day (adapted from Paper 13 [20], p.144).

Finally, in Paper 13 [20] discussion: "*What strikes here is that even experienced teachers understand and integrate CT teaching practices in different ways and levels. Thus, professional development and effective change in terms of CT teaching practices development is a complex challenge, slow and time-consuming process*" [20, p. 149].

In the CRITHINKEDU former outcomes, author A questioned (with other project members) different professionals about their views on the critical thinking needs in their areas. In Paper 14 [21]: "*The focus group technique* (…) *was used with a set of open-ended questions* (…). *The participants were professionals of business companies, organizations, and employers from different areas, namely, Health and Tourism*" [21, p. 214]. As a result:

"*In the Health area, the more mentioned CT were Evaluation, Others (…) such as Interpersonal Skills, Establishment of priorities and Communication skills) and Self-regulation; in the Tourism area, the (…) framework CT skill stood out. In the Health area, all the dispositions got more or less the same number of mentions. However, in the Tourism area, Inquisitiveness and Analyticity are highlighted. Finally, CT skills and CT dispositions examples were different in each of these two professional areas*" [21, p. 221].

Finally, in Paper 15 [22]:

"*We carried out semi-structured interviews with five Portuguese university teachers (…). Interviewed teachers (…) were asked to describe their perceptions about CT teaching, namely: how can CT be promoted in HE; what type of interventions, teaching strategies, and evaluation methods are being used to promote CT; and what challenges and limitations teachers have to face nowadays in their CT instruction*" [22, p. 227].

As a result: "*The teachers interviewed emphasize, as for the challenges in CT education, the need to change the students' and teachers' mindset (change of the institutional culture). Also, other challenges and difficulties are mentioned, namely: the lack of institutional support in the promotion of CT; difficulty in implementing activities due to the size of the class (high number of students), organizational conditions (class length) (…)*" [22, p. 236].

Finally, an important finding was referred to:

"(…) *the need to change institutional culture and conditions towards the support of CT educational practices – this will also enable the long-term integration of CT across the curricula and the transferability of skills and dispositions to other contexts. In general, teachers agreed on the importance of being explicit and clear in their CT teaching practice and using authentic situations, dialogue, and active learning strategies to effectively develop students' CT*" [22, p. 223].

4 Discussion and Conclusions

Active learning environments are more student-centered in encouraging students to develop skills. In an active learning approach, students take responsibility for the learning, and teachers become facilitators for what happens in and out of the classroom [3, 4, 26]. Several learning methodologies were implemented in the authors' reported teaching practices. These methodologies included web-based peer review tasks, think-pair-

share strategy, project work, and discovering mathematical definitions using images. The authors emphasize the importance of cooperative learning activities in enhancing critical and creative thinking skills. They discussed the implementation of these methodologies in different courses and study areas.

Regarding the exploratory studies [27], the authors report their studies about students' understanding and perceptions of creativity and mathematical creativity. They analyzed survey answers from engineering students (and different school years) and found that definitions of creativity were not influenced by gender or the students' original study area. The authors suggest that problem-solving tasks and exploration of problem-posing in various mathematical subjects can encourage creativity and, therefore, mathematical creativity simultaneously.

In the item project results, the authors - author A as a team member and author B as a webPACT member - were involved in an Erasmus+ project, "*Critical Thinking Across the European Higher Education Curricula – CRITHINKEDU*" [28], and the project aimed to improve university learning quality by promoting critical thinking skills and dispositions [28]. The authors report changes in higher education, improvement of curricula design, engagement of academics and researchers, university-business cooperation, and empowerment of teachers' professional development and students' critical thinking. They also mention implementing activities and teaching strategies that foster critical and creative thinking and the need for institutional support, among others, since its implementation needs time. The project results in which the authors were involved show that pedagogical approaches positively impact students' CT and creativity take class time and should be developed along all courses of the graduations or masters. Additionally, the findings highlight the value of professional learning communities and teachers' networks in facilitating the learning and teaching change (at least gradually) in higher education, specifically regarding critical and creative thinking at their Portuguese university.

The authors analyzed 17 papers and a book chapter, all being peer-review submissions (available in the references), and reflecting on our work in the last ten years, we did not dare to make either quantitative conclusions or generalizations. Consequently, we acknowledge our work limitations. Since the papers are from the authors' production, it is a biased view, and the sample size is small. Therefore, this work only provides a comprehensive overview of the research and perspectives of the authors engaged in the webPACT cooperative research group. In the future, even with other colleagues, we may broaden the publications to the webPACT to capture the range of relevant research and perspectives in this cooperative research group.

In summary, critical and creative thinking practices in the authors' courses changed, mainly driven by their participation in the cooperative work of their research group. The thematic analysis of this literature review revealed that, throughout this decade, all the implemented work allowed the two teachers to alter (at least some) features of their practices and contribute to more proactively training the students, preparing them for the changes in this century's daily life and labor market. Teaching using active learning strategies does not necessarily promote CT development, but the changes are still in progress. Professional learning communities still are key drivers for education, in our case, higher education.

Acknowledgments

This work is financially supported by National Funds through FCT – Fundação para a Ciência e a Tecnologia, IP, under the project UIDB/00194/2020.

References

1. Melo, A. S.: Enquadramento histórico legal do processo de Bolonha e o seu impacto no sistema de ensino superior português. Revista Observatório, 3(6), 75–141 (2017).
2. Leite, C., Fernandes, P.: Inovação pedagógica: uma resposta às demandas da sala de aula universitária. Perspectiva, 29(02), 507–533 (2011).
3. Conselho Nacional de Educação – CNE, Estado da Educação 2021. CNE, Lisboa (2022).
4. Benedetti, M. di, Plumb, S., Beck, S. B. M.: Effective use of peer teaching and self-reflection for the pedagogical training of graduate teaching assistants in engineering, European Journal of Engineering Education, 48(1), 59-74 (2023).
5. UNESCO. Reimagining our futures together: A new social contract for education. UN, 2022.
6. Grant, M. J., Booth, A.: A typology of reviews: an analysis of 14 review types and associated methodologies. Health Information & Libraries Journal, 26(2), 91-108 (2009).
7. Ercole, F. F., Melo, L. S. D., Alcoforado, C. C.: Revisão integrativa versus revisão sistemática. Reme: Revista Mineira de Enfermagem, 18(1), 09-11 (2014).
8. *Dominguez, C., Nascimento, M., Maia, A., Pedrosa, D., Cruz, G.: Insights on web-based peer review: a case study with energy engineering students. In: 2013 1st International Conference of the Portuguese Society for Engineering Education. pp. 1-10. IEEE, (2013).
9. *Payan-Carreira, R., Dominguez, C., Nascimento, M.: Estratégias de reforço das capacidades de pensamento crítico: um caso na UTAD. Práticas Educativas: Teorização e Formas de Intervenção, 56-67 (2014).
10. *Dominguez, C., Nascimento, M., Maia, A., Pedrosa, D., Cruz, G.: Come together: peer review with energy engineering students. International Journal of Engineering Pedagogy (iJEP), 4(5), 34-41 (2014).
11. *Dominguez, C., Carreira, R., Morais, M., Nascimento, M., Maia, A., Pedrosa, D., & Cruz, G. Revisão entre pares e pensamento crítico: percurso para uma metodologia transversal. Pensamento Crítico na Educação: Perspetivas atuais no panorama internacional, pp. 357-378. Universidade de Aveiro, Aveiro (2014).
12. *Dominguez, C., Carreira, R. P., Nascimento, M., Morais, M. F.: Learn to cooperate and cooperate to learn: empowering critical thinking skills through cooperative peer review. In: Pensamento crítico na educação: desafios atuais, pp.175-185. UTAD, Vila Real (2015).
13. *Dominguez, C., Nascimento, M. M., Payan-Carreira, R., Cruz, G., Silva, H., Lopes, J., ..., Morais, E.: Adding value to the learning process by online peer review activities: towards the elaboration of a methodology to promote critical thinking in future engineers. European Journal of Engineering Education, 40(5), 573-591 (2015).
14. *Silva, H., Lopes, J., Dominguez, C., Payan-Carreira, R., Morais, E., Nascimento, M., Morais, F. Fostering critical thinking through peer review between cooperative learning groups. Revista Lusófona de Educação, (32), 31-45 (2016).
15. *Catarino, P., Nascimento, M. M., Morais, E., Campos, H., Vasco, P.: Mathematical creativity's understanding in engineering students of a Portuguese university. In 2016 2nd International Conference of the Portuguese Society for Engineering Education (CISPEE), pp. 1-5. IEEE. (2016).

16. *Catarino, P., Nascimento, M. M., Morais, E., Silva, H., Payan-Carreira, R.: Take this waltz on creativity: the engineering students' conceptions. In 2016 2nd International Conference of the Portuguese Society for Engineering Education (CISPEE), pp. 1-6. IEEE. (2016).
17. *Catarino, P., Nascimento, M. M., Morais, E., Campos, H., Vasco P.: Breaking the habit: engineering students' understanding of mathematical creativity, European Journal of Engineering Education, 44(4), 449-460 (2017).
18. *Nascimento, M. M., Catarino, P., Morais, E., Vasco, P.: Com Um Brilhozinho nos Olhos: Três experiências promotoras de ensino do pensamento crítico na área da Matemática. Revista Lusófona de Educação, 44, 191-209 (2019).
19. *Lopes, J., Silva, H., Catarino, P., Morais, E., Vasco, P.: Cooperative learning on promoting creative thinking and mathematical creativity in higher education. REICE. Revista Iberoamericana Sobre Calidad, Eficacia y Cambio En Educacion, 17(3), 5-22 (2019).
20. *Cruz, G., Nascimento, M. M., & Dominguez, C. (2019). With a little help from my peers: professional development of higher education teachers to teach critical thinking. Revista Lusófona de Educação, 44, 141-157.
21. *Nascimento, M. M., Silva, H., Morais, F., Pedrosa, D., Cruz, G., Payan-Carreira, R., Dominguez, C.: Stairway to the Stars: Comparing Health and Tourism Professionals Views About Critical Thinking. In: Tsitouridou, M., A. Diniz, J., Mikropoulos, T. (eds) Technology and Innovation in Learning, Teaching, and Education. TECH-EDU 2018. Communications in Computer and Information Science, vol 993, pp. 210-222. Springer, Cham. (2019).
22. *Morais, F., Silva, H., Cruz, G., Pedrosa, D., Payan-Carreira, R., Dominguez, C., & Nascimento, M. M.: Perceptions of Portuguese university teachers about critical thinking educational practices. In: Tsitouridou, M., A. Diniz, J., Mikropoulos, T. (eds) Technology and Innovation in Learning, Teaching, and Education. TECH-EDU 2018. Communications in Computer and Information Science, vol 993, pp. 223-239. Springer, Cham. (2019).
23. *Nascimento, M. M., Morais, E.: The Show Must Go On II: Statistics In (Engineering) Higher Education. Open Education Studies, 2(1), 214-219 (2020).
24. *Catarino, P., Vasco, P.: Teaching Linear Algebra in Engineering Courses Using Critical Thinking. Open Education Studies, 3(1), 76-83 (2021).
25. *Catarino, P., Nascimento, M. M., Morais, E., Vasco, P., Campos, H., Silva, H., Payan-Carreira, R, Monteiro, M.J.: The Views of Engineering Students on Creativity. In: Nascimento, M., Alves, G., Morais, E. (eds) Contributions to Higher Engineering Education. 135-158 Springer, Singapore. (2018).
26. Mitchell, A., Petter, S., Harris, A. L.: Learning by doing: Twenty successful active learning exercises for information systems courses. Journal of Information Technology Education. Innovations in Practice, 16, 21-46 (2017).
27. Singh, K.: Quantitative social research methods. Sage, New Delhi (2007).
28. CRITHINKEDU Homepage, https://crithinkedu.utad.pt/en/crithinkedu/, last accessed 2023/05/21.