DETEL

Doctoral Education for Technology-Enhanced Learning project

Doctoral Education for Technology-Enhanced Learning in Europe

REPORT

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Title

Doctoral Education for Technology-Enhanced Learning in Europe: report

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- Challenges: Luis P. Prieto and Laia Albó
- Supervision and mentoring: Luis P. Prieto and Laia Albó
- Open-ended questions: Anastasios Economides and Maria Perifanou

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DE-TEL Project can be found on the Erasmus Plus results portal.

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Executive summary

This report informs about the state of doctoral education in the area of Technology-Enhanced Learning (TEL) in Europe. The report aims to inform policy decisions in doctoral education and in the implementation of these policies.

We reviewed 35 cases of institutional doctoral education in TEL identified in 11 European countries. The results indicate that educational institutions use different approaches to doctoral education in technology-enhanced learning. The doctoral degrees in this field are awarded by departments in different academic areas, within different study programs, with correspondingly different curricula, and therefore heterogeneous foundational knowledge.

The report also contains the results of the survey of doctoral education in TEL. The objectives were to inform the design of curricula in the field, improve doctoral education overall, and to collect background on the current practices and challenges. The survey was implemented as an online questionnaire with 31 close and open questions in seven sections: professional background, thematic content, general PhD training topics, research methods, learning sources, challenges, supervision and mentoring, and personal background. In total, 229 participants responded to the survey, including 103 PhD candidates, 92 PhD holders, and 26 Master's degree holders.

The survey results indicate that doctoral courses and educational materials are most needed in the TEL community for the topics: learning analytics, artificial intelligence in education, personalized and adaptive learning, self-regulated / informal learning, smart / intelligent learning environments, pedagogical patterns, gamification, visualization / visual analytics, mixed and augmented reality, and engagement / emotion / affect.

There is a need for courses and enough materials on the general PhD training topics of academic writing and publication, dissemination of research results, communication about research, project management, and research ethics.

The primary learning source for TEL topics is academic publications, for general PhD-level training is supervisor help, and for research methods: supervisor help, academic publications, and courses in the PhD program.

The most difficult barriers for TEL PhD candidates are work-life balance, project management, and psychological challenges. Among the different challenge areas, those related to supervision are the most reliable predictors of student satisfaction with their doctoral studies. Most innovative supervision practices, such as learning how to write scientific papers by example, team supervision, and discussion of the overall PhD ideas, were found useful by both PhD students and PhD holders. Many of the innovative supervision practices are rare within the TEL community.

Overall, doctoral education in TEL reflects the complexity of the interdisciplinary field of TEL. This report provides an input for curricula design, educational and supervision practices, examples of administrative contests, and existing challenges.

1. Introduction

As discussed by Pammer-Schindler et al.[1]*, research fields are, in many ways, set up as communities of shared knowledge and practice[2,3]. Communities differentiate themselves by the agreed objects of interest and by what is considered valid ways of contributing and gaining seniority[4,5]. This includes specific methodological commitments in extension of a generally-shared agreement across disciplines that the generation of new knowledge is the goal. Moreover, this also involves an often unspoken agreement as to which publishing venues are considered acceptable and reputable. Doctoral training is often considered an academic rite of passage[6].

Research fields tend to cascade into Higher Education over time, for instance in the form of doctoral schools, as a way to commodify recruitment and training of future community members. Doctoral education is thereby commonly implemented in non-interdisciplinary academic structures[7], while at the same time aiming to establish a transdisciplinary view of science ('mode 2 science'), driven by grand challenges[8] that do not regard disciplinary boundaries[9].

In principle, one could discuss that "doctoral-level education" (as in "doctoral training program" or "PhD studies") is an oxymoron, as any such expression pretends that the key principles of education could be directly applied to research. Any common definition of 'education' includes the idea of giving and receiving *systematic instruction* to motivate the re-construction or re-development of *existing* knowledge, skills, abilities, and other characteristics by the recipient of education, the learner, of course adapted to given context. Even more thought-provoking, ideas of academic knowledge exchange suggest that skills should be transferred from a knowledgeable scholar (and their academic outputs such as textbooks, journal articles, or online course materials). 'Research' on the other hand requires systematic *investigation*, with the aim to discover or develop a *novel insight*, previously unknown. Delineating it from bachelor (level 6) and master (level 7), the International Standard Classification of Education speaks in this context for its definition of level 8 of requiring submission of "written work of

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[1] Viktoria Pammer-Schindler, Fridolin Wild, Mikhail Fominykh, Tobias Ley, Maria Perifanou, Maria Victoria Soule, Davinia Hernandez-Leo, Marco Kalz, Ralf Klamma, Luis Pedro, Carlos Santos, Christian Glahn, Anastasios A. Economides, Antigoni Parmaxi, Ekaterina Prasolova-Førland, Denis Gillet and Katherin Maillet (2020). Interdisciplinary Doctoral Training in Technology-Enhanced Learning in Europe. https://doi.org/10.3389/feduc.2020.00150

* Parts of the introduction are taken nearly verbatim from this publication by most of the authors of this report.

[2] Bruno Latour (2005). Reassembling the social. An introduction to actor-network-theory.

[3] Jean Lave and Etienne Wenger (1991). Situated Learning: Legitimate Peripheral Participation.

[4] Thomas S. Kuhn (2012). The Structure of Scientific Revolutions. 50th Anniversary Edition.

[5] Jean Lave and Etienne Wenger (1991). Situated Learning: Legitimate Peripheral Participation.

[6] Najah Nadiah Amran and Rozita Ibrahim (2012). Academic Rites of Passage: Reflection on a PhD Journey https://doi.org/10.1016/j.sbspro.2012.09.310

[7] Katrine Lindvig (2018). The implied PhD student of interdisciplinary research projects within monodisciplinary structures. https://doi.org/10.1080/07294360.2018.1474343

[8] Michael O'Rourke, Stephen Crowley, and Chad Gonnerman (2016). Studies in History and Philosophy of Science Part C: Studies in History and Philosophy of Biological and Biomedical Sciences https://doi.org/10.1016/j.shpsc.2015.10.003

[9] Gemma Carr, Daniel P. Loucks, and Günter Blöschl (2018). Gaining insight into interdisciplinary research and education programmes: A framework for evaluation https://doi.org/10.1016/j.respol.2017.09.010

publishable quality that is the product of original research and represents a significant contribution to knowledge in the respective field of study"[10].

On the other hand, the review of the state of the art has become and will become increasingly more complex, as the amount of codified knowledge (publications, research data) grows continuously year after year. In parallel, methods evolve to take up new possibilities to analyze data, and to do so in a more complex manner. For example, public betas ('facebook as a testbed'), open test collections, online crowdsourcing, and participatory approaches such as citizen science promise to lower barriers to research (regarding access, replication, and reuse, see[11,12,13,14]. New requirements emerge regarding ethics, research and research data documentation, and accessibility. From this position, one could argue that methodology, practice, and existing knowledge exhibit increased complexity when operated on, thereby justifying the need for additional training and guidance beyond the prerequisite bachelor and master levels.

Nevertheless, doctoral training is widely accepted to be a key activity of research communities. Technology Enhanced Learning (TEL) is no exception to this.

Within this project (DE-TEL[15]), the goal has been to 1) understand current practice and shortcomings of institutional doctoral training in TEL in Europe, as well as 2) to offer doctoral trainings outside institutions including training materials[16] that take up TEL-specific issues relevant for doctoral students in TEL, and to ramp up cross-institutional doctoral training via the JTELSS summer school[17]. This should help avoid fragmentation in this important research topic in Europe.

In particular, this report informs about the state of doctoral education in the area of technology-enhanced learning in Europe. This serves as the evidence basis for further developments in doctoral training in TEL in general, as well as the evidence basis for further activities that were carried out within this project. To inform about the state of doctoral education in the field of TEL in Europe, the report reviews 35 cases of institutional doctoral education in the area of technology-enhanced learning identified in 11 European countries and presents the results of a survey about doctoral education in technology-enhanced learning. A total of 229 responses to the survey were collected. Respondents included doctoral candidates who are currently working on PhD projects in the field of TEL, researchers with a PhD degree who work in the field of TEL, practitioners with any degree who work in the field of TEL, students who study TEL and are interested in a PhD in this field.

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[10] ISCED (2011). International Standard Classification of Education. Paris: UNESCO Institute for Statistics.

[11] C. W. Cleverdon (1960). The aslib cranfield research project on the comparative efficiency of indexing systems. https://doi.org/10.1108/eb049778

[12] Ben Shneiderman (2008). Science 2.0. https://doi.org/10.1126/science.1153539

[13] Aniket Kittur, Ed H. Chi, and Bongwon Suh (2008). Crowdsourcing user studies with Mechanical Turk. https://doi.org/10.1145/1357054.1357127

[14] Christothea Herodotou, Eloy Villasclaras-Fernández, and Mike Sharples (2014). The Design and Evaluation of a Sensor-Based Mobile Application for Citizen Inquiry Science Investigations https://doi.org/10.1007/978-3-319-11200-8_38

[15] Doctoral Education for Technology-Enhanced Learning (DE-TEL) project, funded by the Erasmus Plus program of the European Union, grant agreement 2019-1-NO01-KA203-060280. The project works on establishing and deepening a strategic partnership for doctoral education in the field of TEL. https://ea-tel.eu/de-tel

[16] Publicly available here: https://ea-tel.github.io/detel-book/toc/

[17] Summer School for doctoral students in TEL, organized by the European Association on Technology-Enhanced Learning https://ea-tel.eu/jtelss

The studies presented in this report aimed to inform the design of the DE-TEL curriculum, improve doctoral education in TEL, and collect background information on the current practices and challenges. The research questions of the studies were:

- RQ1: What TEL doctoral education practices are followed by European Higher Education institutions?
- RQ2: What courses and educational materials do TEL PhD candidates need?
- RQ3: What learning sources do TEL PhD candidates use?
- RQ4: What challenges do TEL PhD candidates have?
- RQ5: What supervision practices are used in doctoral education in TEL?

Chapter 2 describes the methods used in the desk research and design and distribution of the survey. Chapter 3 is focused on desk research, and Chapter 4 reports the survey results. The overall contributions and conclusions of the report are presented in Chapter 5.

2. Methods

2.1 Desk research

The data were collected regarding the content, teaching methodologies, resources and the administrative context of various doctoral programs in TEL. This research did not entail exhaustive research across all PhD and Postgraduate programs offered across all consortium's countries but aimed to present indicative cases. Sampling in this initial study was done by DE-TEL consortium[18]. The sampled data are therefore not exhaustive; and not necessarily representative. However, the sampled data do show patterns of doctoral education of PhD students of research groups who work in the field.

2.2. Survey of Doctoral Education in TEL

The survey was implemented as an online questionnaire using Lime Survey and aimed to collect responses to primary information on doctoral education in TEL from PhD candidates in TEL and researchers involved in doctoral education in TEL or doing research in TEL. Survey had 31 (close and open) questions and was composed of seven sections as shown below (Table 1). See the complete survey with the answers in annex A1.

Table 1. Main structure of the survey.

Section	Theme	Subsections (number of questions)
1	Professional background	- Professional background (1) - Master studies (3) - PhD studies (3) - Professional experience (2)
2	Thematic content	- Need for courses and educational materials on TEL topics (2) - Importance of courses and educational materials on TEL topics (1) - Availability of courses and educational materials on TEL topics (1)
3	General PhD Training Topics	- Need for courses and educational materials on the general PhD training topics (3) - Availability of courses and educational materials on the general PhD training topics (1)
4	Research methods	- Use of research methods by PhD candidates in TEL (2) - Need for courses and educational materials on research methods (2)
5	Learning sources	- Learning sources for the TEL topics (1) - Learning sources for the general PhD-level training topics (1) - Learning sources for research methods (1)
6	Challenges	- Challenges (1)
7	Supervision and mentoring	- Supervision and mentoring satisfaction (1) - Supervision and mentoring support practices (1) - Rating supervision practices (1)
*	Personal background	- Age, gender, country (3)

[18] https://ea-tel.eu/de-tel/

The survey was available to respondents from 14.09.2020 to 16.02.2021 through a page on the EATEL website[19]. The survey was distributed via multiple channels, including the website and social media accounts of EATEL, institutional and individual professional accounts of the DE-TEL project partners, and the mailing lists of EATEL and of the national professional communities of the countries represented in the DE-TEL consortium.

Respondents were informed about the survey data policy. The participation in the survey was voluntary, and answers were registered electronically without tracking any additional personal data, such as IP address. All answers were treated confidentially in the DE-TEL consortium and remained anonymous. All published results are anonymous. All data will be deleted at the latest 31 December 2022. The data management processes were in line with the General Protection Data Regulation.

To achieve the goal of understanding the current state of doctoral education in TEL, after the survey had been administered, all responses for the close-ended questions were recorded and scored for statistical analysis, including descriptive and inferential statistics, using SPSS V25 and R v4.2. Descriptive statistics included the calculation of frequencies and percentages for all categories (sections) displayed in Table 1. Inferential statistics were performed to identify whether any result was statistically significant. More specifically, an independent sample t-test was computed in SPSS to measure the mean differences between PhD candidates' and PhD holders' views regarding the availability of courses and materials. Three one-way analysis of variance (ANOVA) tests were computed to compare the effect of the stage of PhD candidates on the availability of courses and materials, to compare the effect of the PhD topic on the availability of courses and educational materials, and to compare the effect of the Job Type on the availability of courses and educational materials. These inferential statistical results can be found on Annex A4 to A10. To further understand the structure and relationships among the responses about challenge areas, student satisfaction and supervision practices, additional partial correlations, principal component (PCA) and clustering (k-means, multidimensional scaling) and stepwise linear regression analyses were performed using R's bootnet, FactoMineR, stats, and MASS packages. The main results from these explorations appear in sections 4.6 and 4.7, and a more complete description of them can be found in Annex A15.

Several limitations should be noted from the survey data gathering and analyses above:

1. The survey participants were selected by convenience (but very wide) sampling of the European TEL community, mainly centered around the EATEL association and project's partner universities. Hence, responses may suffer from biases (including the self-selection bias of who decides to spend the effort of answering the survey) and not be representative of the actual population of researchers investigating TEL in Europe.
2. The questions in the survey were not formally validated, which threatens the reliability of the findings.
3. Many of the exploratory statistical analyses performed are of correlational nature, and should be understood as fit for hypothesis *generation*, not to establish causality (which the survey design is inherently unfit for).

In order to analyze the participants responses to the open-ended question, content analysis was used. Initially, two researchers independently read and re-read the participants' responses to the open question to identify the suggested TEL topics. Then each researcher allocated the suggested TEL topics into categories and sub-categories. Each researcher tried to allocate similar TEL topics into a single category. Subsequently, the two researchers discussed their taxonomies and came to an agreement for a mutually accepted taxonomy.

[19] https://ea-tel.eu/de-tel/survey

3. TEL doctoral training in Europe

In this section, we try to map the way doctoral education for Technology-Enhanced Learning (TEL) is handled in Europe. More specifically, we identified existing practices followed by European Higher Education institutions in doctoral education in TEL by conducting desk research.

We obtained a total of 35 cases within 11 countries. These were classified in three main categories and some sub-categories:

1. PhD in TEL or related to TEL including the following subcategories:
    1.1. PhD programs in TEL which offer courses (curriculum) or not
    1.2. PhD in Computer science on research topics related to the area of TEL
    1.3. PhD in Education on research topics related to the area of TEL
2. Postgraduate programs which offer a TEL specialization that can lead to a PhD in the area of TEL including the following subcategories
    2.1. Postgraduate programs in TEL
    2.2. Postgraduate program in ICT
    2.3. Postgraduate program in Education
3. Cross-departmental or multidisciplinary programs including the following subcategories:
    3.1. Cross-departmental or multidisciplinary PhD programs
    3.2. Cross-departmental or multidisciplinary postgraduate programs that lead to a PhD in TEL. The cases are described in detail in an online appendix to this paper.

3.1 PhD programs in TEL or related to TEL

The first category comprises PhD programs in TEL as well as PhD programs in Computer Science or Education on research topics related to TEL. An interesting research finding is that most of the PhD programs (12/16) of this category offer PhD courses for PhD students. A representative example of such practices include the Institute of Interactive Systems and Data Science in Austria which offers a PhD program in Computer science, as well as a number of obligatory PhD courses (such as "methods of scientific work") and elective (e.g. "Designing Interactive Systems") for PhD students.

3.1.1 PhD programs in TEL

Based on the research conducted by our team we found three (3) cases (Table 2) of PhD programs exclusively focused on TEL: one is offered by the Open University of Catalonia in Spain, the second one is offered by the University of Aveiro and the third one by the Open University of UK. The PhD program "Education and ICT (e-learning)" offered by the Open University of Catalonia is an indicative example as it focuses on the study of the phenomena linked to technology-mediated online learning systems and include among others any innovative research that uses ICT in the framework of education.

Table 2. PhD programs focused on TEL

University	Department or division	Program title	Country
University of Catalonia	Center for research, innovation and training in e-learning.	Education and ITC (e-Learning) [20]	Spain
University of Aveiro	Communication and Arts Department and the Education and Psychology Department	Multimedia in Education [21]	Portugal
Open University of UK	Faculty of Wellbeing, Education and Language Studies, Research in Education and Educational Technology	PhD in Educational Technology [22]	UK

3.1.2 PhD in Computer science on research topics related to TEL

As aforementioned, in this first category are included PhD programs in Computer science that are related to TEL. More specifically, we have identified eight (8) cases (Table 3) that offer PhD programs in the area of Computer science that focus specifically on TEL related topics. These programs combine study and research and they may offer a specific curriculum or not.

Table 3. PhD programs in Computer science on research topics related to TEL.

University	Department or division	Program title	Country
Graz University of Technology	Department of Computer Science and Biomedical Engineering	Doctoral school Computer science [23]	Austria
Pompeu Fabra University	Department of Information and Communication Technologies	Doctoral program in Information and Communication Technologies [24]	Spain
Cyprus University of Technology	Department of Multimedia and Graphic Arts	Doctoral Program of the Department of Multimedia and Graphic Arts [25]	Cyprus
Cyprus University of Technology	Department of Communication and Internet Studies	CIS Doctoral program [26]	Cyprus
Tallinn University	School of Digital Technologies	Information Society Technologies [27]	Estonia
University of Valladolid	School of Telecommunications Engineering, School of Computer	Doctorate in informatics [28]	Spain

[20] https://studies.uoc.edu/en/doctoral-programmes/education-ict/presentation

[21] https://www.ua.pt/en/course/276

[22] https://iet.open.ac.uk/study/phd-in-edtech

[23] https://www.tugraz.at/en/studying-and-teaching/degree-and-certificate-programmes/doctoral-programmes/doctoral-school-of-computer-science

[24] https://www.upf.edu/web/clik/formacio-doctorands

[25] https://www.cut.ac.cy/faculties/aac/mga/degrees/Doctoral+Studies

[26] https://www.cut.ac.cy/faculties/comm/cis/degrees/doctoral-studies/

[27] https://www.tlu.ee/en/dt/information-society-technologies

[28] http://escueladoctorado.uva.es/export/sites/doctorado/programas/informatica/index.html and https://www.gsic.uva.es/index.php?lang=en

	Engineering, and Faculty of Education & Social Work		
Open University of Netherlands	Faculty of Educational Sciences	Faculty Educational Sciences Doctoral program[29], SIKS[30], Faculty-level[31]	Netherlands
Norwegian University of Science and Technology	Department of Computer Science	Doctoral program: Computer Science[32]	Norway

3.1.3 PhD in Education on research topics related to TEL

On the contrary with above, in the last part of the first category are included PhD programs in Education that are related to TEL. More specifically, we have identified six (6) cases (Table 4) that offer PhD programs in the area of Education that focus specifically on TEL related topics. These programs combine study and research and they may offer a specific curriculum or not.

Table 4. PhD programs in Education on research topics related to TEL.

University	Department or division	Program title	Country
Tallinn University	School of Educational Sciences	Educational Sciences[33]	Estonia
Open University of Netherlands	Faculty of Educational Sciences	Interuniversity Centre for Educational Sciences - "ICO PhD"[34] and Faculty-level[35]	Netherlands
Norwegian University of Science and Technology	Faculty of Social and Educational Sciences	Educational Sciences[36]	Norway
University of Oslo	Department of Computer Science	PhD in Educational Sciences[37]	Norway
University of Bergen	Faculty of Psychology	PhD Program at the Faculty of Psychology[38]	Norway
University of Minho	Institute of Education	"Doctoral Degree in Educational Sciences" with focus on Educational Technology[39]	Portugal

[29] https://www.ou.nl/en/-/phd-opportunities

[30] http://siks.nl

[31] https://www.ou.nl/web/open-universiteit/-/welten-promoveren

[32] https://www.ntnu.edu/studies/phcos/programme-components

[33] https://www.tlu.ee/en/hti/educational-sciences

[34] https://ico-education.nl

[35] https://www.ou.nl/web/open-universiteit/-/welten-promoveren

[36] https://www.ntnu.edu/studies/phuv

[37] https://www.uv.uio.no/english/research/phd/

[38] https://www.uib.no/sites/w3.uib.no/files/attachments/phd_programme_at_the_faculty_of_psychology_1.pdf

[39] https://www.ie.uminho.pt/en/Ensino/Doutoramentos/Pages/DoutoramentoemCienciasdaEducacao.aspx

3.2 Postgraduate programs with a TEL specialization that can lead to a PhD in TEL

3.2.1 Postgraduate programs in TEL which lead to PhDs in TEL

In the second category are included Postgraduate programs in Education that are related to TEL and can lead to PhDs in the same area. More concretely, we have found eight (8) cases (Table 5) of Postgraduate programs in ICT which offer PhD programs in TEL.

Table 5. Postgraduate programs in TEL which lead to PhDs in TEL related topics.

University	Department or division	Program title	Country
University of Tartu	PhD in Educational Science	Educational Sciences[40]	Estonia
University of Piraeus	Department of Digital Systems	e-Learning[41]	Greece
Aristotle University of Thessaloniki	Department of Pre-school Education and Education, School of Education Department of Electrical and Computer Engineering, School of Engineering Department of Medicine	Learning Technologies - Educational Sciences[42]	Greece
University of Western Attica & ASPETE	Department of Biomedical Sciences, Department of Education ASPETE	Introduction to Educational Technology[43]	Greece
University of Western Attica, Kapodistrian University of Athens, University of Thessaly	Department of Electrical Engineering (Uni. of Western Attica), Department of Education & Education in Preschool and Communication (Kapodistrian Uni. of Athens) & Mass Media (Kapodistrian Uni. of Athens) and Architectural Engineering (University of Thessaly)	Information and Communication Technologies for Education[44]	Greece
University of Western Attica, Kapodistrian University of Athens, ASPETE	Department of Informatics and Computer Engineering (Uni. of Western Attica); Department of Philosophy, Education and Psychology (Department of National and Kapodistrian Uni. of Athens), Department of Education of ASPETE	Digital Transformation and Educational Practice[45]	Greece
Open University of UK	Faculty of Wellbeing, Education and Language Studies, Research in Education and Educational Technology	Postgraduate Diploma in Online and Distance Education[46]	UK
University College London	Institute of Education	Education and Technology[47]	UK

[40] https://www.ut.ee/en/phd-educational-science

[41] https://masters.ds.unipi.gr/elearning/en/

[42] http://techlearn.web.auth.gr/techlearn/el

[43] https://edutech.uniwa.gr/course/eisagogi-stin-ekpaideytiki-technologia/

[44] http://www.icte.ecd.uoa.gr/

[45] http://msc-ditrep.uniwa.gr/

[46] https://www.open.ac.uk/postgraduate/qualifications/k43

[47] https://www.ucl.ac.uk/prospective-students/graduate/taught-degrees/education-and-technology-ma

3.2.2 Postgraduate programs in ICT which lead to PhDs in TEL

In this section are presented seven (7) Postgraduate programs in ICT which offer PhD programs in TEL (Table 6). An indicative example is the Cyprus University of Technology which offers a postgraduate program on "Interaction Design" and its graduates can continue their studies for a PhD in various TEL related areas such as Embodied Play and Learning using Technology, Interaction Design and Creative Collaboration Spaces, Inclusive Design and Social Change using Technology, Design for social change and innovation, and Computer-Assisted Language Learning.

Table 6. Postgraduate programs in ICT which lead to PhDs in TEL related topics.

University	Department or division	Program title	Country
Cyprus University of Technology	Department of Multimedia and Graphic Arts	MSc in Interaction Design[48]	Cyprus
Pompeu Fabra University	Department of Information and Communication Technologies	Master in Information and Communication Technologies[49]	Spain
Charles III University of Madrid,	Computer Science and Engineering Department	Master in Computer Science And Technology[50]	Spain
Aristotle University of Thessaloniki	Department of Informatics	Technologies of Interactive Systems[51]	Greece
University of Macedonia	Department of Business Administration, Department of Economics and Department of Accounting and Finance with the collaboration of the SMILE LAB	Interdepartmental Program of Postgraduate Studies in Information Systems[52]	Greece
University of Macedonia	School Of Social Sciences, Humanities and Arts, Department Of Educational & Social Policy	Master of Arts in Adult Education[53]	Greece
University of Twente	Faculty of Behavioural, Management and Social Sciences	English-taught Master's program in Educational Science and Technology[54]	Netherlands

3.2.3 Postgraduate programs in education which lead to PhDs in TEL

In this final section are five (5) Postgraduate programs in Education which offer PhD programs in TEL (Table 7). An indicative example is the Cyprus University of Technology which offers a postgraduate program on "Interaction Design" and its graduates can continue their studies for a PhD in various TEL related areas such as Embodied Play and Learning using Technology, Interaction Design and Creative

[48] https://www.idmaster.eu/

[49] https://www.upf.edu/en/web/masters/tecnologies-de-la-informacio-i-les-comunicacions

[50] https://www.uc3m.es/master/computer-science-technology

[51] https://ihst.csd.auth.gr/courses

[52] https://www.uom.gr/en/mis

[53] https://www.uom.gr/en/ekpmet

[54] https://www.utwente.nl/en/education/master/programmes/educational-science-technology/

Collaboration Spaces, Inclusive Design and Social Change using Technology, Design for social change and innovation, and Computer-Assisted Language Learning.

Table 7. Postgraduate programs in Education which lead to PhDs in TEL related topics.

University	Department or division	Program title	Country
University of Cyprus	Department of Education	Instructional Technology[55]	Cyprus
Aristotle University of Thessaloniki	Departments: of German Studies, French Studies, Education and Philosophy and Economics with the collaboration of the Laboratory of Language Didactics.	Languages, Communication and Management of Educational Services in modern social, economic and technological environment[56]	Greece
University of Macedonia	School Of Social Sciences, Humanities and Arts Department Of Educational & Social Policy	Master of Arts in Adult Education[57]	Greece
National and Kapodistrian University of Athens, Aristotle University of Thessaloniki, National Metsovio Polytechnic	Department of Chemistry, Faculty of Primary Education, Department of History and Philosophy of Sciences (National and Kapodistrian Uni. of Athens), Department of Chemistry (Aristotle Uni. of Thessaloniki) and Department of Chemical Engineering (National Metsovio Polytechnic)	Master of Science in Teaching Chemistry, New Educational Technologies and Education for Sustainable Development[58]	Greece
University of Lisbon	IE-UL (Institute of Education)	Digital Literacy in Adult Education and Training[59]	Portugal

3.3 Cross-departmental or multidisciplinary programs

3.3.1 Cross-departmental and multidisciplinary PhD programs

In the last category, we have included all PhD programs which are cross-departmental or multidisciplinary (Table 8). An indicative example involves the University of Aveiro which offers a PhD program in "Multimedia in Education", a joint degree offered by the Communication and Arts Department and the Education and Psychology Department.

55 https://www.ucy.ac.cy/edu/programmes-of-study/postgraduate-programmes/instructional-technology/

56 https://pms.frl.auth.gr/courses-menu-gr/eidikeusi-didactics

57 https://www.uom.gr/en/ekpmet

58 https://dixinet-eaa.chem.uoa.gr/programma_mathimaton/eidikeysi_nees_ekpaideytikes_technologies/

59 http://www.ie.ulisboa.pt/ensino/cursos-pos-graduados-especializacao/literacia-digital-educacao-formacao-adultos

Table 8. Cross-departmental or/and multidisciplinary PhD programs on research topics related to TEL.

University	Department or division	Program title	Country
University of Valladolid	School of Telecommunications Engineering, School of Computer Engineering, and Faculty of Education & Social Work	Doctorate in informatics [60]	Spain
University of Aveiro	Department of Communication and the Arts Department of Education and Psychology	Doctorate in Multimedia in Education [61]	Portugal

3.3.2 Cross-departmental and multidisciplinary postgraduate programs which lead to PhDs in TEL

In this category we have also identified all the postgraduate programs (Edu/ICT) which lead to PhDs in TEL related topics as the case of the postgraduate program "Information and Communication Technologies for Education" offered by the University of Western Attica (Depart. of Electrical Engineering), the National Kapodistrian University of Athens (Depart. of Education & Pre- school Education and Dep. of Communication & Mass Media) and the University of Thessaly (Depart. of Architectural Engineering) (Table 9).

Table 9. Cross-departmental or/and multidisciplinary Postgraduate programs which lead to PhDs in TEL.

University	Department or division	Program title	Country
Aristotle University of Thessaloniki	Departments: of German Studies, French Studies, Education and Philosophy and Economics with the collaboration of the Laboratory of Language Didactics.	Interdepartmental Postgraduate Studies Program: "Languages, Communication and Management of Educational Services in modern social, economic and technological environment" [62]	Greece
Aristotle University of Thessaloniki	Department of Pre-school Education and Education, School of Education Department of Electrical and Computer Engineering, School of Engineering (Aristotle University of Thessaloniki) Department of Primary Education	Interdepartmental-Interdisciplinary Postgraduate Program "Educational Sciences - Learning Technologies" [63]	Greece
University of Macedonia	Department of Business Administration, Department of Economics and Department of Accounting and Finance with the collaboration of SMILE LAB	Interdepartmental Program of Postgraduate Studies in Information Systems [64]	Greece

[60] http://escueladoctorado.uva.es/export/sites/doctorado/programas/informatica/index.html

[61] https://www.ua.pt/en/course/276

[62] https://pms.frl.auth.gr

[63] http://learntech.web.auth.gr/learntech/node/43?language=en

[64] https://www.uom.gr/en/mis

University of Western Attica, ASPETE (School of Pedagogical and Technological Education)	Department of Biomedical Sciences, Department of Education ASPETE	Pedagogy through Innovative Technologies and Biomedical Approaches [65]	Greece
University of Western Attica, Kapodistrian University of Athens, University of Thessaly	Department of Electrical Engineering (Uni. of Western Attica), Department of Education & Education in Preschool and Communication (Kapodistrian Uni.of Athens) & Mass Media (Kapodistrian Uni. of Athens) and Architectural Engineering (University of Thessaly)	Information and Communication Technologies for Education, PROGRAM: Contemporary Pedagogical Approaches Contemporary Digital Technologies and the Internet, Data networks and e-learning services, Modern pedagogical theories and applications with the use of ICT, E-learning and distance learning systems, Digital storytelling and interstitial narrative processes for learning, Psychosocial and pedagogical approaches to new media. [66]	Greece
University of Western Attica, Department of National and Kapodistrian University of Athens, ASPETE (School of Pedagogical and Technological Education)	Department of Informatics and Computer Engineering (University of Western Attica) Department of Philosophy, Education and Psychology (Department of National and Kapodistrian University of Athens), Department of Education of ASPETE	Master's Degree in `Digital Transformation and Educational Practice [67]	Greece

The following table presents all the findings of our desk research (Table 10). The first column includes the PhD categories, the second and third column show the cases that we have identified and their total number, and finally the last one presents the countries that offer the PhD / Postgraduate programs.

Table 10. PhD and Postgraduate programs in TEL or on research topics related to TEL.

Categories	Cases	Cases	Countries
1.3. PhD in Education on research topics related to TEL	(7) Tallinn University (24) Open University of Netherlands (27) Norwegian University of Science and Technology (29) University of Oslo (30) University of Bergen (33) University of Minho	6	Estonia Netherlands Norway Portugal
2.1. Postgraduate in TEL which lead to PhDs in TEL related topics	(8) University of Tartu (13) University of Piraeus (16) Aristotle University of Thessaloniki (20) University of Western Attica & ASPETE (School of Pedagogical and Technological Education) (21) University of Western Attica, Kapodistrian University of Athens-EKPA University of Thessal	8	Estonia Greece UK

[65] https://edutech.uniwa.gr/

[66] http://www.icte.ecd.uoa.gr/index.php

[67] http://msc-ditrep.uniwa.gr/

	(22) University of Western Attica, Department of National and Kapodistrian University of Athens (School of Pedagogical and Technological Education) (34) Open University of UK (35) University College London		
2.2 Postgraduate program in ICT which lead to PhDs in TEL related topics	(2) Cyprus University of Technology (9) Pompeu Fabra University (12) Charles III University of Madrid (14) Aristotle University of Thessaloniki (17) University of Macedonia (18) University of Macedonia (26) University of Twente	7	Cyprus Spain Greece Netherlands
2.3 Postgraduate program in Education which lead to PhDs in TEL related topics	(5) University of Cyprus (15) Aristotle University of Thessaloniki (17) University of Macedonia (23) National and Kapodistrian University of Athens, Aristotle University of Thessaloniki, National Metsovio Polytechnic (32) University of Lisbon	5	Cyprus Greece Portugal
3.1. Cross-departmental or/and multidisciplinary PhD programs	(11) University of Valladolid (31) University of Aveiro	2	Spain Portugal
3.2. Cross-departmental or/and multidisciplinary Postgraduate programs which lead to PhDs in TEL related topics	(15) Aristotle University of Thessaloniki (16) University of Ioannina & Aristotle University of Thessaloniki (17) University of Macedonia (20) University of Western Attica, ASPETE (School of Pedagogical and Technological Education) (21) University of Western Attica, Kapodistrian University of Athens, University of Thessaly (22) University of Western Attica, Department of National and Kapodistrian University of Athens, ASPETE (School of Pedagogical and Technological Education)	7	Greece

4. DE-TEL survey results

4.1 Participants

In total, 229 participants responded to the survey, 51.5% female and 45% male (1.7% preferred not to specify gender). The most numerous (40.2%) was the cohort 30-39 years old, 27.1% between 40-49 years, 18.8% were 50 or above. and 12.2% were in their twenties (1.7% preferred not to report age).

Table 11. Main workplace or residence of participants.

Country	Frequency	Percentage
Spain	28	12.2
Germany	26	11.4
Portugal	24	10.5
Greece	16	7.0
Norway	12	5.2
Estonia	12	5.2
Italy	10	4.4
Netherlands	10	4.4
United Kingdom	10	4.4
Cyprus	10	4.4
United States	9	3.9
Did not specify	6	2.6
Austria	5	2.2
Brazil	5	2.2
France	5	2.2
Romania	4	1.7
Switzerland	4	1.7
Russian Federation	3	1.3
Sri Lanka	3	1.3
Chile	3	1.3
Finland	3	1.3
Czech Republic	2	0.9
19 countries with f=1[68]	*1 * 19*	*0.4*19*
Total	**229**	**100.0**

[68] Countries with 1 participant: Algeria, Angola, Argentina, Lebanon, Lithuania, Malaysia, Malta, New Zealand, South Korea, Taiwan, Thailand, Turkey, Bulgaria, Canada, Colombia, Croatia, Egypt, Ghana, and India.

Table 11 shows the list of countries where participants had their main workplace or residence. In total, respondents were from 40 different countries around the globe. Spain, Germany and Portugal are the three countries with more participants (34,178% all three) followed by Greece, Norway and Estonia (17.4% all three). As already mentioned in the previous section, the survey was mainly distributed by the partners of the DE-TEL project. As a result, we see that partner countries are more represented although dissemination efforts were focused globally.

Participants' professional background gathered from section 1 of the survey (Figure 1), indicates that 45% (n=103) of respondents were PhD candidates, 40.2% (n=92) were holding a PhD and 11.4% (n=26) were currently holding a Master's degree or equivalent, and this is their highest degree. Only 3.5% (n=8) of participants held a degree that is lower than a Master's or equivalent. PhD candidates responding to the survey were in different stages of their doctoral studies: 52.4% (n=54) were in their late stage - less than one year before their PhD thesis submission and defense; 26.2% (n=27) were in their middle stage; and 21.4% (n=22) in their early stage - first year students.

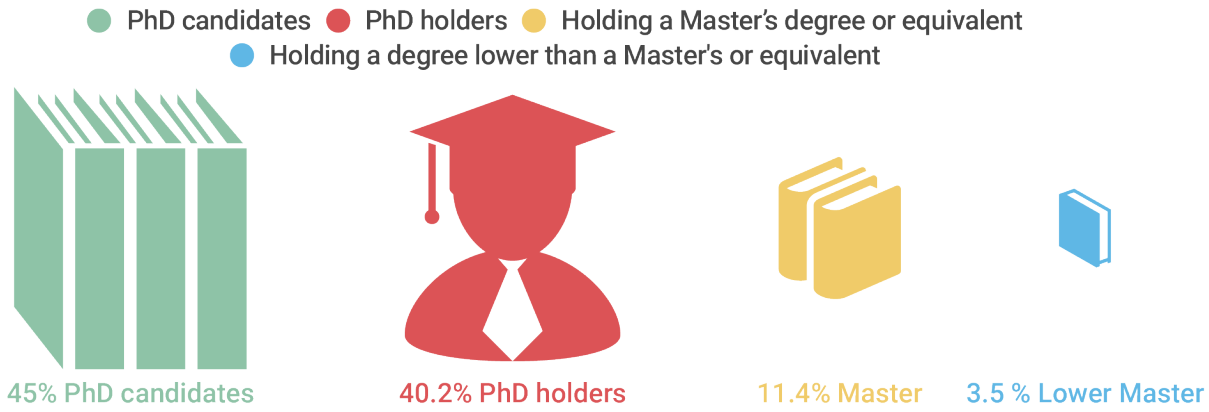

Figure 1. Survey participants breakdown by their educational level.

PhD candidates and holders were asked to choose the option that best describes their PhD project (Figure 2). *Education using technologies (e.g., applying technology for learning in practice)* was the most selected topic (selected by 41.7% of PhD candidates and 34.8% of PhD holders). The second and third topics selected by PhD candidates were *Computing / IT applied to learning (e.g., designing new apps or digital content for learning)* with a 21.4% and *Approximately equal efforts in development of educational technologies and applying them for learning* with a 16.5%. These two topics were selected by PhD holders in the second position with the same percentage each (20.7%).

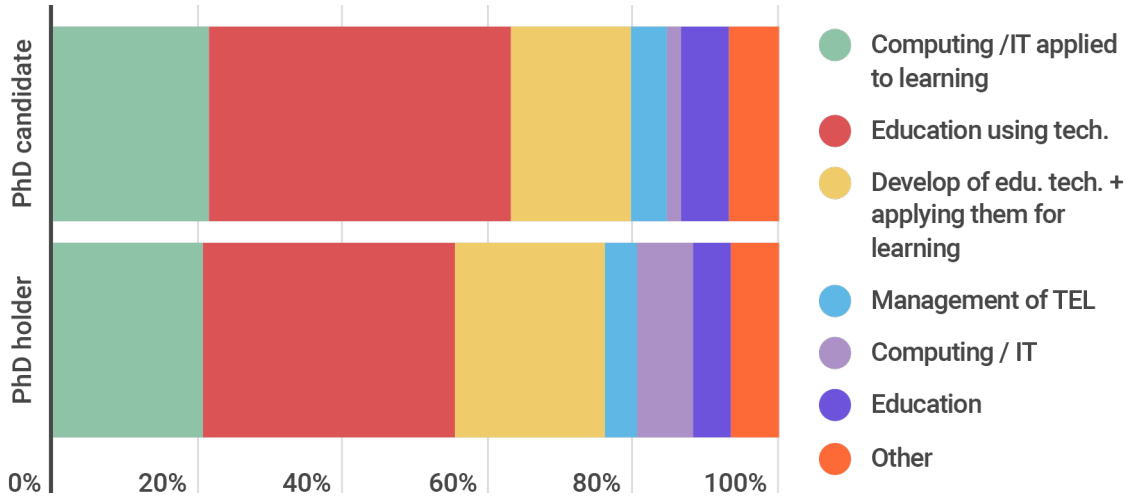

Figure 2. PhD projects topics of candidates and holders.

PhD project topics change depending on the stages of the PhD candidates respondents (Figure 3). Whereas in early and late stages, *Education using technologies* is the most selected topic (40.9% and 44.4% respectively), candidates in a middle stage selected two topics equally as the first option: *Education using technologies* (37%) and *Computing / IT applied to learning* (37%). Third option in all stages was *Approximately equal efforts in development of educational technologies and applying them for learning*. No PhD candidates in the middle stage of their doctoral studies stated that their PhD topic was about *Education*, whereas *Education* was selected in 18.2% of the early stage students and in 5.6% of the late stage candidates.

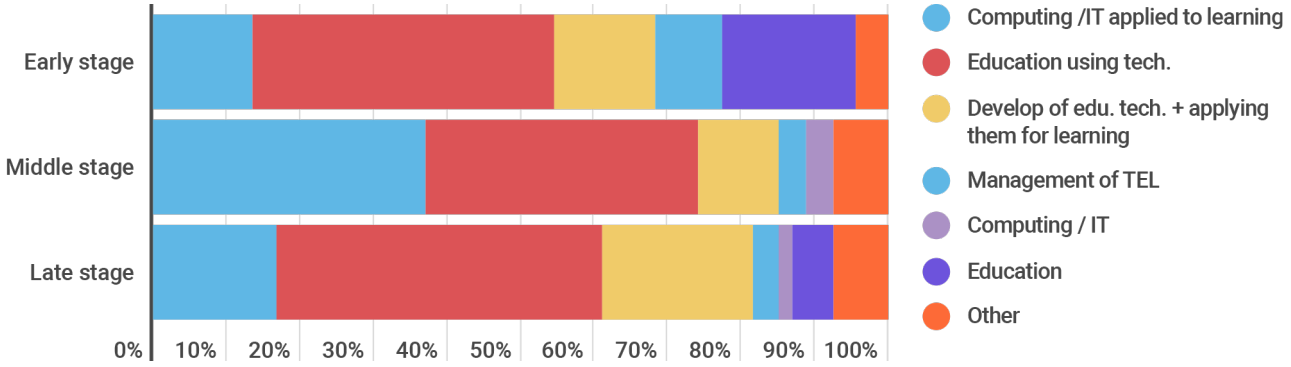

Figure 3. PhD projects topics of candidates depending on their stages.

Last, survey participants stated their professional context (Figure 4) and job (Figure 5) in the past max 10 years (not including Master and PhD projects). Results show that Master's holders respondents work mainly in *Education using technologies* (38.5%) and *Education* (34.6%) contexts (Figure 4). Most PhD candidates work mainly in three professional contexts: *Education using technologies* (28.2%), *Education* (20.4%) and *Computing / IT* (18.4%). PhD holders' professional topics most selected were *Education using technologies* (33.7%), *Education* and *approximately equal efforts in development of educational technologies and applying them for learning* (15.2% each), and *Computing / IT applied to learning* (13%).

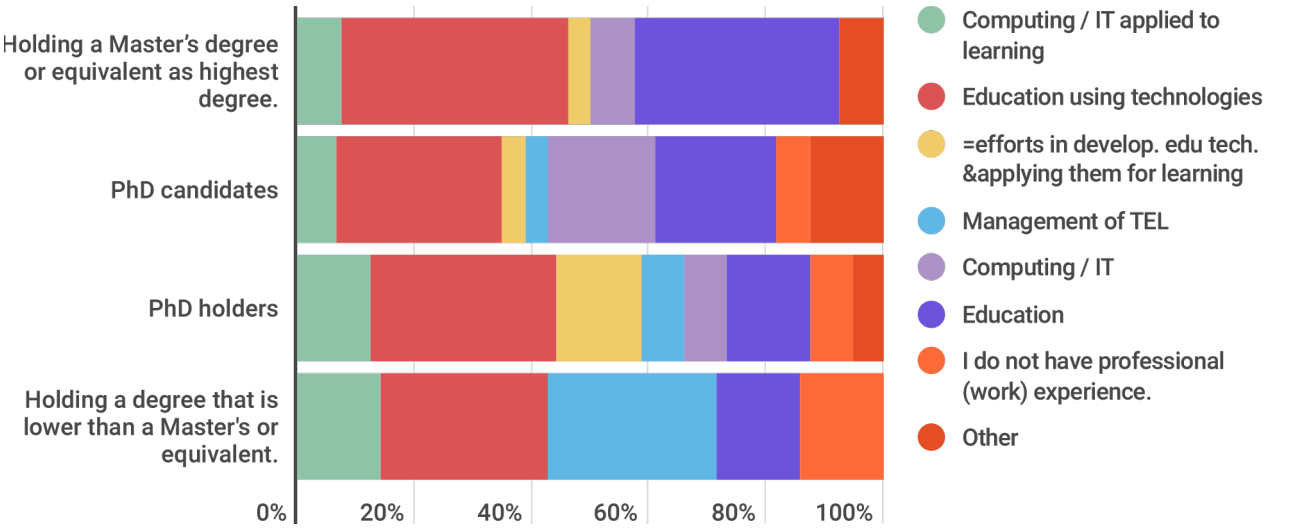

Figure 4. Professional topics of participants depending on their educational background.

As can be seen in Figure 5, most PhD holders, Master's degree holders and PhD candidates respondents stated that they work in academia (83.7%, 65.4%, 48.5% respectively). The highest percentage of participants working in the industry is in the group of graduates (37.5%) followed by PhD candidates (20.4%) and Master's degree holders (15.4%).

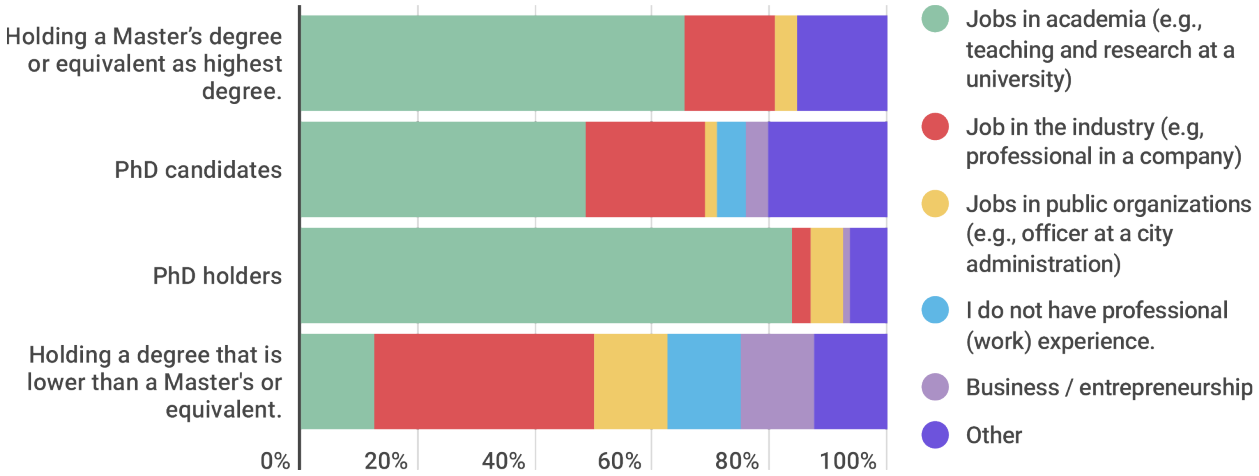

Figure 5. Jobs of participants depending on their educational background.

4.2 TEL topics

This section presents a part of the survey results that covers the thematic content of TEL research from the perspective of training in order to inform the design of an educational curriculum. The results include three main aspects of TEL topics: the need for, the importance of, and the availability of courses and educational materials.

- Doctoral courses and educational materials are most needed and least available in the TEL community for the topics:
  - *Artificial Intelligence in education*
  - *Personalized and adaptive learning*
  - *Smart / Intelligent Learning Environments*
- Doctoral courses and educational materials are highly needed but some already available in the TEL community for the topics:
  - *Pedagogical Patterns*
  - *Learning analytics*
  - *Visualization / Visual Analytics*
  - *Self-regulated / Informal Learning*
- Doctoral courses and educational materials are moderately needed in the TEL community for the topics:
  - *Gamification*
  - *Mixed and Augmented Reality*
  - *Engagement / Emotion / Affect*

The list of TEL topics used in the survey was derived from expert coding 548 sessions (thematic workshops and keynotes) from the programs of the EATEL summer school on TEL between 2005 and 2019. The coding was done by two experts, mediating agreement. Each session could have multiple codes. Coding was performed inductively, starting with the first session in the first year, and adding new codes (or extending existing ones) as we went along in chronological order[69]. The list of TEL topics used in the survey with their corresponding definitions can be found in annex A2.

In this part of the survey (see question 2.1 in the annex A1), participants were asked about their needs for courses and educational materials on the TEL topics (see the list of TEL topics with their definitions in annex A2). Figure 6 displays the results. Considering the responses of all participant types together, the topics with major training needs are learning analytics (93 out of 229 participants selected this option, which represents the 40.6%), artificial intelligence in education (39.7%), and personalized and adaptive learning (30.6%).

[69] Viktoria Pammer-Schindler, Fridolin Wild, Mikhail Fominykh, Tobias Ley, Maria Perifanou, Maria Victoria Soule, Davinia Hernandez-Leo, Marco Kalz, Ralf Klamma, Luis Pedro, Carlos Santos, Christian Glahn, Anastasios A. Economides, Antigoni Parmaxi, Ekaterina Prasolova-Førland, Denis Gillet, and Katherin Maillet (2020). Interdisciplinary Doctoral Training in Technology-Enhanced Learning in Europe. https://doi.org/10.3389/feduc.2020.00150

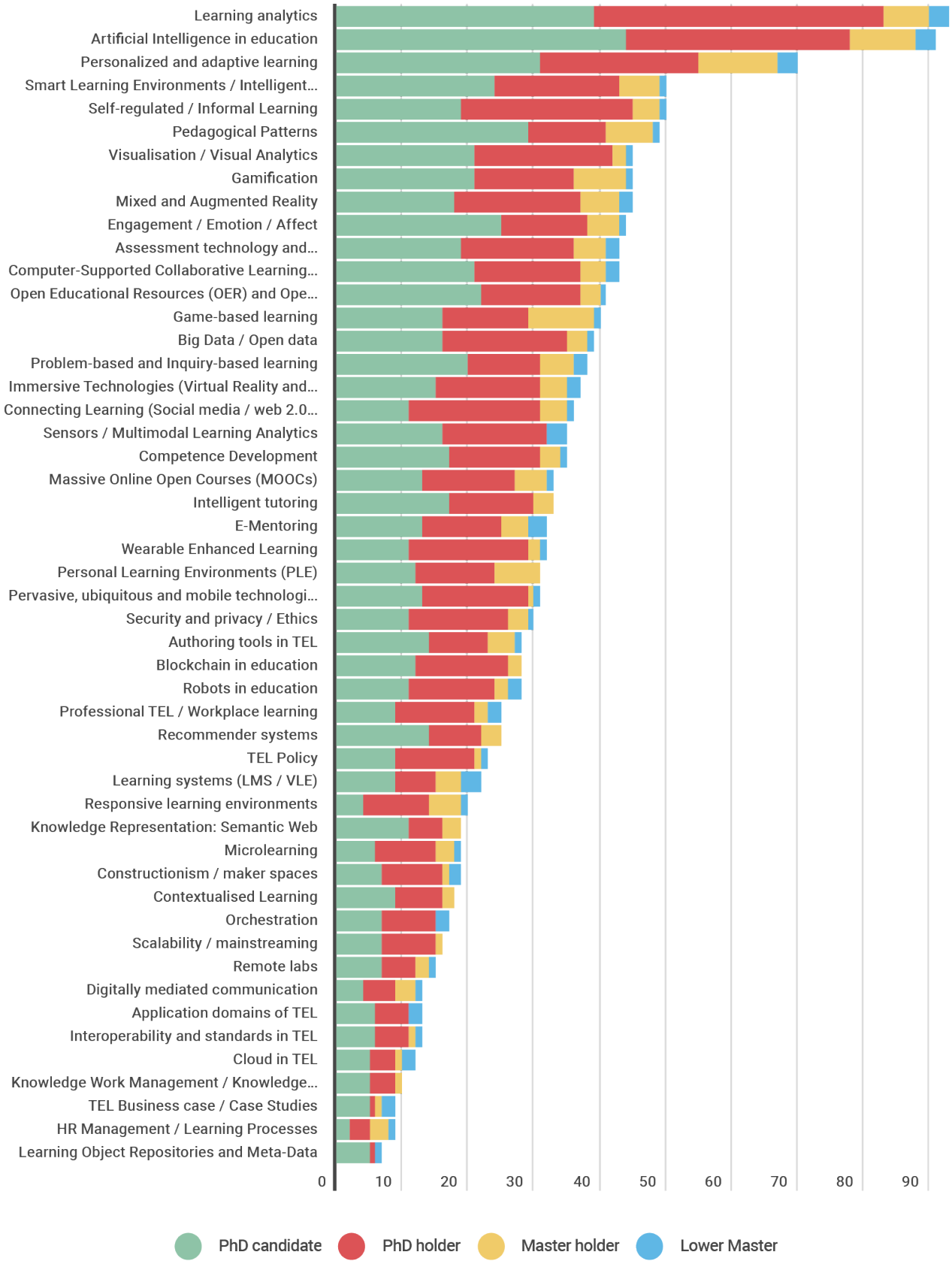

Figure 6. Response to the question "For which topics do you need a course or educational materials?". Frequency of selected topics breakdown by educational background.

However, the results show differences in needs depending on participants' profiles. Table 12 presents the top five most needed courses and educational materials on TEL topics depending on the participants' educational levels. The above three topics, *Artificial Intelligence in education*, *Learning*

analytics and *Personalized and adaptive learning* appear in the top five of all four education levels (PhD candidates, PhD holders, Master holders and Lower Master) but in different positions (e.g., *Learning Analytics* is the top topic for PhD holders, while *Artificial Intelligence in education* is the top one for PhD candidates, and *Personalized and adaptive learning* - for the Master holders). On the contrary, some topics only appear in the top five of one of the participants' profiles. This is the case of *Pedagogical patterns* and *Engagement/Emotion/Affect* topics which appear only on the top five of the PhD candidates participants. Similarly, *Self-regulated/Informal Learning* and *Visualisation/Visual Analytics* topics appear only in the top five list of PhD holders and *Gamification and Game-based learning* in the one from Master holders.

Table 12. Top five most-selected needed courses and educational materials breakdown by educational level (frequencies in brackets).

	PhD candidates	PhD holders	Master holders	Lower Master
#1	Artificial Intelligence in education (44)	Learning analytics (44)	Personalized and adaptive learning (12)	Learning analytics (3) Artificial Intelligence in education (3) Personalized and adaptive learning (3) Sensors / Multimodal Learning Analytics (3) E-Mentoring (3) Learning systems (LMS / VLE) (3)
#2	Learning analytics (39)	Artificial Intelligence in education (34)	Artificial Intelligence in education (10) Game-based learning (10)	
#3	Personalized and adaptive learning (31)	Self-regulated / Informal Learning (26)		
#4	Pedagogical Patterns (29)	Personalized and adaptive learning (24)	Gamification (8)	
#5	Engagement / Emotion / Affect (25)	Visualisation / Visual Analytics (21)	Learning analytics (7)	

The next question in the survey (see question 2.2 in the annex A1) asked participants to indicate how important courses and educational materials on the selected topics from the previous question were for them. Figure 7 presents the sum of rates obtained per topic, broken down by educational background. Not surprisingly, the top three topics considered important by participants coincide with the top three in which more courses and educational materials are needed (Figure 6). However, there are topics that were rated highly, and therefore considered more important, and that they have scaled up in the position of the list comparing both lists (the most needed and the most important). For example, although *Engagement/Emotion/Affect* is in the 10th position regarding the need for educational materials and courses (Figure 6), it is placed in the 6th position in the "importance" list (Figure 7). On the contrary, the topic of *Visualisation/Visual analytics* is placed in the 7th position of the needs list whereas it appears in the 13th position of "importance".

As before, the results show differences regarding the importance of the TEL topics depending on the educational background of the participants. Table 12 presents the top five most-rated courses and educational materials topics breakdown by educational level. As it can be seen in the table, the most important topic for PhD candidates and Master holders is *Artificial Intelligence in education* (together with *Personalized and adaptive learning* in the case of Master holders) whereas for PhD holders are *Self-regulated/Informal learning* and *Learning Analytics*. The most important topic for lower master participants is *Sensors/Multimodal learning analytics*.

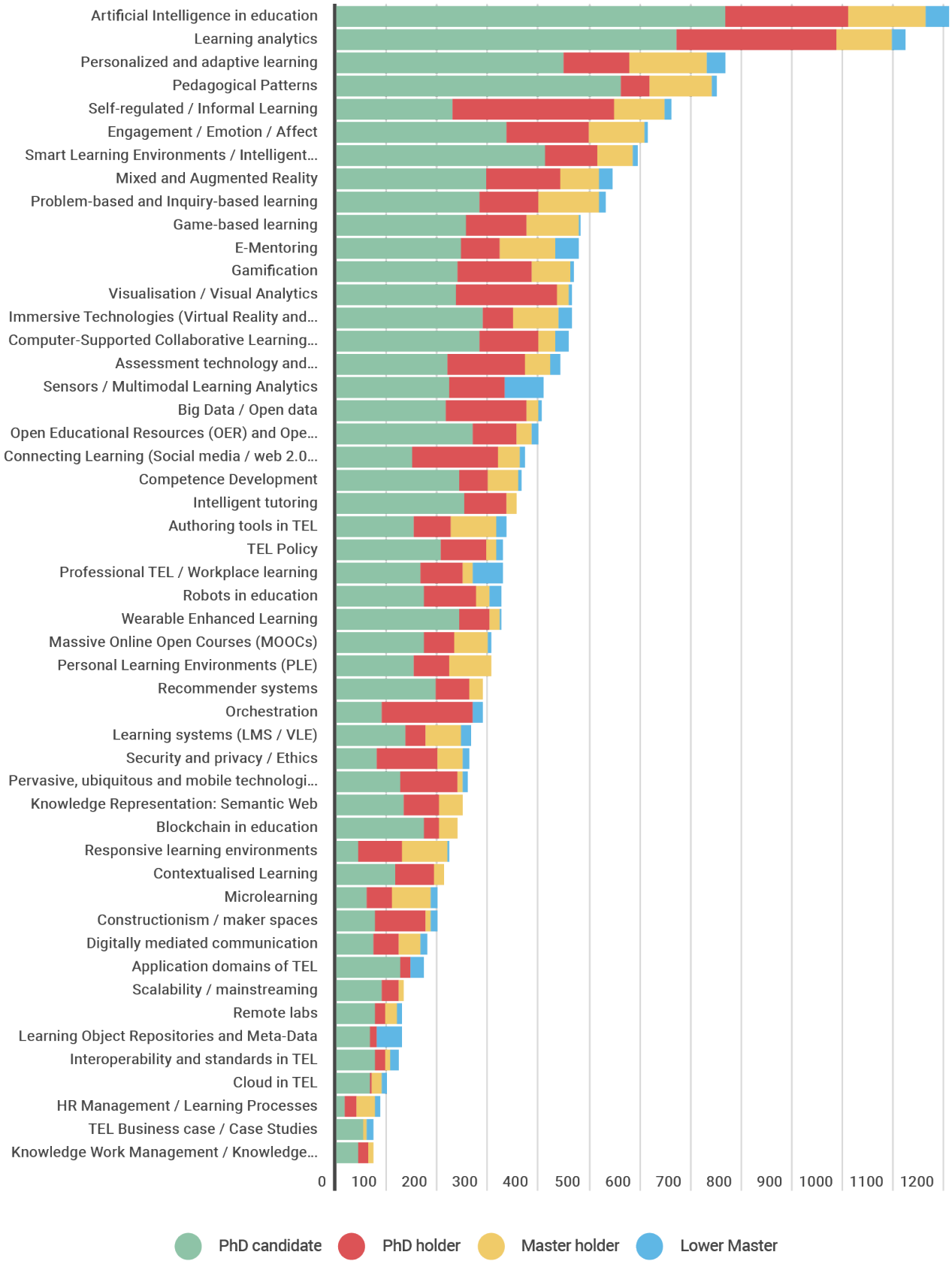

Figure 7. Response to the question "Indicate how important courses and educational materials on these topics are for you" (PhD candidates, Master holders and Lower Master); and "Indicate how important courses and educational materials on these topics are for a PhD candidate in TEL." (PhD holders). Sum of rates obtained per topic breakdown by educational background.

After the participants selected TEL topics for which they *need* courses and educational materials, and rated the *importance* of the selected topics, the next survey question (see question 2.3 in the annex A1) asked them about their *availability* of courses and educational materials for these topics by using a Likert scale from 1 (not available at all) to 5 (easily or plenty available). Figure 8 presents the results of the availability (y axis) related to the need for these materials (x axis) divided into four quadrants (only for the PhD candidates and PhD holders).

The bottom right quadrant is the most relevant in order to inform a doctoral program in TEL since it contains the topics in which there is less availability of courses and educational materials and a higher need by participants. The identified gap includes three topics (ordered by less availability):

- Personalized and adaptive learning
- Artificial Intelligence in education
- Smart/Intelligent learning environments

The upper right quadrant contains the topics that have high availability of courses and educational resources and high need for them. For example, although participants expressed the need for training materials in *Learning Analytics*, they also stated that for this topic some materials are available (a mean of 3.2 out of 5 in the Likert scale of the availability question). The four topics in this quadrant are (ordered by higher availability):

- Pedagogical patterns
- Learning Analytics
- Visualization / Visual Analytics
- Self-regulated / Informal learning

The upper left quadrant contains the topics that have higher availability of courses and educational materials and relatively low need for them. The topics in this quadrant have lower *need* but some courses and educational materials are available, which indirectly indicates that the need for materials and importance for the community were higher in recent years. Therefore, PhD candidate can be advised to look for existing courses and educational materials on these topics, specifically in the top seven (ordered by less availability):

- MOOCs
- Problem-based & Inquiry-based learning
- Game-based learning
- OER & Open content
- Gamification
- Recommender systems
- Intelligent tutoring

The bottom left quadrant informs about the topics with less available educational materials and courses but they are also less needed by participants (less than 20% of participants need them).

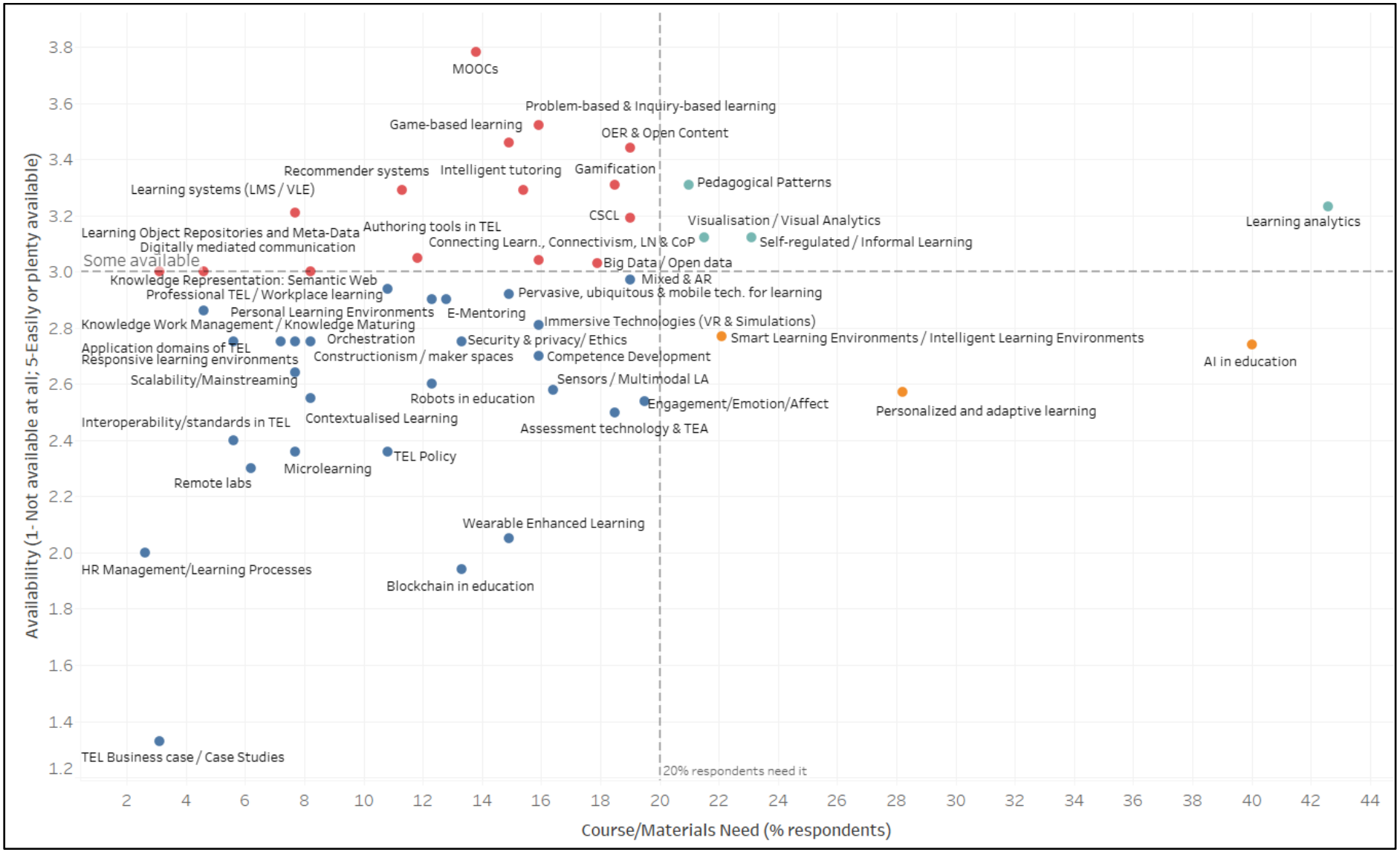

Figure 8. Availability versus Need of courses and educational materials evaluated by PhD candidates and PhD Holders. Interactive figure available online: https://ea-tel.eu/de-tel/survey-results

Finally, most of the participants' responses to the open-ended question: "Is there any other TEL topic not mentioned above, for which courses and educational materials would be useful?" (see question 2.1.2 in Annex A1) were related to the following categories: i) "Educational Theories and Methods in TEL"; ii) "Research Methods in TEL"; iii) "Human Computer Interaction in TEL"; iv) "Management of TEL"; v) "21st century skills" (Table 13).

More specifically, participants suggested the following additional TEL topics:

- 15 responses related to "Educational Theories and Methods in TEL" such as "digital pedagogies", "digital storytelling in TEL", "authentic learning";
- 7 responses related to "Research Methods in TEL" such as "design-based research";
- 5 responses related to "Human Computer Interaction in TEL" such as "accessibility and inclusion in TEL", "user experience";
- 3 responses related to "Management of TEL" such as "intellectual property rights", "management of ICT/TEL/DT", "quality assurance in TEL";
- 2 responses related to "21st century skills" such as "21st-century skills", "technology enhanced language learning & assessment".

Table 13. Extra TEL Topic (not mentioned in the questionnaire), for which courses and educational materials would be useful.

Categories	Subcategories	Freq.	Example
Educational Theories and Methods in TEL	digital pedagogies, digital storytelling, experiential & authentic learning.	15	*"pedagogical and didactical uses of TEL in the knowledge different fields"; "Authentic learning, i.e. support for student to conduct real-world contributions while learning. For example to Wikipedia, software repositories, etc."*
Research Methods in TEL	research methodologies in TEL, design science research, design-based research.	7	*"A course on Design-Based Research Methodology"*
Human Computer Interaction in TEL	accessibility & inclusion in TEL, UI design, user experience.	5	*"Assistive technologies and accessibility"*
Management of TEL	intellectual property rights, management of ICT/TEL/DT, quality assurance in TEL.	3	*"property, rights, and law"*
21st century skills	21st-century skills, TELL.	2	*"Technology Enhanced Language Learning & Assessment"*

Clearly, most responders suggested TEL topics in the category of "Educational Theories and Methods in TEL". They think that TEL topics in this category are important and were missing from the options in the closed-ended questions. Although there were some specific educational theories and methods (such as "constructionism / maker spaces", "connectivism", "problem-based", "inquiry-based", and "game-based learning") in the closed-ended questions, other important learning theories were missing. So, the responders identified this gap.

In addition, the responders identified the absence in the closed-ended questions of important TEL topics that fall in the categories of "Human Computer Interaction in TEL",

"Management of TEL" (although there is a closed-ended question on "orchestration"), and "21st century skills".

Furthermore, the participants suggested TEL topics that were already asked in the closed-ended questions. For example, participants suggested the following TEL topics in the respected categories (Table 14):

- "Ethics" (5 responses, such as "responsible research & development, AI/Ethics/Data Feminism) which is related to the "Security and privacy / Ethics" topic
- "Learning Design" (4 responses such as "online learning design", "blended/hybrid learning design", "instructional design") which is related to the "Pedagogical Patterns" topic
- "Learning Analytics" (3 responses, such as "analytics for teacher professional development") which exists with the same name
- "Artificial Intelligence in Education" (3 responses such as "neural network applications in teaching") which exists with the same name
- "Ubiquitous Learning" (2 responses, such as "mobile learning, "seamless learning") which is related to the "Pervasive, ubiquitous and mobile technologies for learning" topic
- "Virtual Reality Learning Environments" (1 response) which is related to the "Immersive Technologies (Virtual Reality and Simulations)" topic

Table 14. TEL topics' suggestions of the responders about TEL Topic that were already included in the closed-ended questions.

Categories	Subcategories	Freq.	Example
Ethics in TEL	Ethics in teaching, ethics in research	5	*"AI ethics in education technology"; "responsible research & development"*
Learning Design in TEL	Online and blended learning design, instructional design.	4	*"online learning design, blended/hybrid learning design"*
Learning Analytics	Learning analytics in teaching, learning analytics for teacher professional development.	3	*"Particular approaches to carry out learning analytics, like Epistemic Network Analysis, Process mining, Sequential analysis, etc."*
Artificial Intelligence in TEL	AI in teaching.	3	*"Neural network applications in teaching, marking automation"; "Constructing and validating datasets for AI in Education"*
Ubiquitous Learning	Mobile learning, seamless learning	2	*"Seamless Learning"*
Virtual Reality in TEL	Virtual Reality learning environments	1	*"Virtual Reality learning environments"*

The responders to the questionnaire stated in the closed-ended and open-ended questions the TEL topics that they consider useful and essential. So, PhD programs would provide such TEL topics either in independent micro-learning units or in integrated courses where each course contains several related TEL topics. For the second case, an idea for a future questionnaire would be to organize the various TEL topics into comprehensive TEL courses. Then, the responders would say their opinion about a small number of TEL courses and not about a long list of TEL topics.

4.3 General PhD training topics

In this section, we present the results focused on identifying the need for and the availability of courses and educational materials on the general PhD training topics among the TEL researchers.

- PhD candidates believe that they need training on and educational materials on the general PhD training topics:
  - *Academic writing and publication*
  - *Dissemination of research results*
  - *Project management*
- PhD holders believe that PhD candidates need training on and educational materials on the general PhD training topics:
  - *Academic writing and publication*
  - *Project management*
  - *Research ethics*
  - *Dissemination of research results*

In this part of the survey, we asked the participants about their needs for courses and educational materials on the general PhD training topics. Figure 9 displays the results.

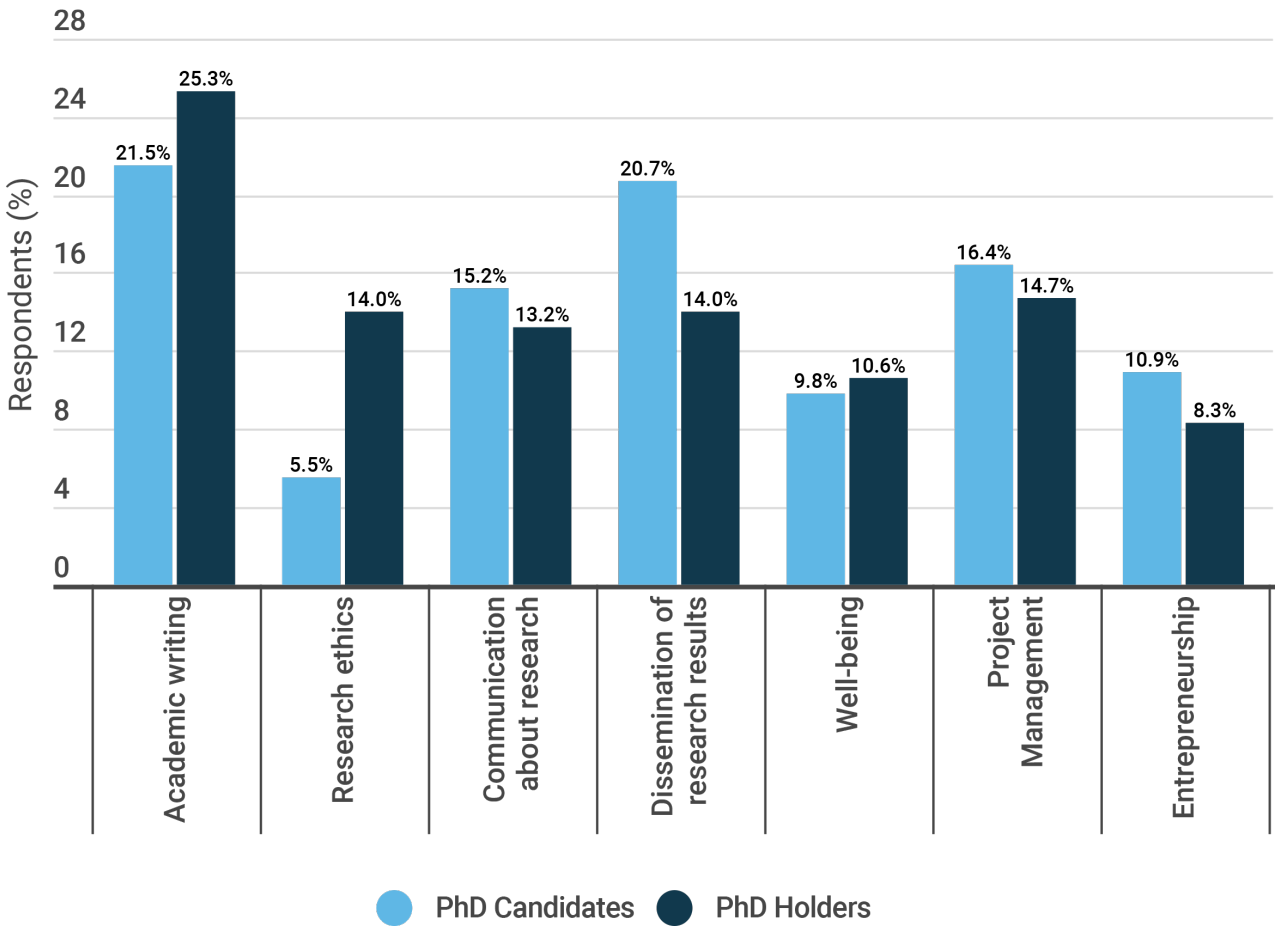

Figure 9. Need for courses and educational materials on the general PhD training topics (PhD candidates vs. PhD holders).

The results obtained for the need of courses and educational materials on the general PhD training topics indicate that PhD candidates and PhD holders coincide in their need for *Academic writing* as the most relevant course (21.5% PhD candidates and 25.3% PhD holders). However, both groups discern in their rank order of preferences for other courses. For instance, PhD candidates selected *Dissemination of research results* as the second most relevant course in which they would like to be trained (20.7%), while for PhD holders, the second most relevant course pertains to the *Project management* category (14.7%). These differences are also observed in the third most selected course for both groups. While PhD candidates identified *Project management* as the third course in which they would like to receive training (16.4%), PhD holders are more interested in *Dissemination of research results* (14%) and *Research ethics* (14%). Interestingly, this course was the least selected by PhD candidates (5.5%). *Communication about research* is the fourth course in the rank order of preferences for both groups (15.2% for PhD candidates, and 13.2% for PhD holders). Finally, Figure 9 shows that both groups have a relatively mid-low interest in receiving training for *Well-being* (PhD candidates 9.8%, PhD holders 10.6%) as well as in *Entrepreneurship* courses (PhD candidates 10.9%, PhD holders 8.3%).

In the open question, the participants were asked to provide additional general PhD training topics, not mentioned in the suggested categories. The answers mostly included categories and variation of the suggested categories in the general PhD training and in research methods sections. Some of the items that were in fact relevant additions included collaboration and networking, open research practices, and history and philosophy of TEL.

4.4 Research methods

In this part of the survey, we investigated the research methods that PhD candidates in TEL use as well as their training needs for research methods.

- The most common method for both PhD students and PhD holders is ★ *Design-based research*
- An exception are researchers working in the field of 'Education using technologies', where ★ *Experimental research* and ★ *Field qualitative methods* are the most reported methods.
- Regardless of the level of training, the participants reported the need for more training in the research methods they work with.

Two survey questions that included six checklist responses were formulated. The response options included six research methods most commonly used in PhD TEL programs. Results from PhD candidates in TEL were compared to those from the PhD holders.

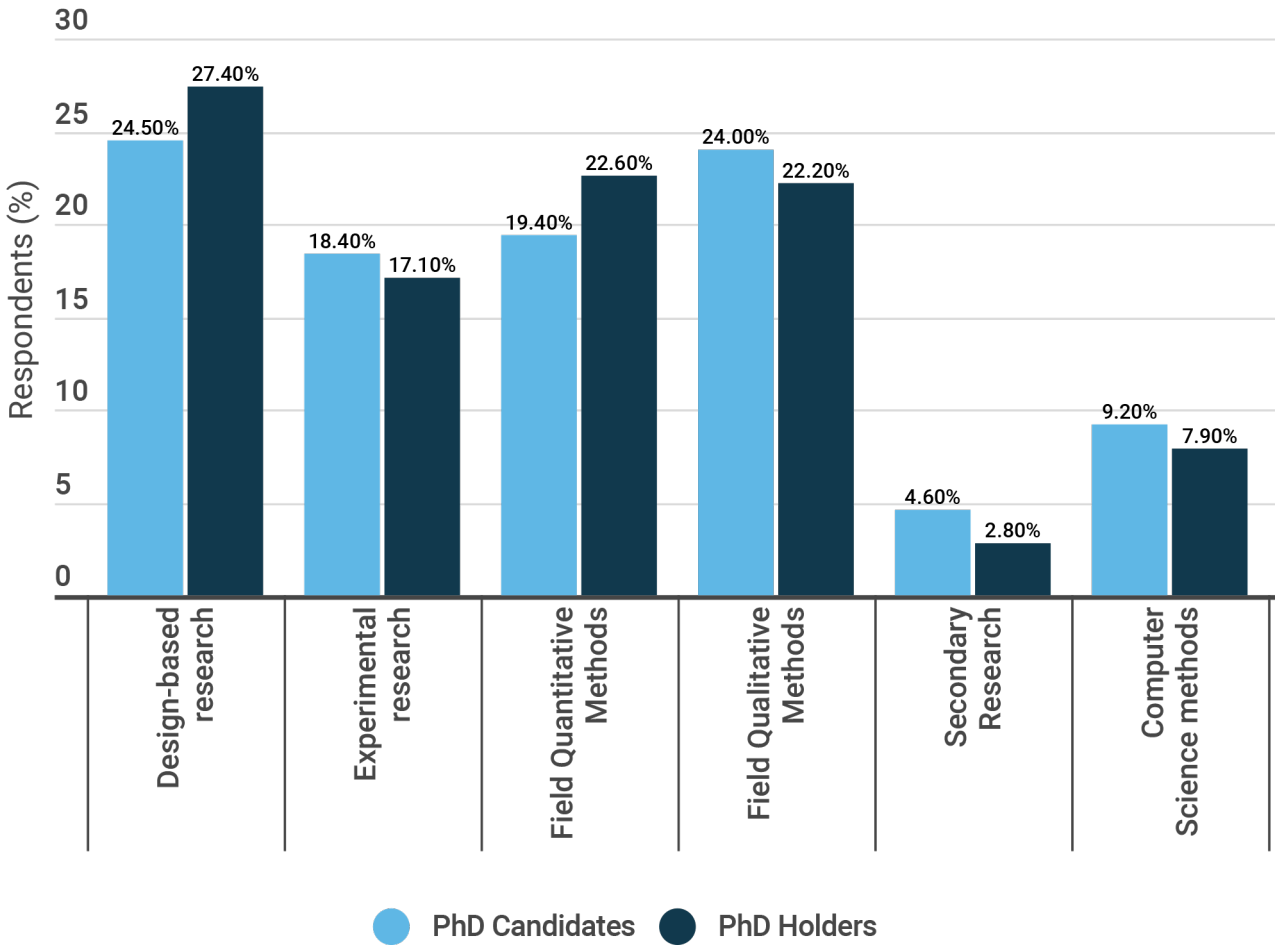

Figure 10. Research methods used by PhD candidates in TEL (PhD candidates vs. PhD holders).

Figure 10 indicates that *Design-based research* (i.e., Contextual Inquiry, Design Studies, Co-Design, Field Studies, participatory design) is the method most used by both PhD candidates and PhD holders,

followed by *Qualitative methods* (i.e., Grounded Theory, Action Research, Ethnographic studies, case studies, Interviews) for the PhD candidates and *Quantitative methods* (i.e., Surveys, Experience Sampling, Log analysis, Text analytics/pattern recognition/ML) for the PhD holders. *Experimental research* (i.e., experimental/quasi-experimental/comparative studies) was the fourth option selected by both groups. Surprisingly, *Computer science methods* (i.e., algorithmic performance, system performance: scalability, speed, robustness) were selected only by 9.7% of the PhD Candidates that participated in the survey, and similarly, only 7.8% of PhD holders selected this option. The least method used was *Secondary research* (i.e., desk research), but while 6% of the PhD candidates selected this option, only 2.7% of the PhD holders reported using this method.

In the open-ended question, few responses were given. The participants suggested "systematic review", "meta-analysis and meta-synthesis", "questionnaires", and "network analysis".

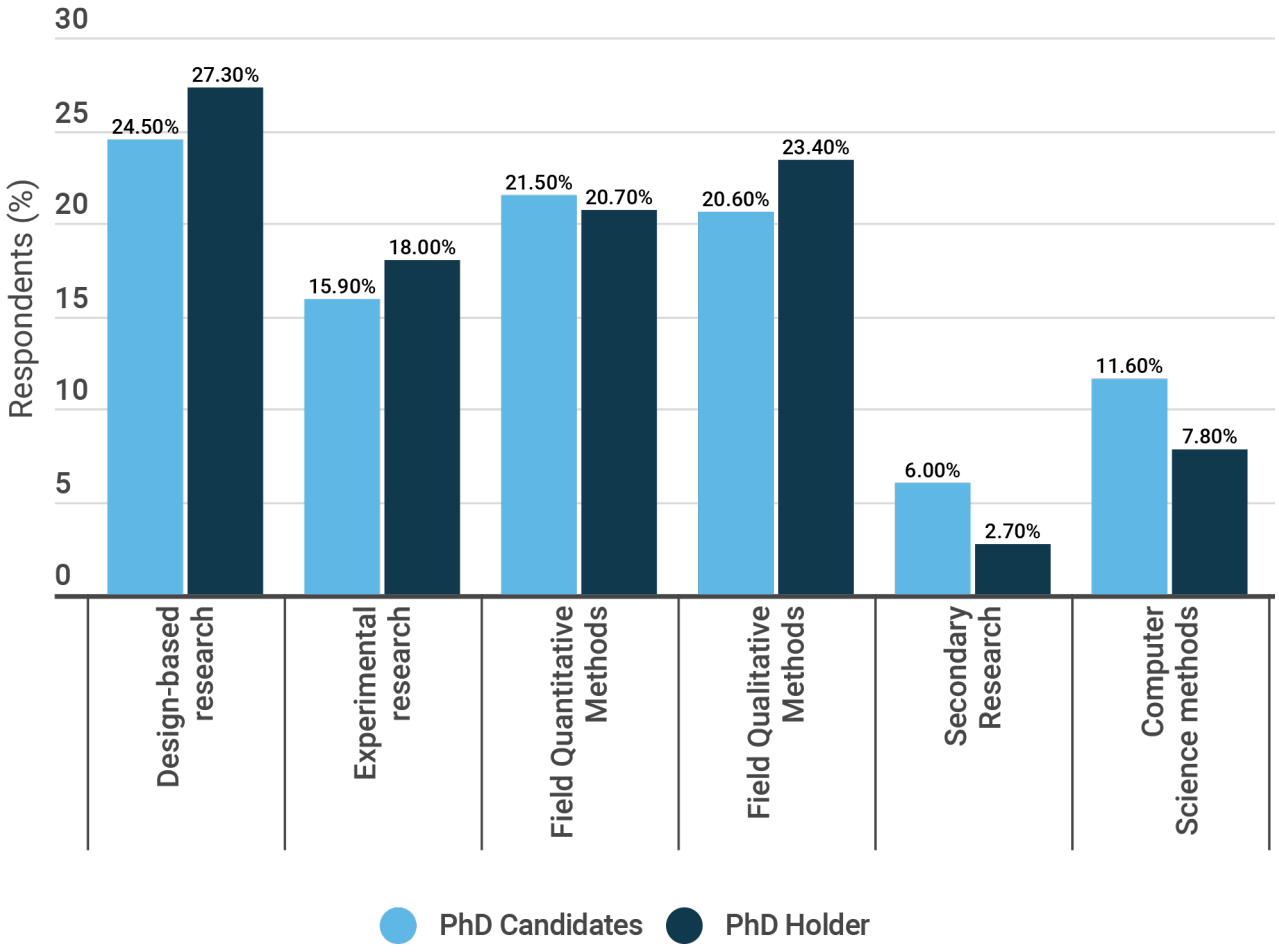

Figure 11. Research methods training needs (PhD candidates vs. PhD holders).

The results obtained for the need of courses and educational materials on research methods are quite similar to those obtained for the use of research methods. For instance, the *Design-based research* category was selected as needed for training by 24.5% of the PhD candidates, that is, the exact same percentage as the use of this method by the PhD candidates (Figure 10). Similarly, PhD holders also chose this category over the others in terms of their research methods training needs. The second research method most needed by PhD candidates are *Quantitative methods* (21.5%) followed by *Qualitative methods* (20.6%). The reverse image can be observed in PhD holders who selected *Qualitative methods* as the second method most needed (23.4%), followed by *Quantitative methods* (20.7%). The fourth research method selected by both groups in terms of training needs was *experimental research*, similar to the findings in Research Methods used (Figure 10). The two least methods selected, as a preference for receiving training, were *Computer Science research methods* and

Secondary research. However, while for the PhD holders the percentage for these categories remained the same as in their responses to the use of research methods, for PhD candidates their interest in receiving training for those categories slightly increased: 2.5% more for training in *Computer Science research methods* and 1.4% more for *secondary research methods*.

In the open-ended few responses were given. The participants suggested "statistics", "network analysis", "evaluation studies and evidence-based research (experimental research)", and "psychometrics", "meta-analysis", and "randomized controlled trials".

A comparison of the data presented in Figure 10 and 11 indicates that both groups would like to receive more training in the research methods that they are already using. This might point out the different levels of expertise in the research methods listed in the survey. However, regardless of the level of training, the participants are seen to be in need of more training in the research methods they work with.

We also investigated the relationship between PhD topics and research methods used in each one of those topics. The data presented in Figure 12 indicate a visible variation of the research methods that are most used according to the different PhD topics. *Design-based research* and *Computer science methods* are the most used methods in 'Computing/IT applied to learning' PhDs. They are also the most used methods in the field of 'Education using technologies' together with *Experimental research* and *Field qualitative methods. Design-based research* is again the most used method in PhDs where there is approximately equal efforts in the development of educational technologies and applying them for learning.

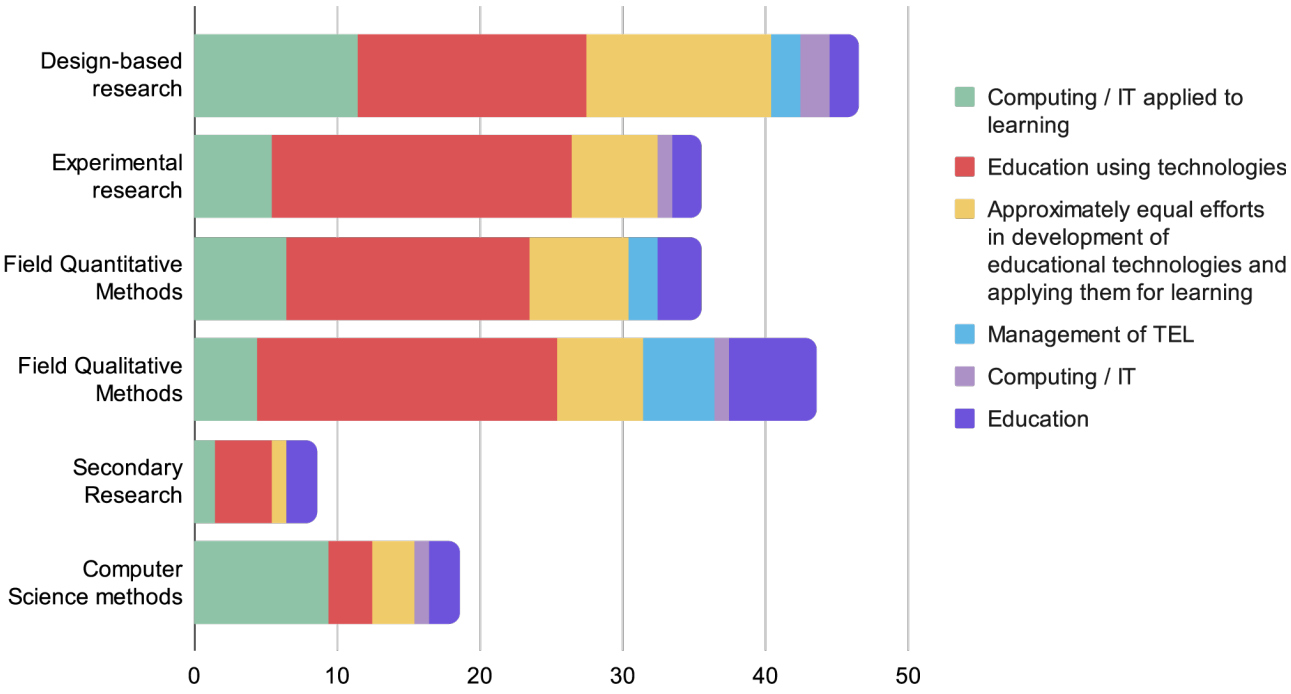

Figure 12. Research methods vs PhD topics.

4.5 Learning sources

In this part of the survey, we asked the participants about the learning sources they use. More specifically, participants were asked about: (1) the learning sources they use for the TEL topics, (2) the learning sources they use for the general PhD-level training topics, and (3) the learning sources they use for research methods.

- The primary learning source for TEL topics is *Academic publications*.
- The primary learning source for general PhD training is *Supervisor help*.
- The primary learning sources for research methods are *Supervisor help*, *Academic* publications, and *Courses in the PhD program*.
- The variety in the learning sources is influenced by the educational background.

The three survey questions included 12 categories:

- Course in the Master programs
- Courses in PhD programs
- Academic publications
- Supervisor help
- Open Educational Resources
- From colleagues
- Peer-to-peer
- Academic conferences
- Academic or non-academic meetups and gatherings
- Trial and error
- Needed to go somewhere else to get support
- Other

Figure 13 below displays the results of learning sources used for TEL topics participants with different educational backgrounds. All participants tended to choose the *Academic publications* as their primary learning source for TEL topics (Figure 13). This is followed by the *Courses received during their Master program* for Master degree holders. For PhD candidates and PhD holders, the next most selected categories were the *Supervisor help* and *Academic conferences*. *Courses in the PhD program* were selected as the fourth most relevant source, both by PhD candidates (9.5%) and PhD holders (10.7%). *Open educational resources* seem to be an important learning source for Master degree holders (12.5%) but not that much for PhD candidates (6.6%) and PhD holders (5.4%). A similar difference in the results of the three groups is observed in the selection of the *From colleagues* category that represents a 10.7% in the learning sources used by MA degree holders, a 6.6% for the PhD candidates, and 7.9% for PhD holders. Another category that obtained different results due to the educational background, is the *Peer-to-peer* category that was selected only by 2.7% of the MA degree holders, but 8.2% of the PhD candidates and by 12.2% of the PhD holders. Interestingly, *Academic or non-academic meetups* was equally selected by MA holders (8.9%) and PhD holders (8.4%), but not by PhD candidates (5.3%). *Trial and error* seems to be more important for the MA holders (9.8%) in comparison to the PhD Candidates (7.1%) and the PhD holders (5.4%). Finally, our participants did not seem to *need to go somewhere else*

to get support on their learning sources used for TEL topics. All these results indicate that the variety in the learning sources selected by the participants is influenced by their educational background.

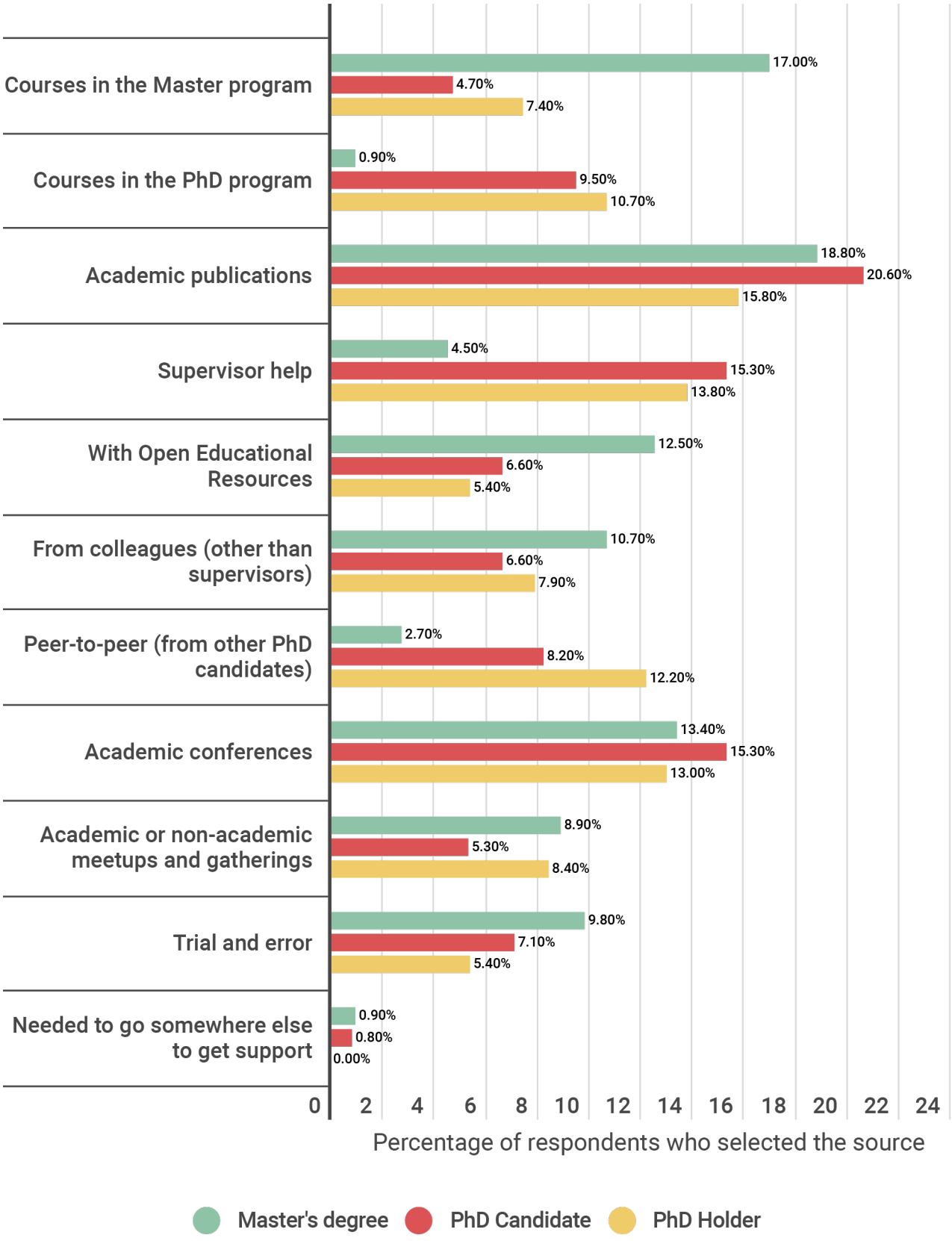

Figure 13. Learning sources used for TEL topics breakdown by educational background.

When asked about the learning sources used for the general PhD-level training topics, PhD candidates, as well as PhD holders, selected *supervisor help* as their primary learning source (Figure 14). The next

category was *Academic publications* for the PhD candidates (15%) but not for the PhD holders (8.7%) who selected *courses in the PhD program* as their second choice in terms of general PhD-level training topics (15.6%). This category was selected in third place for the PhD candidates (14.7%). The next most relevant learning source for PhD candidates is the *Academic conferences* (10.6%), which was equally selected by PhD holders (10.6%), however, for this group other sources seem to be more relevant, for instance, *Peer-to-peer* (14%) and *From colleagues* (11.4%). Less significant learning sources used for the general PhD-level training topics are: *Trial and error* (7.8% PhD candidates vs 5% PhD holders), *Open educational resources* (4.9% PhD candidates vs 5.6% PhD holders), and *Academic and non-academic meetups* (6.2%PhD candidates vs 4.8% PhD holders). *Needed to go somewhere else to get support* is the source used the least by both groups (1.3% PhD candidates vs 0.5% PhD holders).

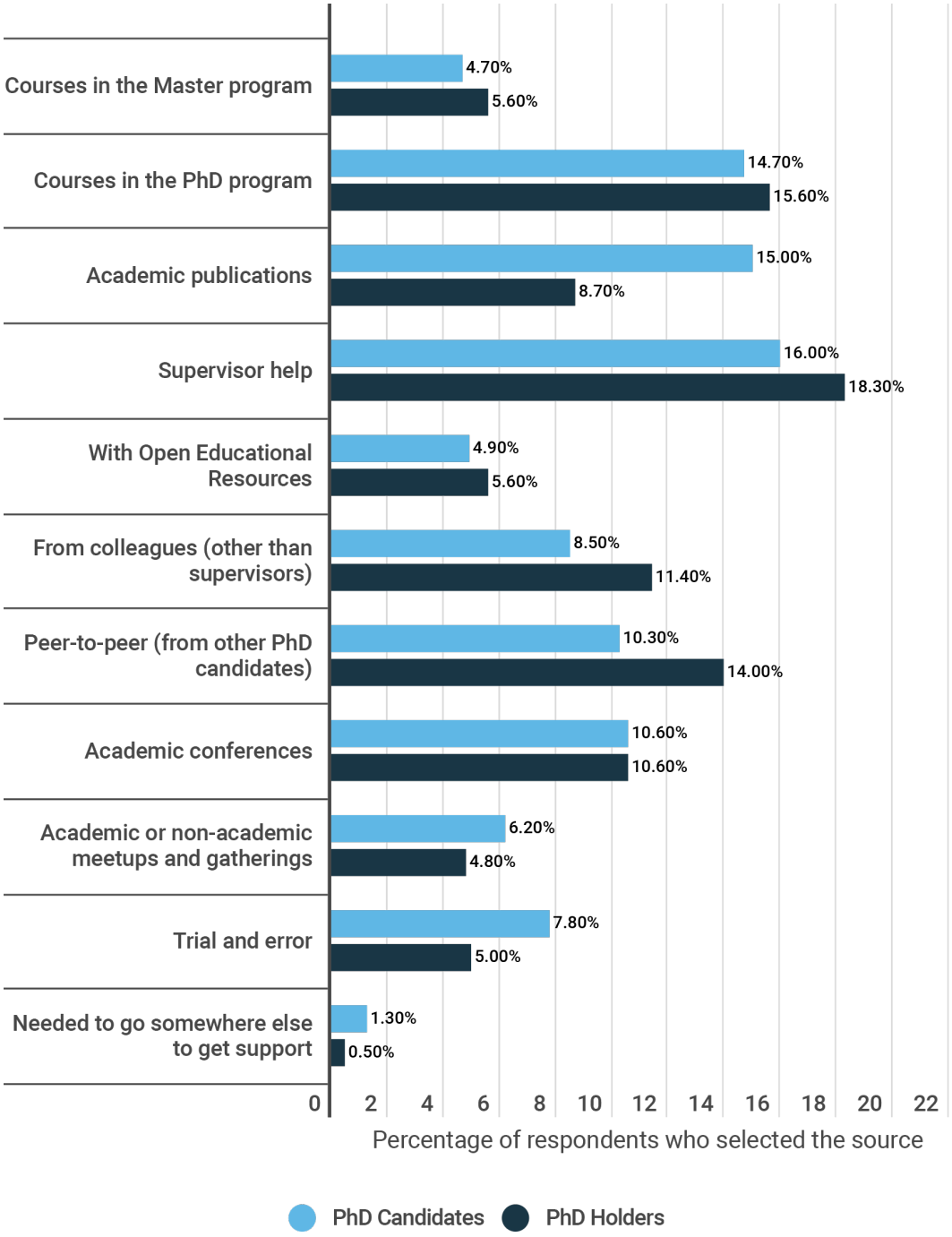

Figure 14. Learning sources used for the general PhD-level training topics (PhD Candidates vs. PhD Holders views)

Three learning sources seem to be the most used by PhD candidates and PhD holders when it comes to research methods (Figure 15):

- *Supervisor help* (17.7% PhD candidates vs 19.6% PhD holders)
- *Academic publications* (17.7% PhD candidates vs 13.5% PhD holders)
- *Courses in the PhD program* (14.2% PhD candidates vs 18.5% PhD holders)

Academic conferences appears in the fourth place for the PhD candidates (9.1%), but not for PhD holders (7.2%) who prioritize *Peer-to-peer* (11.6% for PhD holders vs 8.3% for PhD candidates). These categories are followed by *From colleagues* (8% PhD candidates vs 8.5% PhD holders) and *Courses in the Master program* (7.8% PhD candidates vs 7.7% PhD holders). Among the less selected learning sources are *Trial and error* (6.7% PhD candidates vs 4.1% PhD holders) and *Academic and non-academic meetups* (4.3% PhD candidates vs 3.3% PhD holders). *Needed to go somewhere else* was the least learning source used by both groups (1.3% PhD candidates vs 1.4% PhD holders).

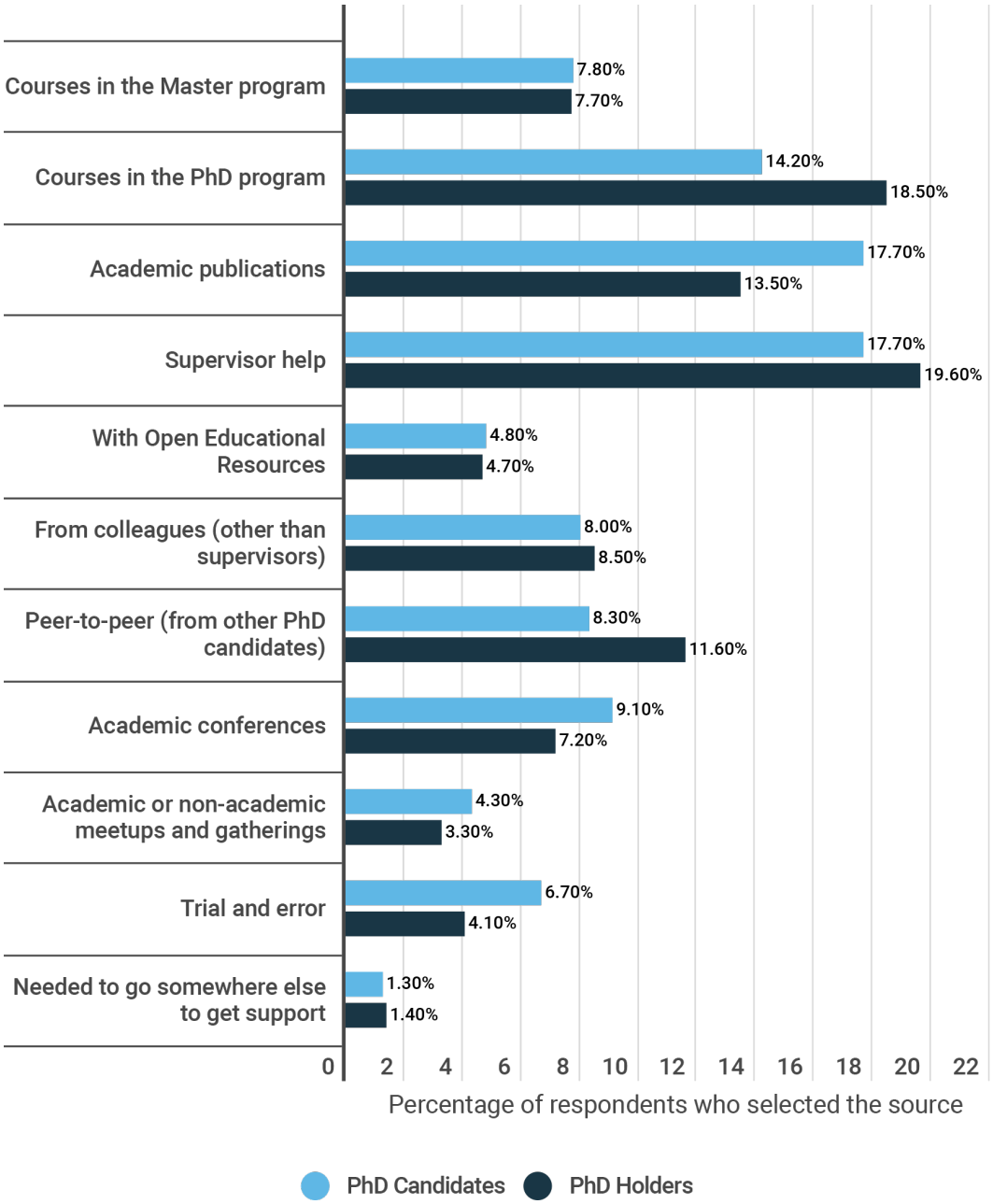

Figure 15. Learning sources used for research methods (PhD Candidates vs. PhD Holders).

Figure 16 compares the results obtained for learning sources in terms of TEL topics, general PhD-level training topics and research methods according to the selection made by PhD candidates. Two sources emerge as the most relevant across the three categories:

- Academic publications (20.6% TEL topics, 15% PhD training, 17.7% Research methods)
- Supervisor help (15.3% TEL topics, 16% PhD training, 17.7% Research methods)

Courses in PhD programs seem to be relevant for general PhD training (14.7%) and Research methods (14.2%), but less for TEL topics (9.5%). Another important learning source for the participants is *Academic conferences* (15.30% TEL topics, 10.60% PHD training, 9.10% Research methods).

We can also see differences of learning sources between the learning domains of TEL topics, general PhD training, and Research methods. Learning sources for TEL topics stand out by the academic publications, academic conferences and OER being significantly more popular than for the general PhD training and research methods. At the same time, courses in PhD programs become learning sources for TEL topics significantly less often, compared with the general PhD training and research methods.

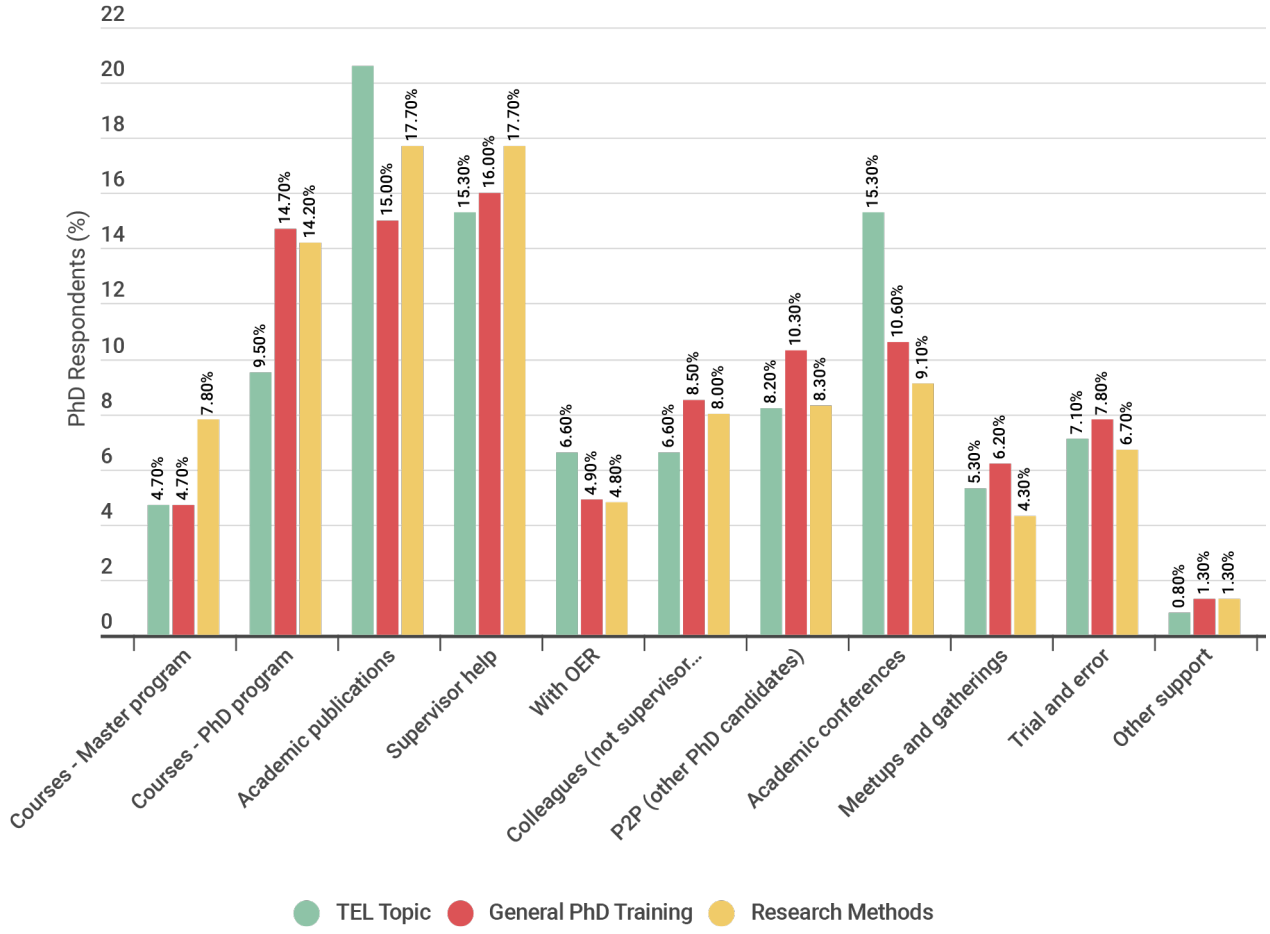

Figure 16. Learning sources used by PhD candidates (TEL topics, PHD training & Research methods).

Figure 17 compares the results obtained for learning sources in terms of TEL topics, general PhD-level training topics and research methods according to the selection made by PhD holders. These results indicate that there are some similarities with the results obtained for PhD candidates (see Figure 16) but also some important differences. For instance, as in the case of PhD Candidates, PhD holders also consider *Supervisor help* as one the most relevant sources across the three categories (13.8% TEL topics, 18,3% PhD training, 19.6% Research methods). Another similarity between the two groups resides in the participants' perception towards *Courses in PhD programs* which, according to the PhD holders, are one of the learning sources most used in terms of general PhD training (15.6%) and Research methods

(18.5%). *Academic publications* also appear as one of the most relevant learning sources, but in the PhD holders' case, this learning source only seems to be relevant for the TEL topic (15.8%) and Research methods (13.5%) categories. *Academic conferences* also constitute relevant learning sources for this group, but only for TEL topics (13%). A distinctive characteristic of this group is found in the *From colleagues* and *Peer-to-peer* sources, which are perceived fairly relevant, the former for the general PhD training category, and the latter across all three categories.

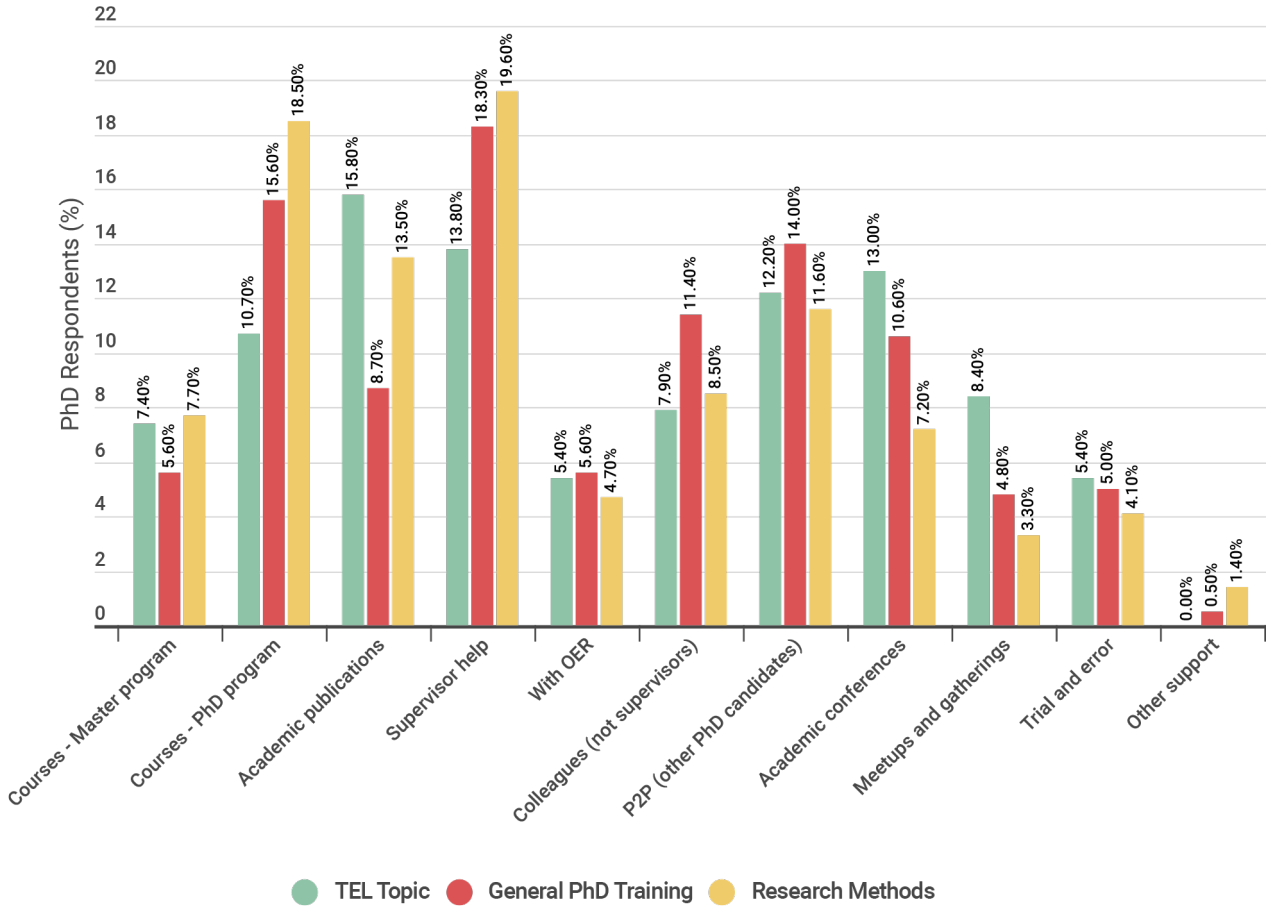

Figure 17. Learning sources used by PhD holders (TEL topics, PHD training & Research methods).

The participants provided only a few responses to the multiple open-ended questions in the section on learning sources. For the general PhD topics, PhD candidates suggested "summer school", "academic writing center", and "teaching job in University", while the PhD holders suggested "books", "asking people", and "discussion with mentors". For the TEL topics, PhD candidates suggested "webinars", "online self-study", associations and communities, "work", "participation in research & training projects", while the PhD holders suggested "books", "hands-on workshops", and "professional learning networks". For research methods, the participants suggested online video resources, books, and the Internet in general.

4.6 Challenges

In this section, we present the survey results related to the challenges of being a doctoral candidate in the field of TEL.

- The most difficult barriers for TEL PhD candidates:
  - ⚠ *Work-life balance*
  - ⚠ *Project management*
  - ⚠ *Psychological challenges*
- Among different profiles of TEL doctoral student, the most numerous is one where students that find ⚠ *Work-life balance* and ⚠ *Project management* difficult.
- Among the different challenge areas, those related to ⚠ *Supervision* are the most reliable predictors of student satisfaction with their doctoral studies.

In this part of the survey, we asked the participants about different areas of the TEL doctoral experience, and how challenging they found each aspect (from 1-Very difficult, to 5-Very easy). More specifically, participants were asked about their challenges in terms of:

- Work-life balance
- Project management (and lack of time)
- Financial aspects
- Administrative aspects
- Doctoral supervision issues
- Psychological aspects
- Training
- Information access
- Technical aspects
- Professional ethics

Overall (N=229), *work-life balance* was considered the most challenging aspect on average (mean=2.27), with *psychological aspects* (mean=2.44) and *project management* (which includes time management or the feeling of lack of time) close behind (mean=2.58). In contrast, *information access* was considered overall the easiest (mean=3.7).

However, it would be especially interesting to know about the self-reported challenges of those participants that are currently doing a TEL doctorate, as they are closer to the actual experience (which may avoid the memory biases of PhD holder participants). Figure 18 displays the results of these challenge-related questions for participants that were at the time doing a TEL PhD.

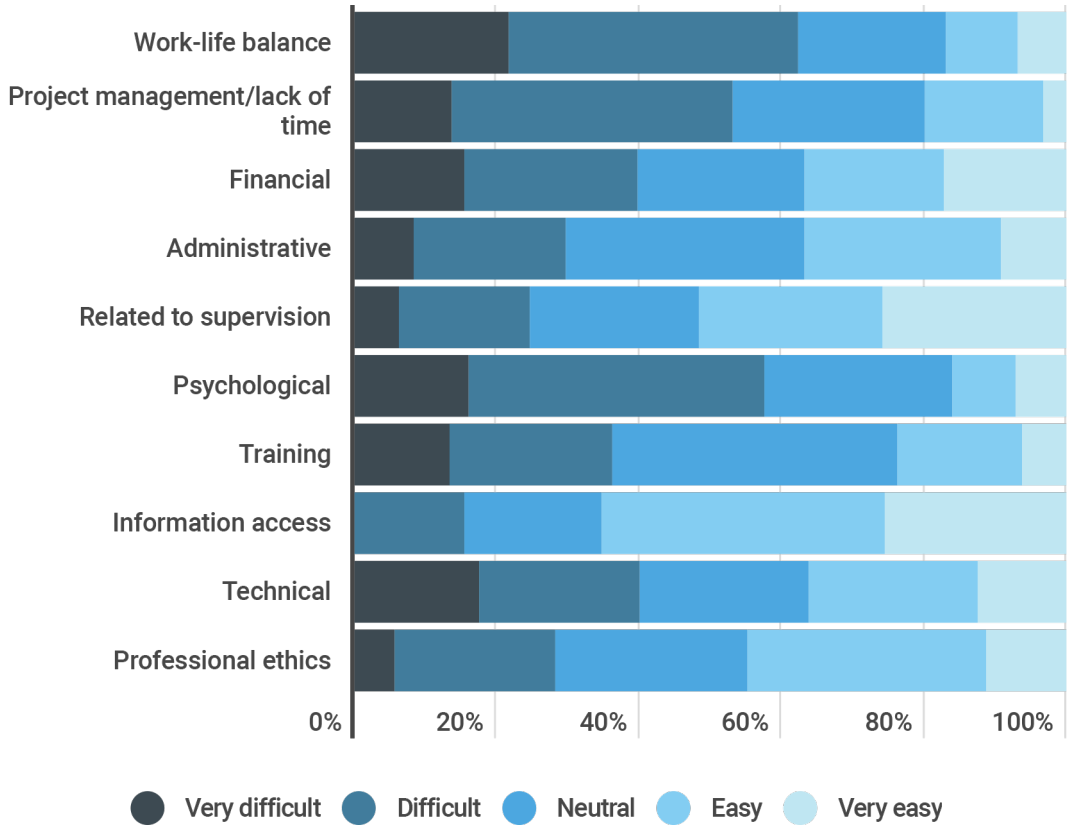

Figure 18. How challenging PhD candidates found different areas of the (TEL) doctoral experience.

We can observe that the same patterns emerge from the PhD candidates' data: *work-life balance* is the most challenging issue (mean=2.40) for them, followed by *psychological aspects* of the doctoral experience (mean=2.50) and *project/time management* (mean=2.56). We could dig even deeper into the participants' data, to understand whether TEL doctoral students at different stages (early/first year vs. middle stage vs. finishing stage) find different aspects challenging. As we can see from Figure 19 below, early stage candidates find *psychological* and *project/time management* most difficult, while for middle-stage participants *work-life balance* appears to be even more challenging. This latter trend also holds for candidates in the latter stage of the doctorate (still with psychological and project management issues as quite difficult aspects).

These results somehow echo recent research about doctoral studies, warning about a "mental health crisis"[70] in postgraduate education. Our data, however, adds a new spin on it, highlighting also the complexity of managing a research project for the first time, including issues of productivity and time management (and their impact on work-life balance). This could be related to doctoral education research studies that emphasize the need for competence[71] and a perception of continuous progress[72] as a key marker of candidates that are able to finish their doctoral studies.

[70] Teresa M Evans, Lindsay Bira, Jazmin Beltran Gastelum, L Todd Weiss, and Nathan L Vanderford (2018). Evidence for a mental health crisis in graduate education https://doi.org/10.1038/nbt.4089

[71] Nicolas Van der Linden, Christelle Devos, Gentiane Boudrenghien, Mariane Frenay, Assaad Azzi, Olivier Klein, and Benoît Galand (2018). Gaining insight into doctoral persistence: Development and validation of Doctorate-related Need Support and Need Satisfaction short scales https://doi.org/10.1016/j.lindif.2018.03.008

[72] Christelle Devos, Gentiane Boudrenghien, Nicolas Van der Linden, Assaad Azzi, Mariane Frenay, Benoit Galand and Olivier Klein (2017). Doctoral students' experiences leading to completion or attrition: a matter of sense, progress and distress https://doi.org/10.1007/s10212-016-0290-0

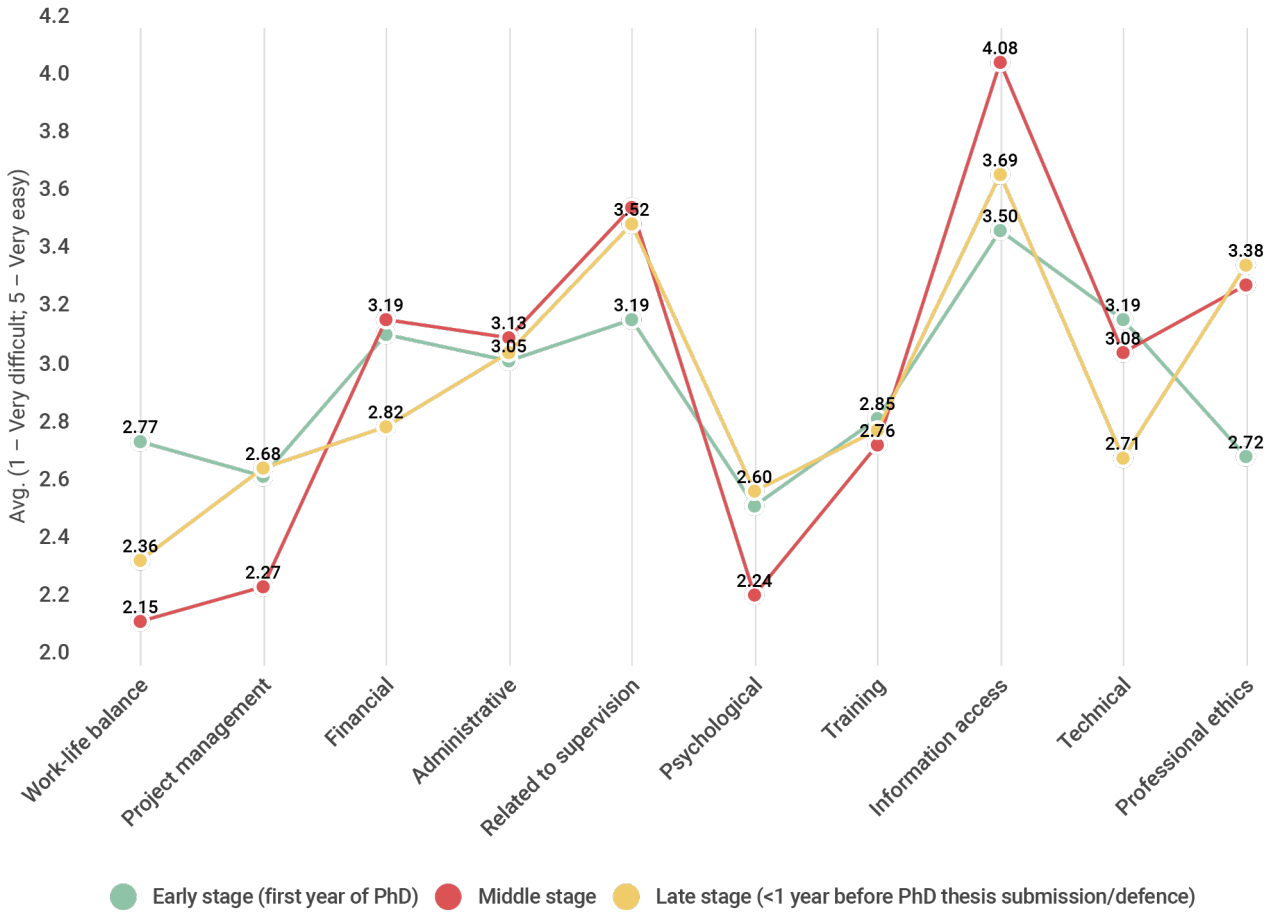

Figure 19. How easy did PhD students at different stages find different aspects of the PhD? (average scores in a Likert-scale question from 1-Very difficult, to 5-Very easy).

Once we have this overall descriptive view of what aspects of the PhD that TEL doctoral students found most (and least) challenging, we can start asking more complex questions, such as: is there a structure to these challenge-related responses? *Are there challenges that tend to occur together in a TEL doctorate?* We used different exploratory statistical methods to understand the answers. Below is a summary of the results obtained from this exploration, and a more detailed view can be found in annex A12.

An initial exploration using correlations showed that all the challenge responses were somewhat correlated with each other. This was later confirmed by a principal component analysis (PCA), which showed that the main underlying factor, accounting for about 30% of the variance in the dataset, could be interpreted basically as "whether the respondent found all aspects challenging" (or not challenging).

One exploratory method that can be used in this kind of heavy collinearity situations is the use of partial correlations, which basically are the correlations between two variables *once we control for all the other variables being analyzed*. These partial correlations can also be arranged graphically as a network where nodes are the different variables under analysis (e.g., how challenging a PhD student found supervision aspects), and edges are the partial correlations between them. Such a network can help understand potential relations and effects between variables[73]. Yet, it is worth remembering that these are exploratory, correlational tools that can help us generate hypotheses, but not find causal relationships (until later research is done to confirm such relations).

[73] Sacha Epskamp and Eiko I Fried (2018). A tutorial on regularized partial correlation networks https://doi.org/10.1037/met0000167

We used such a method on the different aspects of the TEL PhD that respondents found challenging, and added a couple of demographic variables (gender, age group), to control for those as well. While we analyzed separately the responses of doctoral students and more senior researchers, we found similar trends in both collectives. We could observe that there are several challenges that tend to appear together, like *work-life balance, psychological challenges* and *project management challenges*. Some of the challenge variables were more central in the network, maybe indicating that they are more influential. *Supervision challenges tended to co-occur with information access, professional ethics, administrative, technical and psychological challenges*. Finally, we can see a certain relationship between demographic aspects like (gender and age), and certain challenges: *older respondents tend to find financial aspects more challenging*, while *female respondents tend to find technical aspects of the PhD slightly more challenging*, once we control for all the other variables in the network.

We may apply these exploratory results in practice when designing training actions for TEL doctoral students, by simultaneously addressing challenges that tend to co-occur (as there is a high chance that participants will face such a combination of challenges). Within DE-TEL, we could for example create training actions that try to address not only the psychological challenges of the PhD (e.g., mental health issues[74]), but also the work-life and project management (e.g., productivity) challenges that seem to be related with them (e.g., through the notion of making steady progress in the PhD project[75]). We could also try to provide training or advice for TEL doctoral supervisors (more on this in section 4.7 below), since supervision challenges tend to have wide-ranging ramifications in the network of challenges of a TEL PhD.

Aside from these relationships between challenge *variables* (and demographic ones), we may also ask ourselves whether there are particular *"doctoral student profiles"*, i.e., types of doctoral students that tend to find the same aspects challenging. We can again explore the dataset using techniques such as multidimensional scaling and k-means clustering. Using such techniques we found, for example, the following five clusters of students, which gives us different profiles of TEL students/researchers (NB: these clusters seem independent of the type of respondent, indicating that these profiles may be independent of whether one has finished the PhD or still is in the process of doing one):

1. *Supervision- and ethics-challenged (N=22).* Although overall this group of participants found all aspects averagely challenging, they tended to consider psychological, and work-life balance *less* challenging. However, they found supervision and professional ethics aspects of the PhD rather challenging.

2. *Everything is easy (N=25).* For this collective of respondents, all aspects of the PhD seem to be comparatively easy, especially the supervision and information access (which probably indicates an involved and capable supervisor(s) and good institutional support). Within this general sense of ease, aspects like project management, work-life balance and psychological issues are still considered the most challenging, comparatively (as in, neither easy nor difficult).

3. *Everything is difficult (N=34).* For respondents in this group, every aspect of the PhD was considered more or less challenging. Psychological and work-life balance issues were especially perceived as challenging, followed by supervision and project management aspects. On the other hand, information access and professional ethics were considered comparatively less challenging.

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[74] Teresa M Evans, Lindsay Bira, Jazmin Beltran Gastelum, L Todd Weiss, and Nathan L Vanderford (2018). Evidence for a mental health crisis in graduate education https://doi.org/10.1038/nbt.4089

[75] Christelle Devos, Gentiane Boudrenghien, Nicolas Van der Linden, Assaad Azzi, Mariane Frenay, Benoit Galand and Olivier Klein (2017). Doctoral students' experiences leading to completion or attrition: a matter of sense, progress and distress https://doi.org/10.1007/s10212-016-0290-0

4. *Work-life, training and ethics challenged (N=31).* This group of respondents showed average levels of challenge in general. Still, for them work-life balance, training and professional ethics aspects (as well as psychological ones) were considered challenging. Information access was generally considered less challenging by these respondents (followed by administrative and financial issues).

5. *It's hard to keep on top of things (including life)(N=62).* This, the most numerous profile, showed average levels of challenge, but stronger variations between some aspects and others. For instance, work-life balance was considered most challenging, followed by project management and psychological aspects of the PhD. On the other hand, access to information, professional ethics and supervision were less challenging for these people.

It is worth noting that these clusters do not seem to be associated with particular gender, age groups or other demographic variables. Yet, these clusters are somehow reminiscent of those elicited in recent studies (on general doctoral populations), by DeClercq et al[76]. In this study, for example, aside from generally satisfied and unsatisfied students (resembling our profiles #2 and #3), they also found competence-deficient ones (which resembles our profile #4).

This exploratory cluster analysis again may have practical implications for institutions developing TEL doctoral programs, as it may help them create more targeted training or counseling actions, to support these different kinds of PhD students in overcoming their most challenging aspects.

Finally, we could also ask from our dataset whether there is a relationship between these different kinds of challenges, and the overall satisfaction of respondents with their TEL PhD. In other words, *how much each kind of challenge seems to be contributing to the (dis)satisfaction with the doctorate*. A stepwise linear regression of doctoral student satisfaction with their ongoing PhD using demographic and challenge variables as predictors (using the Akaike Information Criterion to select models that are at the same time predictive and parsimonious), gave out a model in which the *clearest predictor of satisfaction is the supervision challenges* (doctoral students that find supervision aspects easy, tend to be more satisfied). Other (non-significant) predictors included the *student's age* (older students tend to be more satisfied) and the *difficulty of information access* (students that are overcoming harder information access challenges seem to be more satisfied). This very simple model, accounts for 34% of the variance of the data from PhD student respondents. Similar models for respondents already holding a doctorate also showed supervision as a positive predictor, and information access as a negative one. Such models could also be helpful for TEL doctoral program decision makers, as they suggest that efforts should focus on solving their supervision challenges first (either through changes in policy or training for supervisors, see the next section), rather than on, e.g., rehauling their information access strategy as a first step towards higher student satisfaction.

[76] Mikaël De Clercq, Mariane Frenay, Assaad Azzi, Olivier Klein, and Benoit Galand (2021). All You Need is Self-Determination: Investigation of PhD Students' Motivation Profiles and Their Impact on the Doctoral Completion Process https://doi.org/10.28945/4702

4.7 Supervision and mentoring

In this section, we present the results of the survey that cover the supervision and mentoring practices in the TEL research community.

- Most innovative supervision practices, such as *Learning how to write scientific papers by example*, *Team supervision*, *Discussion of the overall PhD ideas*, were found useful by both PhD students and PhD holders.
- Many of the innovative supervision practices are relatively rare within the TEL doctoral community.
- The most reliable (and positive) predictors of TEL doctoral student satisfaction are *Support to scientific writing*, *Critical thinking*, and *Emotional support.*

Our survey also contained questions related to the doctoral candidates (and PhD holders) satisfaction with their supervision and mentoring (in a Likert scale from 1-Very dissatisfied, to 5-Very satisfied). We also asked participants about the kinds of supervision practices they had experienced, and how useful they found them. As we can observe in figure 20 below, participants were majoritarily satisfied with the supervision and mentoring received, with current candidates slightly more satisfied on average (mean=3.9) than TEL PhD holders (mean=3.7).

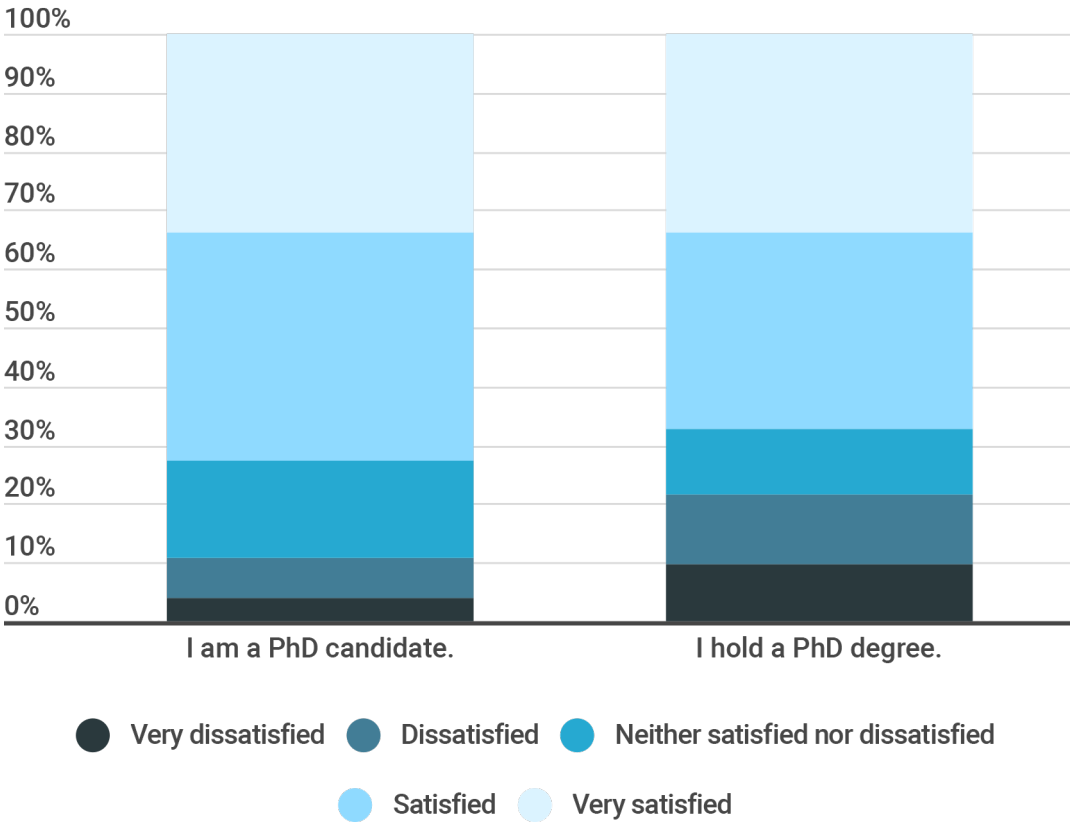

Figure 20. PhD satisfaction with supervision and mentoring. PhD vs. Doctors.

Delving deeper into the data from our TEL doctoral candidates, we can see how satisfied they were with their mentoring at different stages of the PhD (early/first year vs. middle stage vs. finishing stage). As we can see from Figure 21 below, early stage candidates are, on average, the least satisfied with the

supervision/mentoring they are receiving (mean=3.7), with middle-stage participants and candidates in the latter stage being progressively more satisfied (mean=3.9 and mean=4.0, respectively).

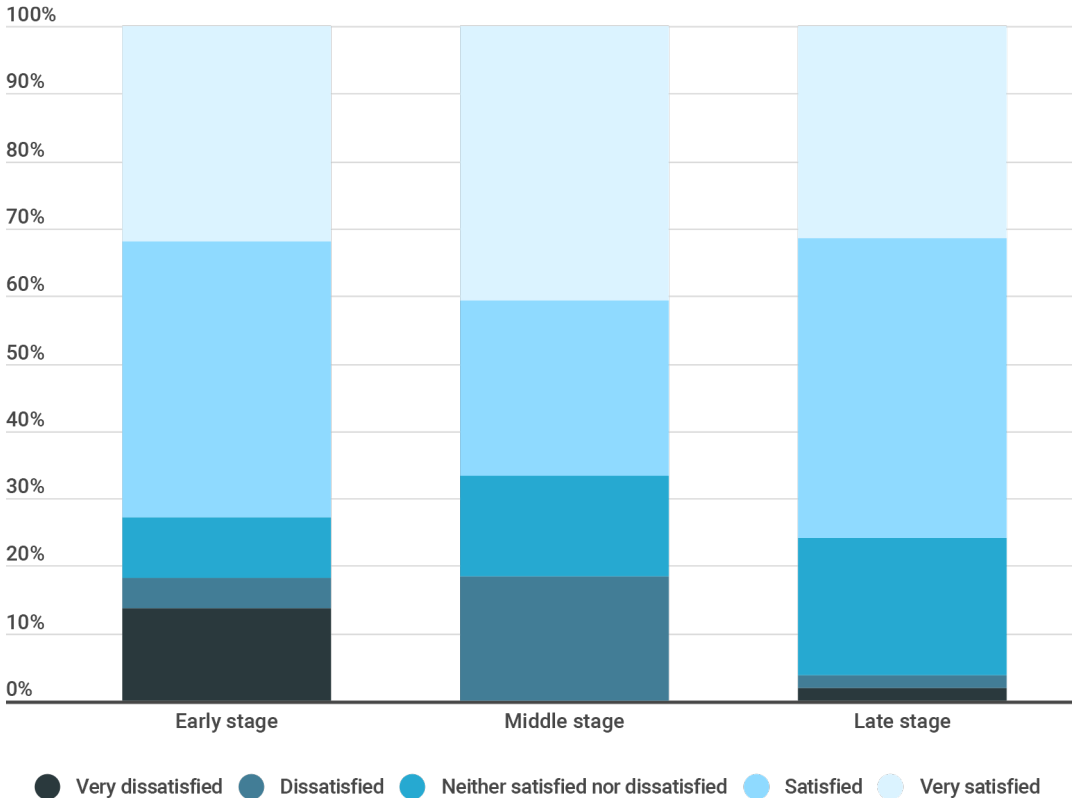

Figure 21. PhD satisfaction with supervisors/mentors breakdown by PhD stages.

We suggested the participants 19 common doctoral supervision practices (described in annex A3 of this report), so that they could select those they experience. The suggested practices are:

- Single-supervisor support
- Co-supervision support
- Team supervision
- Learning how to do research by example
- Learning how to write a grant proposal by example
- Learning how to prepare an ethics application by example
- Learning how to review the literature by example
- Learning how to write and publish scientific texts by example
- Learning how to analyze data by example
- Learning project management by example
- Doctoral writing groups
- Supervision contracts
- Regular discussion of the overall thesis plan with supervisors or other colleagues
- Inclusion of external experts or other researchers into the PhD research
- Support in integrating into your disciplinary scientific community
- Support to your critical thinking skills
- Emotional support
- Support for your autonomy as an independent researcher
- Material support

From the participant responses related to the different supervision practices, we can see (Figure 22) that the *most common supervision practice is to have a single supervisor*. Less frequent but still numerous were: having more than one supervisor (CoSupervision), receiving material support from the supervisor, discussing the overall thesis with the supervisor, or learning scientific writing by example, support to critical thinking and emotional support. Other innovative but relatively rare supervision practices include learning to do research by example, support to the student's autonomy/independence, learning about literature reviews by example, learning about grant writing by example, or the involvement of external experts in the dissertation work. The *rarest supervision practice was that of supervision contracts at the start of a PhD, or learning about writing ethics applications by example*, followed by team supervision (i.e., being supervised by a wider team of more experienced colleagues, e.g., postdocs), integration into scientific communication, doctoral writing groups, and learning about data analysis or project management by example.

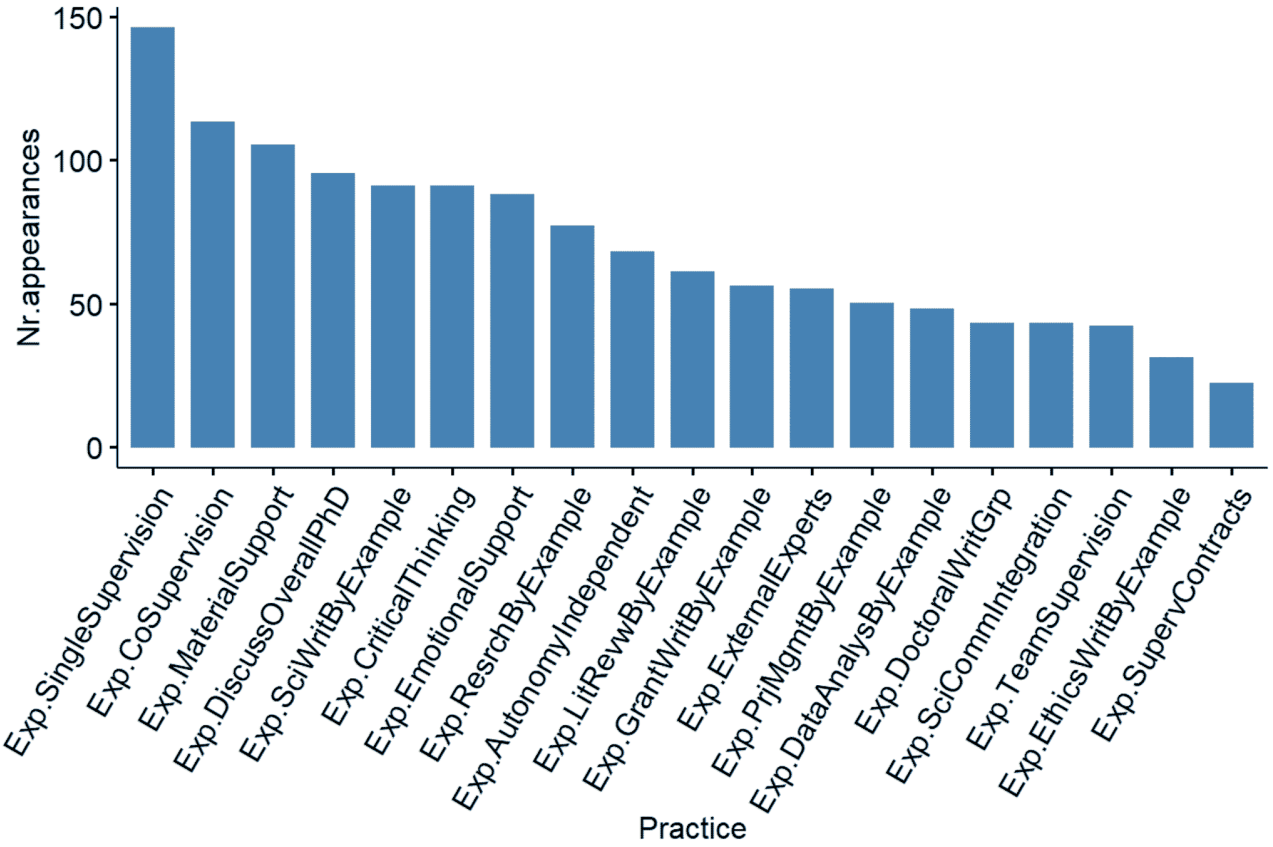

Figure 22. Supervision practices experienced by participants.

However, we also asked respondents that had experienced a certain supervision practice, to rate its usefulness (in a Likert scale from 1-Extremely useless, to 5-Extremely useful). As we can see in Figure 23 below, TEL PhD candidates found most useful (on average) being provided with material support, support to critical thinking and learning about scientific writing by example (mean=4.5), followed by learning to do research by example (mean=4.4). While those were also valued by TEL doctorate holders, these appreciated most learning about data analysis by example (mean=4.4). Both collectives appreciated the least supervision contracts, when they experienced them.

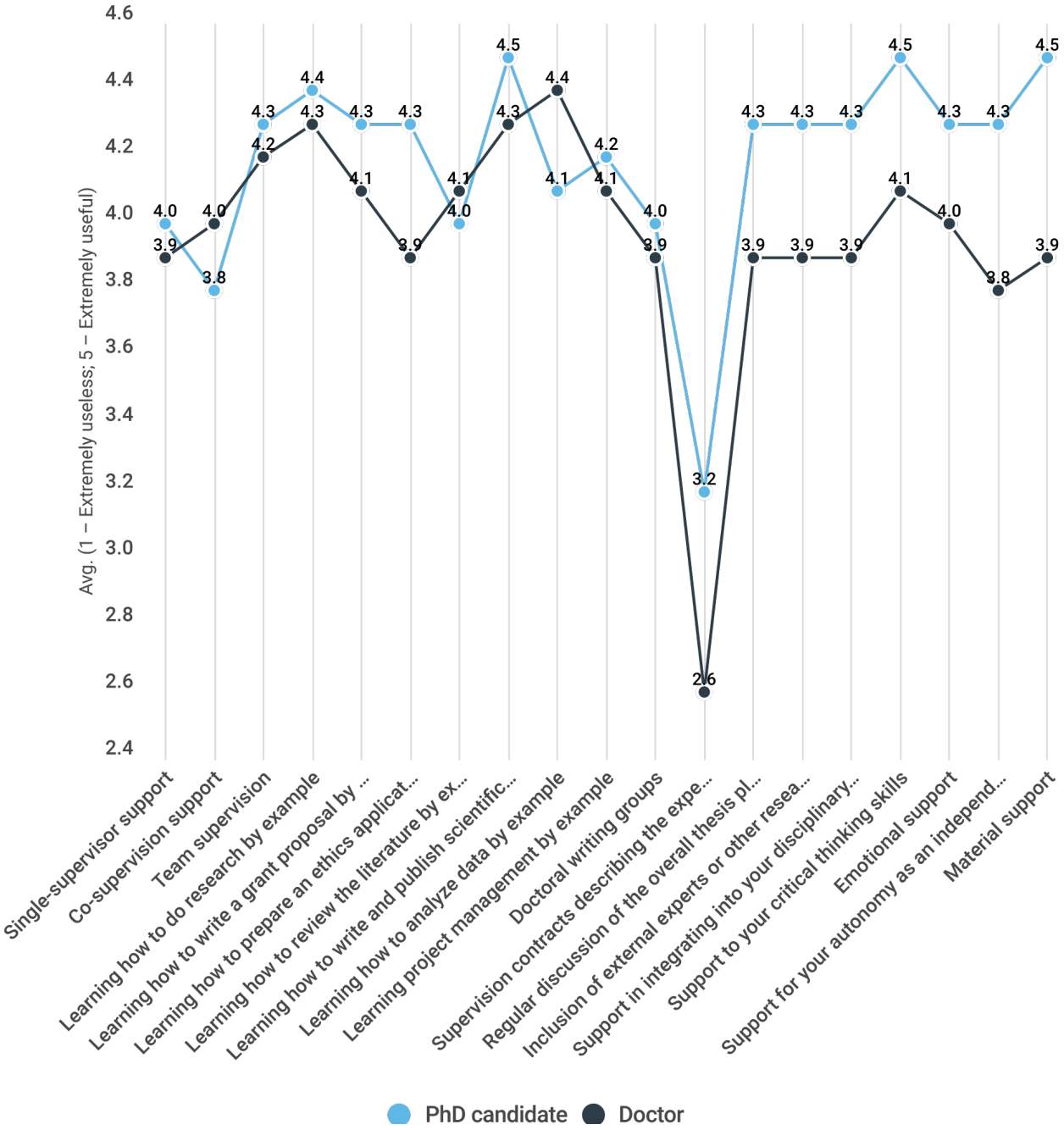

Figure 23. Average Rating supervision practices PhD candidates vs. doctors.

If we plot both the common-ness and usefulness of such practices in a two-dimensional plane, we can obtain a more actionable picture to guide future TEL supervisors (and supervisor trainers) in what kinds of practices to focus on (Figures 24 and 25). By looking at the top-left quadrant of the graphs, we can see practices that are considered useful, but which are still rarely implemented by supervisors. There, we can find support for critical thinking, scientific communication, or many of the practices to learn about diverse aspects of research (grant writing, ethics application writing), by example. The relatively rare model of team supervision is also considered highly useful by both doctoral students and PhD holders alike.

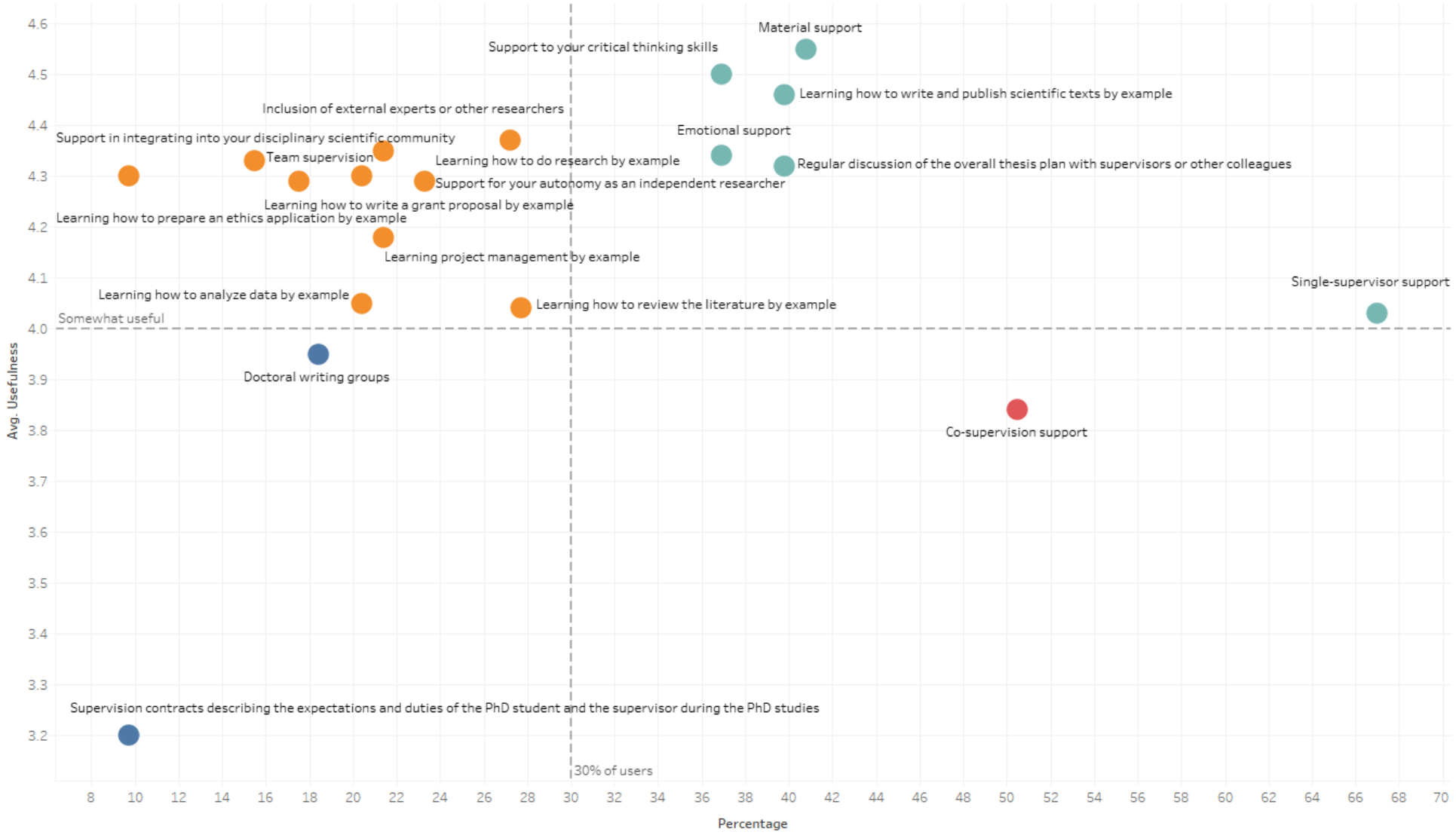

Figure 24. Usefulness of supervision practices vs. most used ones (PhD candidates). Available online at https://ea-tel.eu/de-tel/survey-results

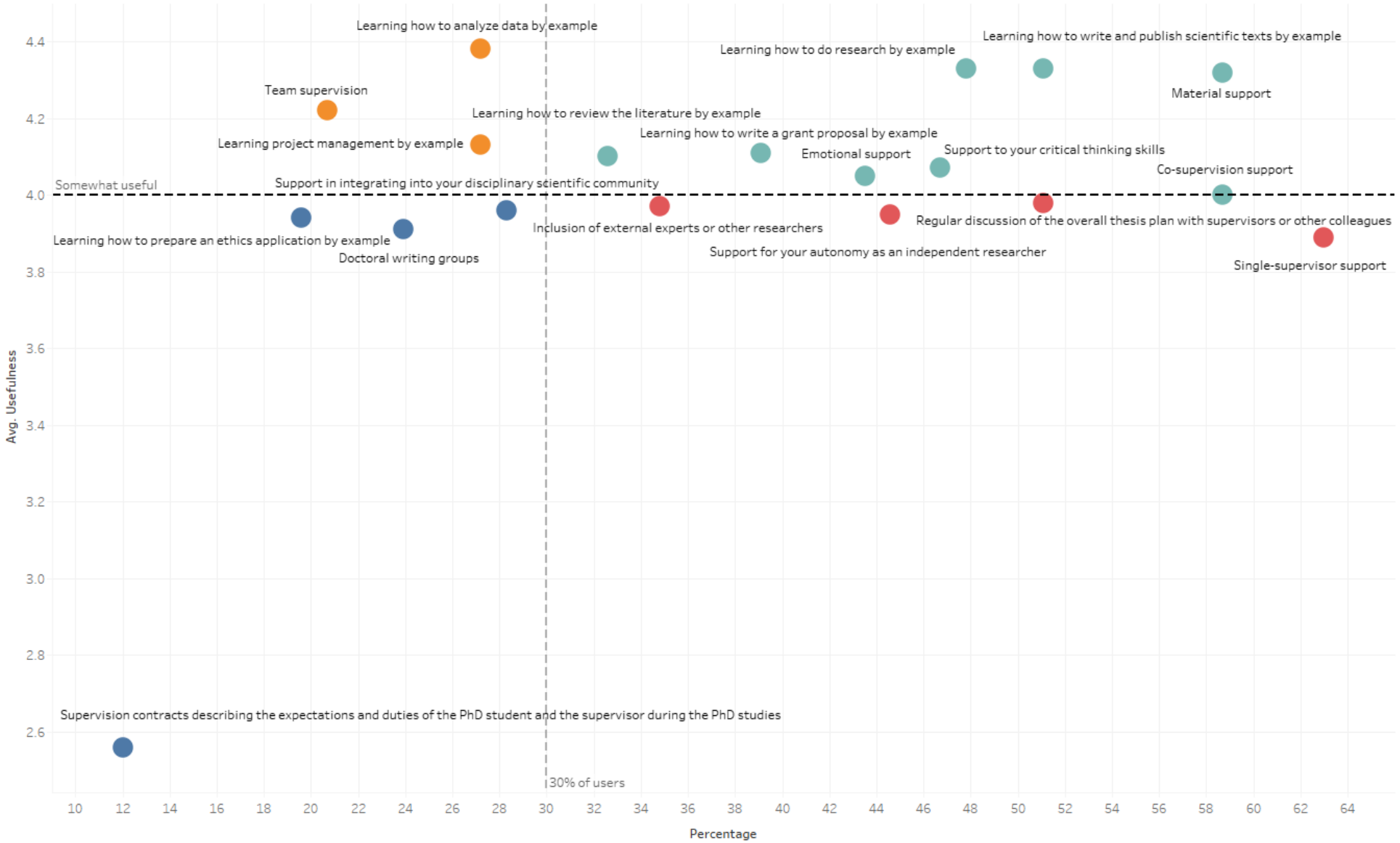

Figure 25. Usefulness of supervision practices vs. most used ones (PhD holders). Available online at https://ea-tel.eu/de-tel/survey-results

We could also be interested in knowing *whether there are dominant supervision styles* (i.e., kinds of supervision and supervision practices that tend to appear together) – see the full analysis and graphs in annex A13. A multiple correspondence analysis (MCA) of participant responses about what kind of supervision they experienced, showed a large concentration of TEL PhD students that experienced few or none of the "innovative supervision practices" mentioned in previous paragraphs. The rest of the respondents were spread on a continuum of supervision practices that tend to appear together, with ethics, literature reviews, grant writing or project management by example in one end, and doctoral writing groups, emotional support, overall PhD discussion and critical thinking support, on the other. It is worth noting that doctors and doctoral students both showed similar distributions of variables and participants, suggesting that this state of affairs seems to be quite stable in time.

We could also ask *whether there are relationships between any of these practices and a higher satisfaction with the TEL doctorate*. A first approximation to this question is to compare the distribution of satisfactions of doctors and PhD students that have experienced a kind of supervision (or practice), and those that did not. The graph below (Figure 26) shows the results of such comparisons, looking at the average satisfaction (and its 95% confidence interval).

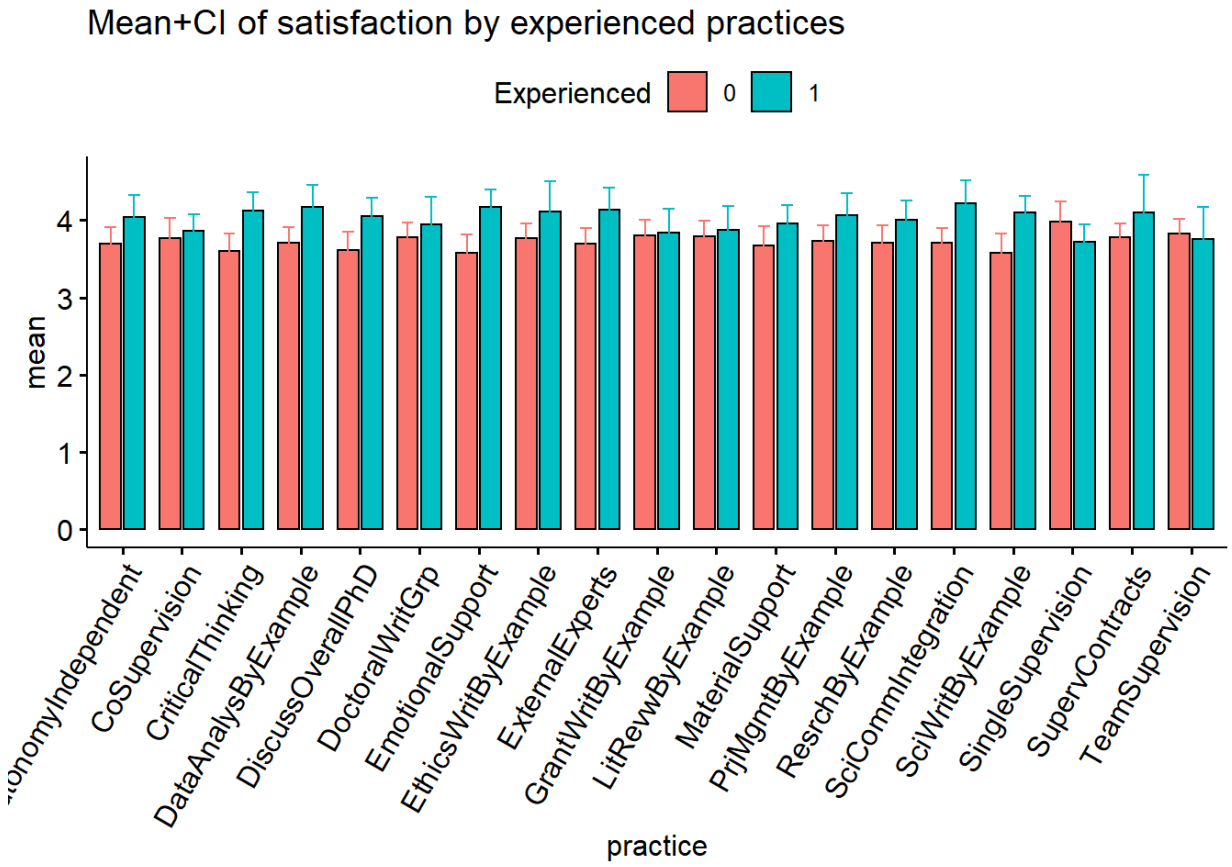

Figure 26. Comparison of average satisfactions between respondents (TEL PhD students and doctors) that experienced a kind of supervision, vs. those that did not.

We can observe that single-supervisor mentorship is the only dynamic that is clearly associated with lower satisfaction, while team and co-supervision have a less clear association with satisfaction. On the other hand, all the other supervision practices we asked about seemed associated with higher satisfaction, with emotional support, scientific writing and data analysis by example, discussing the overall PhD, scientific communication integration, or support to critical thinking, having the most dramatic association with higher satisfaction.

These results already contain interesting practical insights for TEL doctoral supervisors and program managers. First, encouraging (and training) supervisors to use many of these practices (especially the ones noted in the previous paragraph) can be beneficial for PhD students. Also, that co- and team-supervision should probably be preferred over single-supervisor mentoring.

Given the large collinearity among the experiencing of many of these supervision practices, and with doctoral satisfaction, we can use again partial correlations to define networks of variables that seem to often co-occur with each other (including also demographic variables). Aside from observing the clusters of practices that tend to appear together (mentioned above), this exploratory analysis showed that satisfaction seemed unrelated to demographic factors and the type of supervision received (single or co-supervision), once we control for all the other supervision practices. Only emotional support, support to critical thinking and to scientific writing by example, seem to relate directly to such satisfaction. With small deviations, similar networks were found if we analyze doctors and PhD students separately.

Finally, to look at the question of *which supervision practices seem most associated with higher (or lower) satisfaction* with a TEL PhD, we can build models trying to predict how satisfied a respondent was, as a function of the supervision practices experienced. Using stepwise linear regression models, we could observe again that support to scientific writing, critical thinking and emotional support seem to be positive predictors of satisfaction, while the presence of team supervision seems to have a (non-significant) negative value.

If, in turn, we try to predict *whether the respondents found supervision aspects challenging*, again scientific writing support by example has again a positive association, along with team supervision (as it provides additional sources of mentoring beyond the main supervisor), supervision contracts (probably due to their setting expectations for supervision early on), and material support during the PhD.

These last analyses paint a somewhat complex, nuanced picture for those supervisors looking for practical insights in supporting a TEL PhD: certain supervision practices seem to be more important (or leading to higher satisfaction and lower perceived supervision challenges), like supporting scientific writing by example, or emotional support. However, it seems that the effects of each of the analyzed practices, in isolation, are relatively small. Hence, an additive approach in which supervisors are trained in (and encouraged to use) multiple "innovative" supervision practices, might be a more consistent way of achieving successful and satisfied TEL PhD students.

5. Conclusions

In the studies presented in this report, we collected and analyzed different data to answer five main research questions. We provide concrete answers to the questions in sections 5.1 and 5.2.

Our desk research study was solely dedicated to answering *RQ1: What TEL doctoral education practices are followed by European Higher Education institutions?* The conclusions are given below in section 5.1.

In our survey, we collected data that helped us to answer the remaining four research questions. Detailed conclusions are given in section 5.2. Question *RQ2: What courses and educational materials do TEL PhD candidates need?* helped us to understand how to improve the doctoral curricula in TEL, including the courses on the subtopics in the field, research methods, and general PhD training topics.

Question *RQ3: What learning sources do TEL PhD candidates use?* allowed us to better understand the learning processes in the TEL community and can be the grounding for designing balanced learning activities and relevant information sources. The data on how the learning sources differ for TEL topics, research methods, and general PhD training topics allows for further finetuning.

Question *RQ4: What challenges do TEL PhD candidates have?* gave us data to improve the doctoral education process overall. As we can see, training is seen as rather difficult but there are other challenges that are more serious and that should also be addressed.

Question *RQ5: What supervision practices are used in doctoral education in TEL?* allowed us to understand the specifics of supervision in the multidisciplinary field of TEL. We can see that the supervision practices in the TEL community can be improved.

5.1 Conclusions from the desk research

The available data show that there is not a single way in which doctoral students in TEL are awarded their PhD. PhD candidates in research groups who do research in TEL follow mono-disciplinary[77], multi-disciplinary[78], interdisciplinary[79] and trans-disciplinary[80] doctoral educational programs, some of which do offer a dedicated set of courses or curriculum, and some of which do not. Therefore, the studied PhD programs also provide their students with a heterogeneous foundational knowledge; such that the creation of common ground within the field of TEL must be understood to be outside the structures within higher education institutions. Furthermore, not all PhD programs are available in English, such that sharing of existing resources is further made difficult.

5.2 Highlights from the survey

In this section, we present a summary of the survey results in the form of highlights - the most important lessons learnt - from each section.

[77] A discipline-focused department awards the PhD.

[78] Two or more departments collaborate to create a joint PhD program. However, the collaborating professors do not try to adapt their disciplinary competences to TEL.

[79] Two or more departments collaborate to create a joint PhD program. The collaborating professors synthesize and modify their disciplinary perspectives and approaches.

[80] Two or more departments collaborate in developing the postgraduate programs and award the PhD in TEL together. The competences within each department cross the disciplinary boundaries of the department.

5.2.1 TEL Topics

For TEL topics, we conclude that doctoral courses and educational materials are most needed and least available in the TEL community for the topics:

- Artificial Intelligence in education
- Personalized and adaptive learning
- Smart / Intelligent Learning Environments

Doctoral courses and educational materials are highly needed but some already available in the TEL community for the topics:

- Pedagogical Patterns
- Learning analytics
- Visualization / Visual Analytics
- Self-regulated / Informal Learning

Doctoral courses and educational materials are moderately needed in the TEL community for the topics:

- Gamification
- Mixed and Augmented Reality
- Engagement / Emotion / Affect

5.2.2 General PhD training

For the general PhD training topics, we conclude that PhD candidates believe that they need training on and educational materials on the general PhD training topics:

- Academic writing and publication
- Dissemination of research results
- Project management

PhD holders believe that PhD candidates need training on and educational materials on the general PhD training topics:

- Academic writing and publication
- Project management
- Research ethics
- Dissemination of research results

5.2.3 Research methods

For the research methods, we conclude that the most common method for both PhD students and PhD holders is Design-based research. An exception are researchers working in the field of 'Education using technologies', where experimental research and field qualitative methods are the most reported methods. Regardless of the level of training, the participants reported the need for more training in the research methods they use.

5.2.4 Learning sources

For the learning sources, we conclude that the primary learning source for TEL topics is academic publications. The primary learning source for general PhD training is supervisor help. The primary learning sources for research methods are supervisor help, academic publications, and courses in the PhD program. The variety in the learning sources is influenced by the educational background.

5.2.5 Challenges

For the challenges in doctoral education in TEL, we conclude that the most difficult barriers for TEL PhD candidates are:

- Work-life balance
- Project management
- Psychological challenges

Among different profiles of TEL doctoral candidates, the most numerous is one where the candidates find work-life balance and project management difficult. Among the different challenge areas, those related to supervision are the most reliable predictors of student satisfaction with their doctoral studies.

5.2.6 Supervision and mentoring

For the supervision and mentoring, we conclude that the most innovative supervision practices, such as learning how to write scientific papers by example, team supervision, and discussion of the overall PhD ideas, were found useful by both PhD students and PhD holders. Many of the innovative supervision practices are relatively rare within the TEL doctoral community. The most reliable (and positive) predictors of TEL doctoral student satisfaction are support for scientific writing, critical thinking, and emotional support.

5.3 Conclusions from the survey

The survey of doctoral education in Technology-Enhanced Learning has been the first attempt to gather comprehensive insights into the topic. Even though the survey had some limitations, related to the geographical distribution and representation of different sub-communities in the sample, we gained valuable information on the state of the art of TEL not only as a doctoral topic but also as a research field.

In order to inform the curricula of TEL doctoral education, we first identified the major relevant subtopics of the field by analyzing the academic programs of a series of doctoral training events. Based on the survey results, we plotted these subtopics of the TEL field according to the need for and availability of courses and educational materials on these subtopics. This highlights the subtopics that should be included in the curricula - those with the higher need for resources. This also highlights the subtopics for which more educational resources should be created - those with low availability. At the same time, we can see the topics for which enough resources are already available, while the need for these resources is relatively low. Finally, the topics with low need and low availability are likely to be less relevant for the TEL community.

We confirmed that there is no single dominant research method used in the TEL community, and that educational resources are needed for multiple methods. Design-based research is the most common method for both PhD students and PhD holders. Naturally, there is an exception in researchers working in the field of 'Education using technologies', where experimental research and field qualitative

methods are the most reported methods. In general, and regardless of the level of training, the participants reported the need for more training in the same research methods they already use.

The survey results have also shown that the variety in the learning sources used by TEL researchers is influenced by their educational background, although all tended to choose the academic publications as their primary source for learning about TEL topics. This indicates that the field is still developing fast, and longer-lasting sources such as textbooks are not yet dominant. Moreover, for the general PhD-level training topics, both PhD candidates and PhD holders selected supervisor help as their primary learning source. One of the more significant findings to emerge from the survey results is that three learning sources seem to be the most used by PhD candidates and PhD holders when it comes to research methods: supervisor help, academic publications, and courses in the PhD program. A careful conclusion can be made that adequate PhD courses are only available for research methods, while all other topics are learnt elsewhere.

With respect to the challenges TEL researchers face, work-life balance, project management and psychological challenges are among the most difficult for TEL PhD candidates. However, there exist different TEL doctoral student profiles in terms of challenges, with students that find work-life balance and project management difficult being the most numerous. Interestingly, the results indicate that among the different challenge areas, those related to supervision are the most reliable predictors of student satisfaction with their doctoral studies.

Turning to supervision and mentoring, the study has identified that the most innovative supervision practices (e.g., learning how to write scientific papers by example, team supervision, discussion of the overall PhD ideas) which were found useful by both PhD candidates and PhD holders are still relatively rare within the TEL doctoral community. Support for scientific writing, critical thinking, and emotional support seem to be the most reliable (and positive) predictors of TEL doctoral candidate satisfaction.