A Systematic Mapping of E-Learning Research: An Interdisciplinary and Multi-paradigmatic Perspective from the Universitat Oberta de Catalunya

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Abstract: E-learning research is a dynamic and ever-expanding interdisciplinary field. Research in this area is often conducted at the intersection of social science, cognitive science, learning sciences, as well as engineering and computer science. Common concerns in the field include ambiguity and confusion toward how best to approach methodological design as well as tensions around whether the field is coherent or fragmented. E-learning research has been characterized as a multi-paradigmatic knowledge field with distinct theoretical foundations and a horizontal knowledge structure composed of "specialist" languages. There has been a remarkable increase in systematic literature reviews in the field, representing a burgeoning research industry. Although there is a clear division between technical and social scientific approaches, there is a scarcity of literature which attempts to synthesize the evidence on how e-learning research is conducted across disciplines and within distinctive research communities from a multi-paradigmatic perspective. The objective of the current study is to systematically map research done in the field of e-learning in higher education at the Universitat Oberta de Catalunya (UOC) within the frame of an institutional analysis. The aim is to identify key features and distinctive approaches to research across disciplines in this area from a multi-paradigmatic perspective. A systematic mapping review has been conducted, synthesizing research published between 2015-2020 by authors affiliated with the UOC. The study identified 291 articles, the majority of which use quantitative approaches following both design-based research methods as well as design and development research aims across three distinct research areas (a) educational research, (b) discipline-based education research and (c) learning engineering research. Fragmentation was identified across distinct research areas and communities of practice, particularly between research aims and the methods used to achieve these aims. By empirically examining the claims about methodological capacity and coherence in e-learning research, recommendations are offered for reorienting the field by: (a) increasing interdisciplinary collaboration through integrated research agendas; (b) supporting the expanding profession of the 'learning engineer'; and (c) promoting methodological capacity, clarity and innovation.

Keywords: e-learning, educational technology, interdisciplinary, systematic review, research methods

1. Introduction

How research is conducted in the dynamic field of e-learning has been studied extensively in recent years and remains an important and consistent debate within the broader domain of educational technology (EdTech) (Castañeda, Salinas and Adell, 2020, Reeves and Oh, 2017). Identifying and mapping e-learning research patterns has become a lively and well-established research area, aiming to identify priorities for the advancement of knowledge in the field (Bond et al., 2020). EdTech research, in which e-learning is situated, is dominated by the social sciences accounting for roughly half of research output, along with computer sciences and engineering (Bozkurt, 2020). Although there is a clear division between technical and socially oriented approaches, there is a scarcity of literature which attempts to synthesize the evidence on how e-learning research is conducted across disciplines and within distinctive research communities, particularly in the context of online higher education (OHE). A common concern across such communities is the ambiguity and confusion toward how best to approach methodological design in e-learning research from both social science (Bulfin et al., 2014, Castañeda, Salinas and Adell, 2020) and computer science (Caballé, 2019) perspectives, as well as tensions around whether the field is coherent and cohesive or fragmented (Czerniewicz, 2010).

EdTech has been characterized as a multi-paradigmatic knowledge field with distinct theoretical foundations and a horizontal knowledge structure composed of "specialist" languages (Czerniewicz, 2010 p.2). Such languages, as Czerniewicz (2010 p.2) argues, have "specialized modes of interrogation and criteria for the construction and circulation of texts", and are comprised of clusters such as *Instructional Design*, *Learning Science*, *Learning Technology*, *Computer Supported Collaborative Learning* and *Networked Learning*. As the field

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evolves with the unceasing development of more powerful and sophisticated technologies, newer clusters emerge with particular relevance for online and distance education, such as *Learning Engineering* (Dede, Richards and Saxburg, 2019), defined as "the application of engineering methodologies to develop learning technologies and infrastructures to better support learners and learning" (Caballé, 2019 p.548). With a diverse and heterogenous knowledge structure, e-learning is a highly varied field of critical inquiry with an ever-expanding scope and scale.

The purpose of the current study is to map the key features and distinctive approaches to e-learning research across disciplinary boundaries and distinct research communities in higher education, through an institutional analysis of the Universitat Oberta de Catalunya (UOC) in Barcelona, Spain. First, we situate this research within current literature about e-learning research within the broader EdTech field. Then, we outline the study context and justification, study aims and research design. Next, we present the main findings followed by a discussion on e-learning research from a multi-paradigmatic perspective, where we make recommendations for the future development of the field, transferable to other research communities and contexts.

1.1 Related Literature

It has become clear that one of the key tensions that define research in this area is methodological capacity across distinct research communities (Bulfin et al., 2014, Caballé, 2019). Computer science and EdTech are relatively young interdisciplinary fields and as Caballé (2019) and Castañeda, Salinas and Adell (2020) note, both face an identity crisis when confronted with how best to approach research problems and methodological design, as well as in making relevant contributions to educational practice. In particular, Caballé (2019) notes there is no clear consensus in the literature about how to conduct quality and rigorous academic work in e-learning from a computer science perspective. This is an increasing concern, particularly given the rise of emerging and interdisciplinary fields of study with specialist approaches such as learning engineering and the rise of specialized sub-fields which engage with big data, data visualizations, learning analytics, machine learning and artificial intelligence. The current study, therefore, raises the question of how a lack of consensus around clear research guidelines across diverse research communities may affect the relevance of research and its capacity to influence educational practice across the many sub-communities which make up the field. Are specialized communities of research practice in e-learning disparate and mutually exclusive paradigms? Or are they different perspectives and approaches on the same object of study with common research problems, aims and themes?

A study on the methodological capacity of researchers within the field reveals a clear preference for basic forms of descriptive research (Bulfin et al., 2014). Moreover, observers have long characterized the study of educational technology as an under-theorized field (Hew et al., 2019), and recent research has revealed that such critiques have some merit corroborating previous claims that there is a clear preference for basic forms of descriptive research and that "explicit engagement with theory is absent in the majority of previous studies" (Hew et al., 2019 p.967), with many studies theoretically agnostic or making ambiguous theoretical positioning. Many of these challenges result in a lack of credibility of educational research and the low transferability of research results on policy formulation and practices (Castañeda, Salinas and Adell, 2020, Gorard and Cook, 2007).

In recent years, a number of EdTech systematic literature reviews have been developed, representing a burgeoning industry (Polanin, Maynard and Dell, 2017, Zawacki-Richter et al., 2020). While EdTech systematic literature review's act as fundamental ways to critically synthesize published research, they can also point toward important and critical directions for identifying the research that is needed (Reeves and Lin, 2020). For example, Ifenthaler and Yau (2020) synthesize evidence on utilising learning analytics to support study success in higher education; Zawacki-Richter and Latchem (2018) review four decades of conceptual and thematic development in EdTech research interrelated with evolving technologies and theories; and Nortvig, Petersen and Balle, (2018) offer a comprehensive systematic review of factors influencing e-learning and blended learning in relation to learning outcome, student satisfaction and engagement.

1.2 Study Context

Although education research is experiencing the rapid growth of a systematic review industry, including fast changing data-driven approaches (Bond et al., 2019, Zawacki-Richter et al., 2020), it is rare that a systematic review has been conducted at one site which covers diverse communities of research practice. We present a case study of e-learning research conducted at the UOC across distinctive research communities and areas, led by 500 researchers, professors, instructional designers, and learning engineers organised into 51 recognized research groups. The UOC was recently ranked as Spain's leading online university for research (Ranking CYD, 2020).

1.3 Justification and Aim

The UOC is positioned as a unique institutional case which reflects highly varied and diverse research communities of practice. E-learning is one of the core areas in which the UOC has carried out research and researchers have considerable access to large student datasets and virtual learning environments for experimentation, observation and data generation, with 87,000 distance education students. Keeping in mind current debates from a multi-paradigmatic perspective concerning (a) whether the field is cohesive or fragmented, and (b) confusion and ambiguity toward how best to approach methodological design, the UOC case has been selected for its unique character as a site of institutional analysis, providing new insight through an interdisciplinary perspective.

The objective of the current study is to describe distinctive approaches and key features to e-learning research conducted across disciplinary boundaries and distinct research communities and areas. The current study has defined the following research questions:

- Research Question (RQ) 1: How is e-learning research conducted at the UOC across research areas, disciplines, and communities?
- RQ2: What relationships can be identified between aims of and approaches to e-learning research across distinctive research areas and disciplines?
- RQ3: What differences and similarities exist in how researchers conduct e-learning research across research areas and disciplines?

Resolving these questions will bring a cross disciplinary and multi-paradigmatic perspective to the distance education and e-learning field by (a) emphasizing differences in research patterns across disciplines and research communities, (b) deepening our understanding of the relationships between the aims of and approaches to research in this field, and (c) empirically examining the claims made about methodological capacity and coherence.

2. Research Design

This study follows a systematic mapping review and synthesis (Grant and Booth, 2009). E-learning research is characterized as an expansive and interdisciplinary field at the intersection of social science, cognitive science, learning science, and computer science. We use an inclusive definition developed by Sangrà, Vlachopoulos and Cabrera (2012), who define e-learning as:

> *An approach to teaching and learning, representing all or part of the educational model applied, that is based on the use of electronic media and devices as tools for improving access to training, communication and interaction and that facilitates the adoption of new ways of understanding and developing learning* (p.152).

2.1 Search Strategy

Scopus and Web of Science (WOS) were selected as bibliographic databases, since they are considered the most relevant coverage of peer-reviewed, international, and multidisciplinary academic literature (Aghaei Chadegani et al., 2013). The search was restricted to the range from 2015 to February 2020. The search strategies were drafted and elaborated in collaboration with two information scientists from the UOC library team. The search was carried out between February 14-28, 2020. Both databases were searched using the UOC author affiliation search field while adopting the query using the individual keywords and string queries as depicted in Table 1. In each database, lists were compiled with all the results, and duplicates were removed automatically before exportation.

Table 1: Search key words

Dimension	String query	Boolean Operator
Terms related to E-learning	(E-Learn*) OR (eLearn*) OR (Online Learn*) OR (Online Education*) OR (Digital learning) OR (Digital Education*) OR (ICT and Education*) OR (Information* and Communication*) OR (Technolog* and Education*) OR (Education* Technolog*) OR (Ed* Tech*) OR (Technology-Mediated Learning) OR (Online Higher Education*) OR (Distance Education*) OR	AND

Dimension	String query	Boolean Operator
	(Open Education*) OR (Open Education* Resourc*) OR (Learning Technolog*) OR (Technolog* Enhanced Learn*) OR (MOOCs) OR (Massive Open Online Cours*) In TITLE and ABSTRACT and KEYWORDS fields	
Author affiliation	(Universitat Oberta de Catalunya) OR (UOC) in AFFILIATION field	

2.2 Inclusion Criteria

In order to be included in the review, articles needed to report on e-learning focused research published between 2015 and the search date. The inclusion criteria were:

- *Study focus* within the broad domain of e-learning, as defined by Sangrà, Vlachopoulos and Cabrera (2012).
- *Study language* in English or Spanish.
- *Study affiliation* with an author from UOC.
- *Study accessibility* through UOC Library and open databases.

The inclusion criteria was piloted by two independent reviewers who screened a random sample of 20% of the articles in order to establish a common understanding and application of the inclusion criteria, based on title and abstract. Results were compared and disagreements were resolved through discussion. If the discrepancy could not be resolved among the first two reviewers on the application of the inclusion criteria, a third reviewer was used.

2.3 Study Selection

In total, 750 articles were identified for review. After duplicates were removed (n=178), article metadata, including titles and abstracts, were downloaded and imported into an Excel Worksheet used to manage the study selection, while the available full-text manuscripts were downloaded and integrated into Mendeley, for use as a reference manager. In the following step, all articles considered eligible (572) were independently assessed and screened by the primary reviewer and reasons for exclusion of full-text articles were documented. A range of documents were accepted if they met the above inclusion criteria, including systematic reviews, theoretical and methodological papers, and book chapters reporting research. After screening based on defined inclusion criteria using the PRISMA guidelines, 291 publications were selected for final analysis, as shown in the PRISMA workflow (Liberati et al., 2009) in Figure 1.

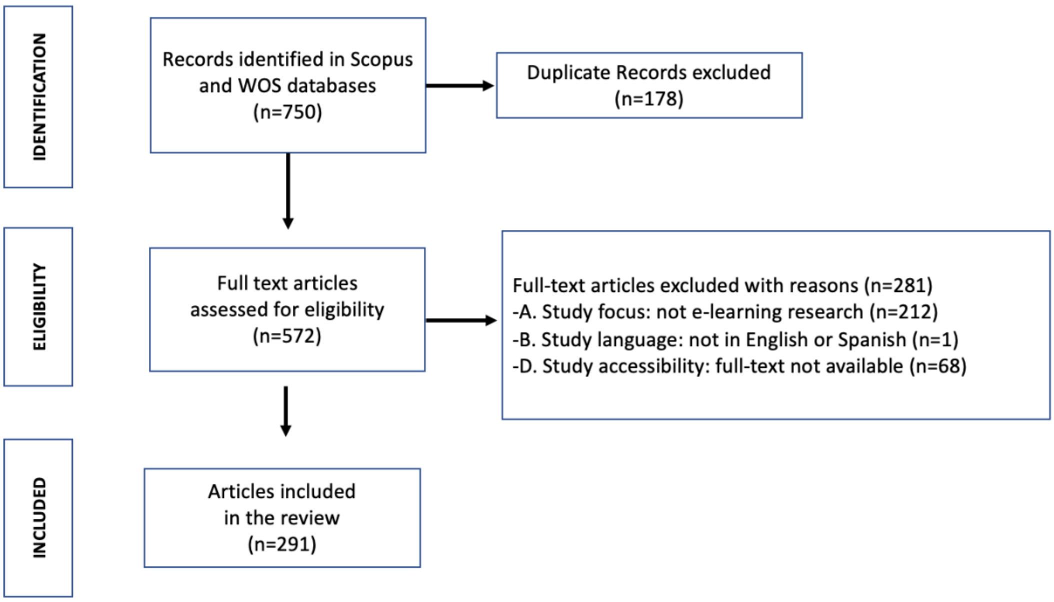

Figure 1: PRISMA Workflow Diagram

2.4 Data Coding

Data coding followed four steps. First, as shown in Table 2, a hybrid coding scheme was developed for data extraction and coding. The hybrid coding scheme allowed for both deductive (closed) and inductive (open) coding to occur in relation to the specific objectives of the study. Except for "theme" and "theory" categories in

Table *2*, the majority of the coding scheme was deductive and based on the methodological literature from previous studies which systematically reviewed e-learning or EdTech research (Hew et al., 2019, Raffaghelli, Cucchiara and Persico, 2015, Reeves and Oh, 2017, Reeves and Lin, 2020). Step two involved both importing the metadata of the selected documents entering the coding scheme into an Excel worksheet used to organize coding and subsequent analysis. Once the coding scheme was complete, the third step involved two independent reviewers applying the coding scheme to a random sample (20%) of the selected articles, managing, annotating and coding the articles using the reference management software Mendeley. This phase of double coding emphasized double-checking for accuracy and reliability to ensure that the coding scheme was being applied consistently. As in the screening phase, discrepancies between reviewers on the application of the coding scheme were resolved through discussion, and with the involvement of a third reviewer when necessary. The fourth step involved the first author coding the remaining articles.

Table 2: Description of the coding scheme

Categories	Description
Discipline	Disciplinary field where the research can be placed, based on Scopus and WOS definitions.
Research Area	Specific area where the research can be placed, based on WOS definitions and adapted from Caballé (2019).
Method	Research method embraced by the author(s) following a common classification: Quantitative, Qualitative, Mixed Methods, Theoretical/Conceptual Development/Synthesis, & Literature Review (Reeves and Oh, 2017).
Design	Design choices made by the authors aligned with research method (i.e., quantitative, qualitative, mixed methods, conceptual, literature review) (Farrow et al., 2020)
Data Collection	Procedures used for data collection, including classical (surveys) and emergent (learning analytics data tracking) (Kiliç-Çakmak et al., 2013, Raffaghelli, Cucchiara and Persico, 2015).
Data Analysis	Procedures used for data analysis, including classical (i.e., statistical procedures, thematic analysis) or more recent (i.e., data mining or data visualisation).
Theme	Relates to the specific thematic subject or research topic addressed in the study
Aim	Guiding research purpose typology from Reeves and Oh (2017).
Theory	Most relevant theories identified to frame research design and analysis, where present.
Study Population	Characterization of the study population based on educational level.
E-Learning Mode	Characterization of the learning processes under study according to mode of e-learning (i.e., online higher education, blended learning, informal online learning,.).

2.5 Data Analysis

Descriptive statistics and crosstabs were used to analyze the coded data. To examine the statistical significance of differences across groups, Fisher's exact test was used, as the sample size of the review corpus (n=291) was too small for a Chi-square test (Everitt, 2019). Common patterns and relationships between the codes were examined for subsequent interpretation and synthesis to respond to the research questions. Analyses were performed using XLSTAT Version 22.5.1.

3. Results

3.1 RQ1: How is e-learning research conducted at the UOC across research areas, disciplines, and communities?

Analysis of the conduct of e-learning research is shown in Table 3 presenting a range of categorical variables to provide as global a view as possible. Two broad disciplinary fields, social science (66.3%) and engineering and computer science (33.7%) and three research areas, education research (ER) (49.1%), learning engineering (LE) (33.7%) and discipline-based education research (DBER) (17.2%) were identified. Most research in the current study was quantitative in nature (46.0%), while the second most common research approach involved theoretical, conceptual, or methodological development (22.7%). Mixed methods (14.1%), qualitative (11%), and literature review (6.2%) research were detected considerably less within the review corpus.

The most common research design included a *design science research framework* (28.1%), while the second most common was correlational (16.4%), emphasizing the examination of association or relationship between factors of interest. The most common thematic domains were (a) design and evaluation of learning resources/tools/spaces (18.5%) and (b) learning analytics and automatization of learning (17.8%).

When considering research goals, two research aim categories presented in Table 3, contributed to just over half (53.8%) of observed research: (a) design/development (31.9%) and (b) exploratory/hypothesis testing (20.9%). This finding characterizes analyzed e-learning research as focused on developing solutions to educational problems with an emphasis on specifying how education works by testing conclusions related to theories and models of teaching, learning, and student performance.

Table 3: Characteristics of the 291 articles featured in the review

Category	Codes	N (%)
1. Discipline	Social Sciences	193 (66.3%)
	Engineering & Computer Science	98 (33.7%)
2. Area	Education Research	143 (49.1%)
	Learning Engineering	98 (33.7%)
	Discipline-Based Education Research	50 (17.2%)
3. Type of Article	Empirical	207 (71.1%)
	Non-Empirical	84 (28.9%)
4. Method	Quantitative	134 (46.0%)
	T-C-M* Development	66 (22.7%)
	Mixed Methods	41 (14.1%)
	Qualitative	32 (11.0%)
	Literature Review	18 (6.2%)
5. Design	Design Science Approach	82 (28.2%)
	Correlational Design	48 (16.5%)
	T-C-M* Development	42 (14.4%)
	Case-study	18 (6.2%)
	Literature Review	18 (6.2%)
	Evaluation Research	15 (5.2%)
	Exploratory/Descriptive	14 (4.8%)
	Education Design Research	13 (4.5%)
	Generic Qualitative Design	13 (4.5%)
	Quasi-Experimental Design	8 (2.7%)
	Causal-Comparative Design	7 (2.4%)
	Experimental Design	7 (2.4%)
	Action Research Design	3 (1.0%)
	Mixed Methods Sequential Design	3 (1.0%)
6. Theme	Design and evaluation of learning resources/tools/spaces	54 (18.5%)
	Learning Analytics and Automatization of Learning	52 (17.9%)
	E-learning adoption	48 (16.5%)
	Innovative Pedagogies & Technologies	48 (16.5%)
	Student/Teacher Learning Practices/Performance	46 (15.8%)
	Assessment & Feedback	23 (7.9%)
	Collaboration & Interaction	20 (6.9%)
7. Aim	Design/Development	93 (32.0%)
	Exploratory/Hypothesis Testing	61 (21.0%)
	T-C-M* Development	53 (18.2%)
	Descriptive/Interpretive	44 (15.1%)
	Action/Evaluation	40 (13.7%)
8. Theory	One or more theories/frameworks used	154 (53.0%)
	Unclear Theoretical Positioning	111 (38.1%)
	N/A Review	26 (8.9%)
9. Study Population	Higher Education	225 (77.3%)
	Mixed Levels	36 (12.4%)
	Primary & Secondary School (K-12)	24 (8.2%)
	Professional Training and Development	6 (2.1%)
10. Mode of E-learning	Online Higher Education	136 (46.7%)
	Mixed Modes (Formal)	90 (30.9%)
	Face-to-face Mediated through Technology	31 (10.7%)
	MOOC	24 (8.2%)
	Mixed Modes (Informal)	10 (3.5%)

*T-C-M Development = theoretical-conceptual-methodological development

Concerning the use of theory in research, just over half (53.0%) implemented one or more theories/frameworks, while a significant amount (38.1%) held ambiguous theoretical positioning. In regards to study population, most research focused on formal education at the HE level (77.3%), indicating the case of the UOC is principally focused on the domain of HE, with a significant focus on the mode of distance and online higher education (OHE) (46.7%), followed by mixed modes of e-learning (30.9%), including blended, hybrid, or other forms of mixed integration of technology mediated learning.

Figure 2 presents the range of data collection techniques used in empirical research, accounting for 71.1% (n=207) of the review corpus. Most empirical quantitative, mixed methods, or qualitative research employed more than one data collection technique. Each article may be coded for more than 1 category as coded data collection categories are not mutually exclusive. Moreover, some studies included up to four techniques (i.e. survey, interviews, student data tracking, and documents collection), while others only used one technique, most commonly survey instruments. The two most common overall data collection procedures were quantitative, including survey technique (61.5%) and student data tracking in virtual learning environments (28.0%), which often includes tracking assessments, forum posts/discussions or other traces of digital learning artefacts. The third most common procedure was qualitative interviews and focus groups, occurring in 21.2% of reviewed research. System data tracking (11.1%), including the use of system log files, was the fourth most used procedure.

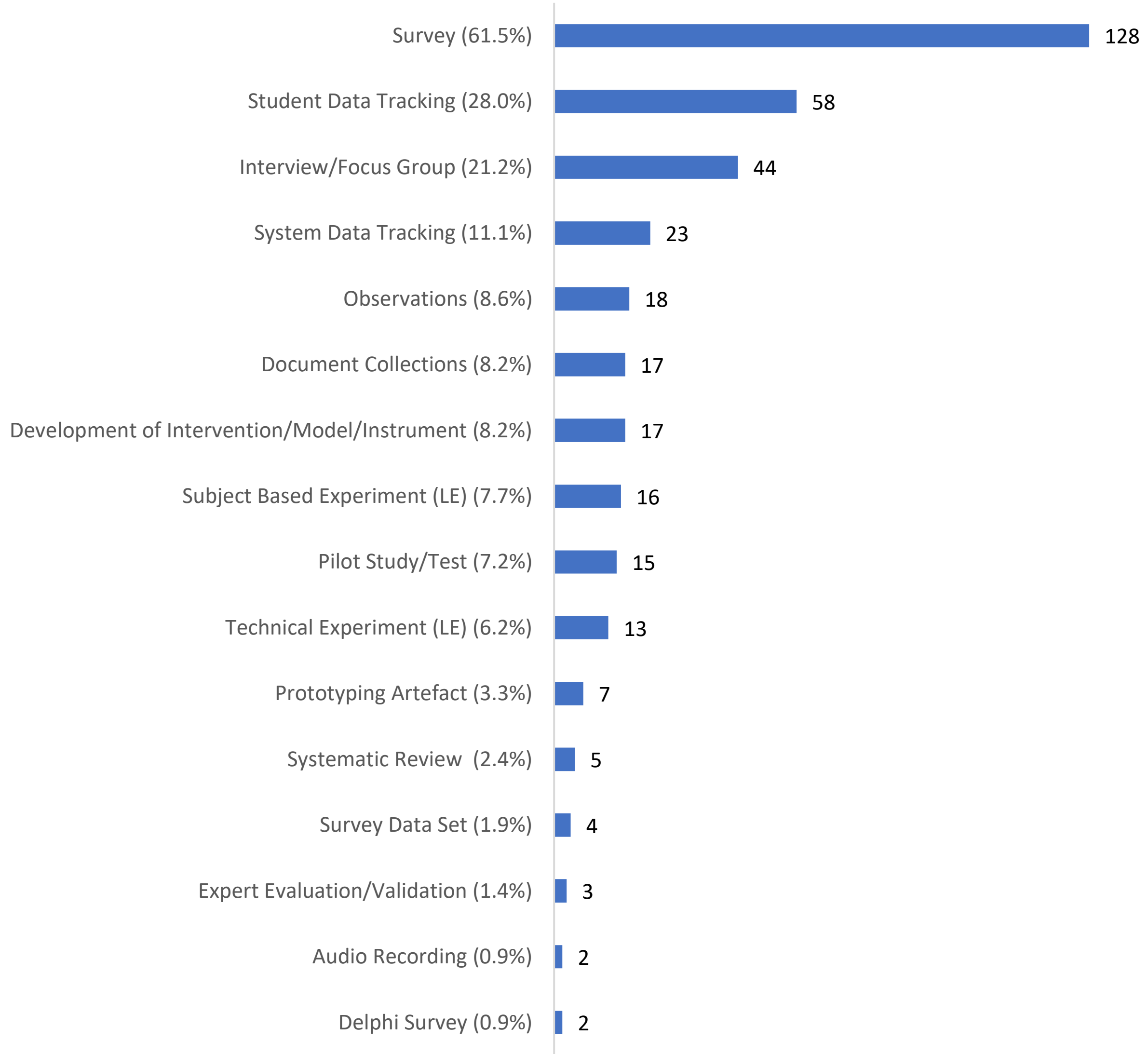

Figure 2: Distribution of data collection procedures within empirical research (n=207)

Note: *Data collection categories are not mutually exclusive and an empirical article may be coded for more than one data collection category

Figure 3 presents the most common techniques for quantitative data analysis procedures (n=175). For example, descriptive statistics (67.4%) was most common, followed by bivariate analysis (36.0%), aiming to identity relations between two variables, while multivariate analysis techniques (32.0%) were less often used. As in the data collection techniques, more than one analytical technique is often used within each study, for example, most advanced statistical techniques (i.e. multivariate analysis, educational data mining, social network analysis) are most often preceded by descriptive statistics and/or bivariate analysis. There is a clear presence of both traditional techniques, which appear most frequently through statistical analysis and quantitative content analysis and more emerging data-driven techniques which appear less frequently yet are rapidly changing approaches to educational research through learning analytics, data visualizations, educational data mining, and social network analysis.

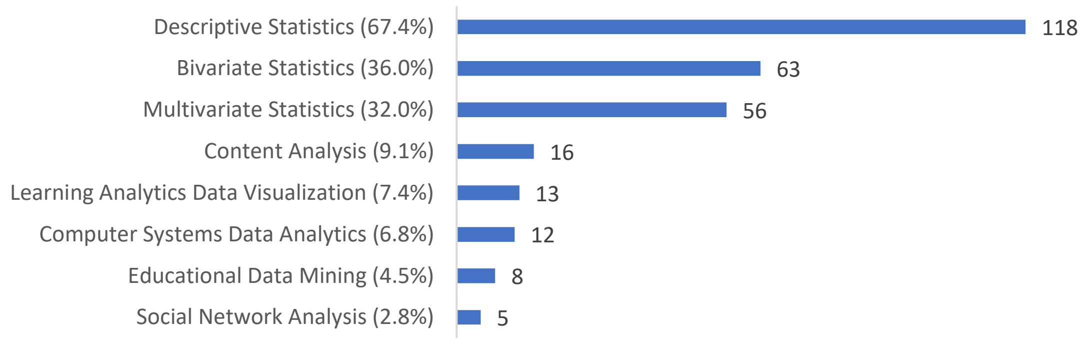

Figure 3: Distribution of research by quantitative data analysis procedure within quantitative or mixed methods studies (n =175)

*Data analysis categories are not mutually exclusive and an empirical article may be coded for more than one data analysis category across quantitative or mixed methods studies

Figure 4 presents qualitative data analysis techniques which appear much less frequently among qualitative and mixed methods studies (n=73), due to the predominance of objectivist-driven research dominated by quantitative approaches. More than one technique can be used within a single empirical study. For example, a thematic analysis can be complemented by a systematic knowledge synthesis. Surprisingly, the most common qualitative analytical procedure among empirical research was a generic qualitative approach, observed in 20.5% of cases, where the research design makes no clear allegiance to an established form of methodological development, followed by a procedure of description of categories and dimensions (16.4%) used for developing frameworks, thematic analysis (17.8%), and basic coding and categorization (16.4%).

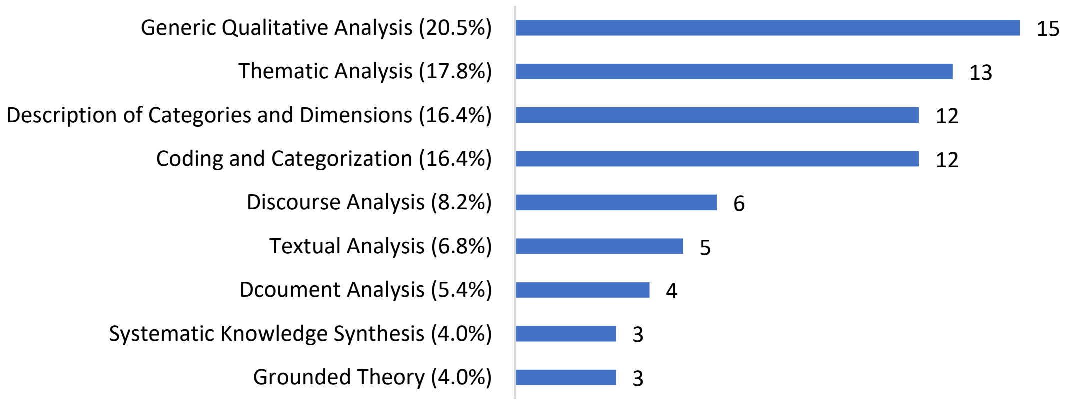

Figure 4 Distribution of research by qualitative data analysis procedure within qualitative or mixed methods studies (n=73)

*Data analysis categories are not mutually exclusive and an empirical article may be coded for more than one data analysis category across qualitative or mixed methods studies

3.2 RQ2: What relationships can be identified between aims of and approaches to e-learning research across distinctive research areas and disciplines?

Figure 5 examines the relationship between study purpose and research methods since these two elements are closely associated. Having clearly established research aims at the beginning of a study enables a greater focus on a research design and allows researchers to make more informed choices of the most appropriate method to achieve that goal (Reeves and Oh, 2017). Predictably, results demonstrate that some research methods are more strongly associated with certain research areas and disciplinary boundaries than others. Quantitative research was the most common method across all research areas, for example, 56% of all DBER, 48.9% of all LE research and 46% of all ER used such a method. The next most common approach was theoretical-conceptual-methodological development, where 31.6% of LE research, 21.6% of ER, and 8.0% of DBER used this method for synthesizing and developing theoretical knowledge.

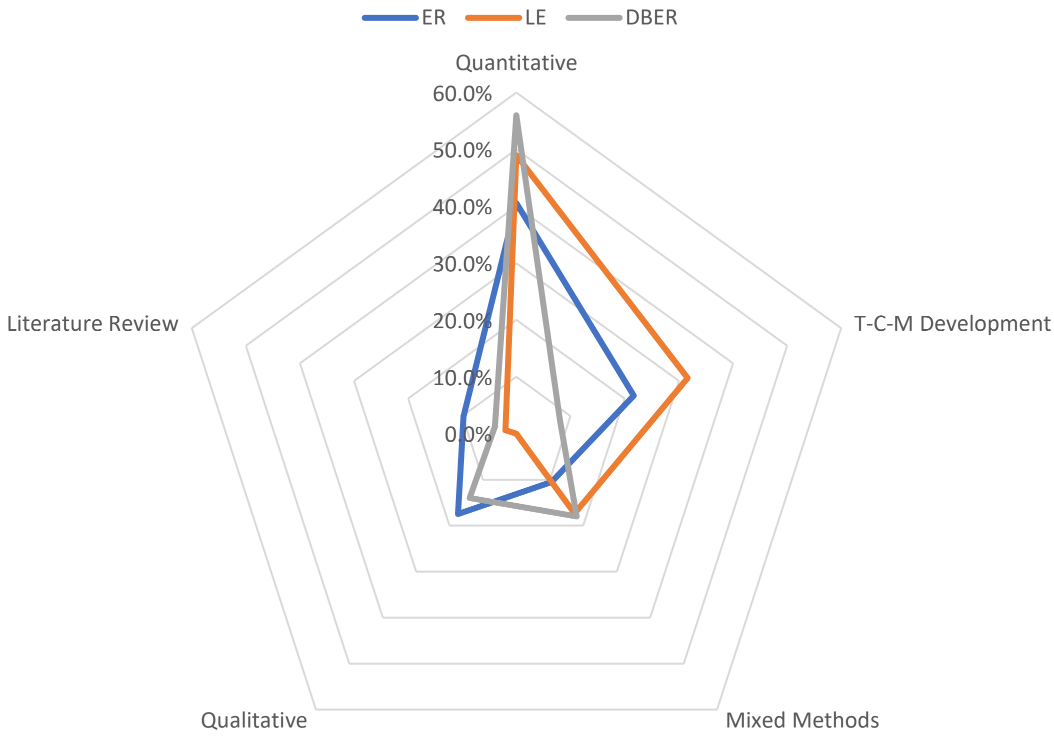

Figure 5: Distribution of research approach X area (relative frequencies)

In Figure 6 research aim categories are correlated to research areas, showing that ER was distributed roughly evenly between four categories (Exploratory/Hypothesis testing, 27.9%; T-C-M Development Synthesis, 25.8%; Descriptive/Interpretive 22.3%; Design/Development 16.0%). In contrast, LE research mostly focused on Design/Development 66.3%. Most DBER research was focused across three research aim categories: Exploratory/Hypothesis testing (32.0%), Action/Evaluation (32.0%) and Descriptive/Interpretive (20.0%).

Comparison of Figures 6 and 7 show some interesting trends. When research approaches are related to research aims, as shown in Figure 7, we see that certain research goals are significantly associated with specific approaches; for instance, 95.0% of research with Exploratory/Hypothesis testing, 82.5% of Action/Evaluation research, and 41.9% of Design/Development research use quantitative methods. Research which follows a theoretical or conceptual development approach is understandably associated with Theory Development/Synthesis (66.0%) and Design/Development (32.2%) goals. In contrast, 34.0% of Mixed Methods and 54.5% of Qualitative research are associated with Descriptive/Interpretive goals.

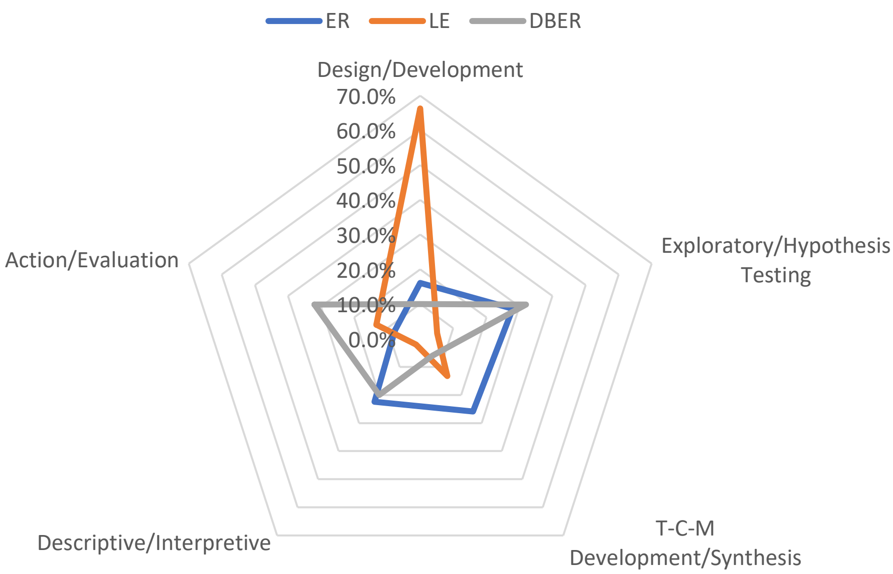

Figure 6: Distribution of research aims X area (relative frequencies)

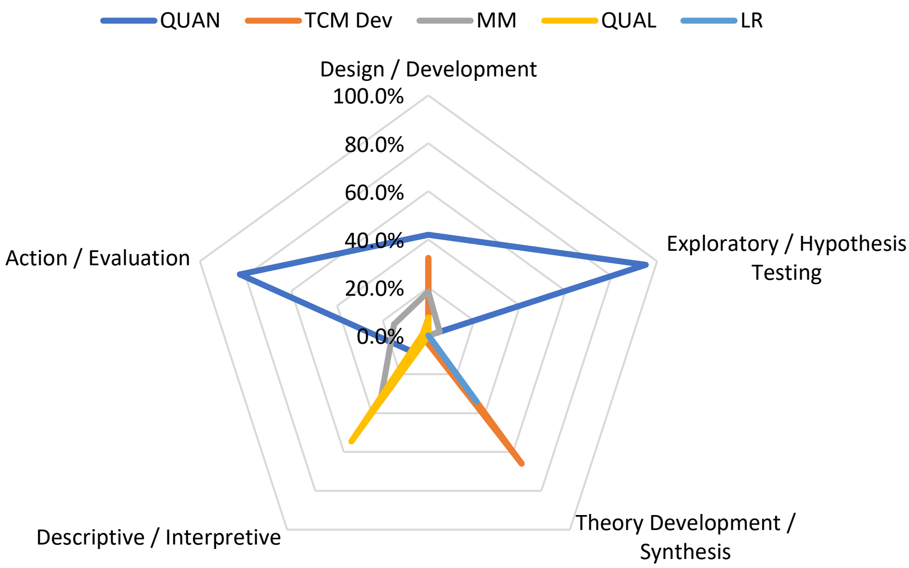

Figure 7: Distribution of research aims X approach (relative frequencies)

As shown in Table **4**, the most common research aim category was *design/development* research (93/291=31.9%), most commonly from computer science (69.8%). In contrast with other research aim categories, *design/development* approaches are dispersed, where the most common approach (QUAN) accounted for only 41.9% of studies. As can be seen, the most common approaches relate to the thematic domain of learning analytics and the automation of learning (38.7%), using a design science framework (68.8%), often unsupported by a clear theoretical positioning (50.5%). The most common data collection technique is survey (35.4%), followed by descriptive statistics (37.6%) as the most common analytical procedure. The most common study context was in HE (80.8%) where the modality of e-learning was OHE (59.1%).

Table 4: Distribution of most common research approaches X research aims (relative frequencies)

Approaches / Aims	Design / Development (n=93)	Exploratory / Hypothesis-testing (n=61)	Theory Development / Synthesis (n=53)	Descriptive / Interpretivist (n=44)	Action / Evaluation (n=40)

Discipline	CS (65/93=69.8%)	SS (56/61=91.8%)	SS (39/53=73.5%)	SS (42/44=95.4%)	SS (27/40=67.5%)
Area	LE (62/93=66.3%)	ER (40=61=65.5%)	ER (37/53=69.8%)	ER (32/44=72.7%)	DBER (16/40=40%)
Method	QUAN (39/93=41.9%)	QUAN (58/61=95.0%)	T-C-M Development (35/53=66.0%)	QUAL (24/44=54.4%)	QUAN (34/40=85.0%)
Theme	Learning Analytics and Automation of learning (36/93=38.7%)	E-Learning Adoption (25/61=40.9%)	Student/Teacher Learning Practices/Performance (15/53=28.3%)	Student/Teacher Learning Practices/Performance (18/44=40.9%)	Design of learning resources and spaces (11/40=27.5%)
Design	Design Science (LE) (64/93=68.8%)	Correlational Design (40/61=65.5%)	T-C-M Dev. (29/53=54.7%)	Generic Qualitative Design (12/44=27.2%)	Design Science (LE) (12/40=30.0%)
Theory	Unclear (47/93=50.5%)	One or More Frameworks Used (42/61=68.8%%)	N/A Lit Review (24/53=45.2%)	One or More Frameworks Used (30/44=68.1%)	Unclear (21/40=52.5%)
Data Collection	Survey (33/93=35.4%)	Survey (61/61=100%)	N/A Review (31/53=58.4%)	Interviews/Focus Groups (20/44=45.4%)	Survey (24/40=60.0%)
Data Analysis	Descriptive Statistics (35/93=37.6%)	Multivariate Analysis (43/61=70.4%)	N/A Review (31/53=58.4%)	Descriptive Statistics (13/44=29.5%)	Descriptive Statistics (16/40=40.0%)
Study Population and Mode of E-Learning	HE (76/93=80.8%) OHE (55/93=59.1%)	HE (44/61=70.9%) OHE (33/61=54.0%)	HE (32/53=60.3%) Mixed Modes (41/53=77.3%)	HE (37/44=84.1%) OHE (20/44=45.4%)	HE (36/40=90.0%) OHE (22/40=55.0%)

*Percentage in each cell represents the most frequent value, based on relative frequency within each research aim category. CS = computer science; SS = social science; LE = learning engineering; ER = educational research; DBER = discipline based educational research; QUAN = quantitative; QUAL = qualitative; T-C-M = theoretical/conceptual/methodological development; HE = higher education; OHE = online higher education

In contrast, research which pursued exploratory/hypothesis-testing aims represented 21% (61/291) of all reviewed research, mostly from a social science perspective (91.8%) from an educational research area (65.5%) using quantitative approaches (95.0%). The most observed thematic domain was E-Learning Adoption (40.9%) where a correlational design (65.5%) was most often used. It is noteworthy that within this category there was a significant tendency to use one or more theoretical frameworks (68.8%%), data collection procedures which rely on survey collection (100%) while using more advanced statistical techniques through multivariate statistical procedures (70.4%). In research which pursed exploratory/hypothesis-testing, the most common study population was also HE (70.9%) commonly examining OHE (54.0%).

Theory development/synthesis-based research represented 18.2% (53/291) of the review corpus, with most studies coming from social science (73.5%). Research which pursues theory development goals typically rely on theory focused methods (66.0%) and research designs (54.7%). Research which pursued descriptive/interpretivist goals represented 15.1% (44/291) of all reviewed research. A significant majority was from social science (95.4%), conducting ER (72.7%) using a qualitative approach (54.4%). Like theory-oriented research, the thematic domain most common in descriptive/interpretivist aimed research was student and/or teacher learning practices/performance (40.9%). A wide range of designs were used, however the most common was generic qualitative design (27.2%).

3.3 RQ3: What differences and similarities exist in how researchers conduct e-learning research across research areas and disciplines?

In Table 5 an alignment between the research variable categories and research areas is displayed. A significant and exclusive relationship between disciplines and research areas is shown according to Fisher's exact test. ER and DBER were associated with social science, while engineering and computer science were exclusively associated with LE. When considering research method in relation to research area, Fisher's exact test rejected the null hypothesis that methods are equally likely to be present in the same research area, with LE being associated with T-C-M development and ER with qualitative methods. Overall, 98.0% of LE research is highly concentrated in quantitative, T-C-M development and mixed methods approaches.

When examining the relationship between research aim and research area, results reveal that studies with design and development goals have a significant relationship ($p<0.001$) with LE (66.0%) and ER (16.0%). Over one third of the review corpus reported an unclear theoretical positioning and a significant relationship was identified with the LE (52.4%) research area. Fisher's exact test also rejected the null hypothesis that research areas are equally likely to implement theory, with DBER implementing one or more theoretical frameworks in 66.0% of observations.

In relation to the distribution of research themes across research area, Fisher's test shows a significant relationship between the thematic domain of Learning Analytics and Automatization of Learning (45.9%) and LE. Similarly, Student/Teacher Learning Practices/Performance (26.7%) was significantly related to ER, while Innovative Pedagogies and Technologies (28.0%) was associated with DBER.

Table 5: Distribution of research approaches and procedures X research area

	Research Area	**ER**	**LE**	**DBER**	**Total**
Discipline, n(%)	Social Science	143 (100)[a]	0 (0)[a]	50 (100)[a]	193 (66.3)
	Engineering & C.S.	0 (0)[a]	98 (100)[a]	0 (0)[a]	98 (33.7)
Method, n(%)	Quantitative	58 (40.6)	48 (48.9)	28 (56.0)	134 (46.0)
	T-C-M Development	31 (21.7)	31 (31.6)[b]	4 (8.0)[c]	66 (22.6)
	Mixed Methods	15 (10.5)	17 (17.3)	9 (18.0)	41 (14.0)
	Qualitative	25 (17.5)[d]	0 (0)[a]	7 (14.0)	32 (10.9)
	Literature Review	14 (9.7)[e]	2 (2.0)[f]	2 (4.0)	18 (6.18)
Aim, n(%)	Design/Development	23 (16.0)[a]	65 (66.3)[a]	5 (10.0)	93 (31.9)
	Exploratory/Hypothesis Testing	40 (27.9)	5 (5.10)[a]	16 (32.0)	61 (20.9)
	T-C-M development	37 (25.8)	13 (13.2)	3 (6.0)	53 (18.2)
	Descriptive/Interpretive	32 (22.3)	2 (2.0)[a]	10 (2.0)	44 (15.1)
	Action/Evaluation	11 (7.6)	13 (13.2)	16 (3.0)	40 (13.7)
Theory, n(%)	One or More Theories Used	80 (55.9)	41 (4.)[d]	33 (66.0)	154 (52.9)
	Unclear Theoretical Positioning	47 (32.8)	51 (52.0)[g]	13 (26.0)[d]	111 (38.1)
	N/A Review	16 (11.1)	6 (6.1)	4 (8.0)	26 (8.9)
Theme, n(%)	Design and evaluation of learning resources, tools and spaces	25 (17.6)	17 (17.3)	12 (24.0)	54 (18.5)
	Learning Analytics and Automatization of Learning	4 (2.8)[a]	45 (45.9)[a]	3 (6.0)	52 (17.8)
	E-learning adoption	29 (20.4)	12 (12.2)	7 (14.0)	48 (16.4)
	Innovative Pedagogies & Technologies	23 (15.4)	11 (11.2)	14 (28.0)[i]	48 (16.4)
	Student/Teacher Learning Practices/Performance	38 (26.7)[a]	2 (2.0)[a]	6 (12.0)	46 (15.8)
	Assessment & Feedback	12 (8.4)	10 (10.2)	1 (2.0)	23 (7.9)
	Collaboration & Interaction	12 (8.4)	1 (1.0)	7 (14.0)	20 (6.8)
	Total	143 (100)	98 (100)	50 (100)	291(100)

Values displayed are significant at the level alpha=0.05. a. $p<0.0001$; b. $p=0.012$; c. $p=0.005$; d. $p=0.001$; e. $p=0.014$; f. $p=0.040$; g. $p=0.009$; h. $p=0.044$; i. $p=0.021$

4. Discussion

The purpose of the current systematic mapping review was to describe how e-learning research is conducted across distinct research areas and communities of practice through an institutional case-study in order to offer recommendations and critical analysis for future directions in the field. The current move to remote, emergency online education provoked by the global COVID 19 pandemic has only amplified and intensified the critical role of e-learning, particularly in higher education. The outlook for the coming decade is that EdTech will continue to grow in significance with on-going developments and issues. In the current study, a clear picture emerged of e-learning research with a majority focus on HE, nearly half which examines the modality of OHE, in line with recent research (Bozkurt and Zawacki-Richter, 2021). Clear fragmentation was identified between social scientific research, encompassing ER and DBER research areas, and computer science-oriented research approaches. This finding is consistent with the observations of Daenekindt and Huisman (2020), who claim higher education research is a highly specialized and fragmented domain, where research communities tend to inhabit their own islands. Finding synergies between and across disciplines and research areas could be a way to develop innovative approaches to e-learning research, as well as a way to detect inefficiencies in the field across research communities who may address the same theme, but use different conceptual, theoretical and methodological approaches.

In regard to RQ1, a majority of research in the current study was quantitative in nature, in line with objectivist research trends reported in other reviews (Baydas et al., 2015, Kiliç-Çakmak et al., 2013). Bozkurt (2020) identifies the strong belief in a positivist paradigm as an Achilles heel of the EdTech movement, linked to a "never-ending quest to prove whether educational technology is effective" (p.12). The most common research design included a *design science research framework*, which involves interdisciplinary approaches from a learning engineering and computer science perspective, appropriate for optimizing the impact of distance and online HE. Design/Development was the most frequent research aim reflecting the significant growth of design-based research in recent decades across many areas of educational inquiry (Reeves and Oh, 2017). Educational design research is a genre of research that shows promise in developing iterative solutions to complex educational problems while also engaging with and advancing theory (Reeves and Lin, 2020), and should be continued to be supported at institutional levels. Because design-based research approaches where used in both social scientific and computer science disciplines, this could be an obvious focus for developing trans-disciplinary synergies and advancing the e-learning field.

With regards to RQ2, the relationship between study aim and research methods have been examined since these two elements are closely aligned through research design. Results revealed that research methods are closely associated to research aims across distinct research communities, seeing the LE research community drawn to design/development approaches closely associated with quantitative techniques, while ER pursues broader research aims such as hypothesis testing, theoretical development or descriptive/interpretive objectives through quantitative, qualitative and mixed methods traditions. As e-learning and EdTech continue to grow in scale, reach, and significance in the 2020´s, and as new areas of technical capabilities and expertise emerge (Castañeda and Williamson, 2021) greater understanding of research aims, and the methods used to pursue them, can contribute to developing well-defined research guidelines, methodological capacity, and impact in the field.

4.1 Increase interdisciplinary collaboration using an integrated research agenda

With respect to RQ3 results demonstrated that research across distinct areas and communities of practice was fragmented. An example is the patterns observed between research aims and research areas, and the methods used to achieve these aims. Increasing interdisciplinary collaboration using an integrated research agenda across distinctive communities on an institutional level could be one directive for building more cohesion and clarity in the field. Building interdisciplinary collaboration can help mitigate fragmentation across research areas and designs, where common objects of research, including shared aims and thematic domains, are often pursued. Coordinated and intentional efforts are required to build multi-faceted partnerships across the islands of HE research, developed through years of specialized research training. Some of the most interesting and innovative new ideas in EdTech research form at the boundaries of social science and computer science scholarship, and thus bridges should be attempted to be built in order to reimagine the field in new directions (Selwyn et al., 2020). Progress in this regard would be reflected in building multi-disciplinary research teams and projects. Universities and research institutions must therefore challenge themselves to develop substantial, cross-institution efforts committed to integrated research agendas aiming to solve complex research problems (Wilcox and Sarma, 2016). Researchers, for their part, must continue to develop new methods while advancing theoretical frameworks in the pursuit of building their "theoretical and methodological toolboxes required to examine educational technology as they (*EdTech*) continue to mutate, evolve, extend to new settings and expand in their (un)intended uses¨(Castañeda and Williamson, 2021 p.11).

4.2 Support the expanding profession of the learning engineer

As reflected in the results of this study, the scope and scale of e-learning research from a computer science perspective is a call for supporting the expansion of the learning engineer as an emerging field of critical inquiry. The design and optimization of current and future e-learning experiences will be supported through the role of the learning engineer, among many other actors, which requires developing well-defined methods to conduct systematic and rigorous research (Caballé, 2019). Solving current and future educational problems in online and distance education will often require expertise in a range of fields such as instructional design, discipline-based knowledge, pedagogy/andragogy, learning sciences, data science, and systems engineering. Such problems often exceed any one researcher's or discipline's ability to solve, requiring integrated research teams across disciplinary boundaries. Many institutions are leading the movement toward Learning Engineering as an emerging profession and academic discipline (i.e., Stanford, Harvard and Carnegie Mellon University). A core thread through all of these programs is the belief that learning engineers should have a solid foundation in the learning sciences, be fluent in educational technology, and have a strong understanding of design principles in both research and practice (Wilcox and Sarma, 2016). It is clear then, to support such a specialized professional profile, strategic institutional support is essential.

4.3 Promote methodological capacity, clarity, and innovation

In the last 10 years, the field of EdTech has seen notable growth in methodological innovations related to the sophistication of digital computing technologies. At the same time, many observers have lamented the general inadequacy and irrelevance of research in relation to both methodological capacity and theorization practices (Bulfin et al., 2014, Castañeda, Salinas and Adell, 2020, Hew et al., 2019). Ambiguity and confusion continue to endure as to how best to approach and theorize research problems, and basic forms of descriptive research continue to prevail (Hew et al., 2019). Authors should be explicitly clear in research conduct and reporting to avoid ambiguity in methodological design and to promote quality and rigor. An emphasis on methodological innovation and professional development initiatives to support and expand methodological capacity among e-learning researchers should be prioritized and incentivized. Both bottom-up and top-down approaches can exist in this regard, fostering research communities of practice which sustain activities such as methodological seminars, sharing of best practice, and opportunities to present research in-process with the goal of receiving critical feedback to improve the quality and rigor of the work. Finally, mixed methods approaches should be considered, combining the strengths of quantitative and qualitative methods, as dependence on narrow research methods may restrict our understanding of certain e-learning research problems.

5. Conclusions

In the current study, a systematic mapping and synthesis of the key characteristics and features of e-learning research (2015-2020) conducted at the UOC has been presented as an institutional case-study. The objective was to offer a contemporary vision of e-learning research through cross disciplinary and multi-paradigmatic perspectives, emphasizing differences in research patterns across disciplines and research communities. The results have several implications for the development of e-learning research with a view toward a post-pandemic reality which will see a continued, amplified and intensified role for EdTech, particularly in the higher education context. We present a critical analysis which supports an integrated and multi-paradigmatic view on e-learning research, particularly relevant for online and distance education research and development. We hoped to deepen our understanding of the relationship between the aims of and approaches to research in this field while emphasizing the importance of researchers continuously assembling their methodological toolboxes. By empirically examining the claims about methodological capacity and coherence in EdTech research, we have been able to offer a critical analysis for reorienting the field by: (a) increasing interdisciplinary collaboration through integrated research agendas; (b) supporting the expanding profession of the 'learning engineer'; and (c) promoting methodological capacity, clarity and innovation.

Despite an abundance of recent systematic reviews in EdTech, rarely has research been synthesized through a multi-paradigmatic perspective. Systematic reviews can generate new knowledge and insightful implications for researchers aiming to navigate the field and predict and shape its future by critically examining its recent past. We have hoped to contribute to the development of the field of e-learning by informing the design of future research initiatives and institutional policies, transferable to wider e-learning research contexts. Future systematic reviews could continue to develop multi-paradigmatic perspectives across socially oriented and computing approaches and employ different techniques of analysis, such as visualizing bibliometric networks. Lastly, we hope the results and discussion emphasise the need to critically reflect on methodological capacity and relevance of e-learning research and the role of institutions in supporting systematic and rigorous research conduct using well-defined research methods when resolving complex research problems.

Availability of data and material

The authors wish to report that their data is currently not openly published, but is available upon request.

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References

Aghaei Chadegani, A., Salehi, H., Md Yunus, M. M., Farhadi, H., Fooladi, M., Farhadi, M. & Ale Ebrahim, N. 2013. A comparison between two main academic literature collections: Web of science and scopus databases. *Asian Social Science,* 9**,** 18-26.

Baydas, O., Kucuk, S., Yilmaz, R. M., Aydemir, M. & Goktas, Y. 2015. Educational technology research trends from 2002 to 2014. *Scientometrics,* 105**,** 709-725.

Bond, M., Buntins, K., Bedenlier, S., Zawacki-Richter, O. & Kerres, M. 2020. Mapping research in student engagement and educational technology in higher education: a systematic evidence map. *International Journal of Educational Technology in Higher Education,* 17.

Bond, M., Zawacki-Richter, O. & Nichols, M. 2019. Revisiting five decades of educational technology research: A content and authorship analysis of the British Journal of Educational Technology. *British Journal of Educational Technology,* 50**,** 12-63.

Bozkurt, A. 2020. Educational technology research patterns in the realm of the digital knowledge age. *Journal of Interactive Media in Education,* 2020.

Bozkurt, A., & Zawacki-Richter, O. 2021. Trends and Patterns in Distance Education (2014–2019): A Synthesis of Scholarly Publications and a Visualization of the Intellectual Landscape. *The International Review of Research in Open and Distributed Learning*, 22, 19-45.

Bulfin, S., Henderson, M., Johnson, N. F. & Selwyn, N. 2014. Methodological capacity within the field of "educational technology" research: An initial investigation. *British Journal of Educational Technology,* 45**,** 403-414.

Caballé, S. 2019. A computer science methodology for online education research. *International Journal of Engineering Education,* 35**,** 548-562.

Castañeda, L., Salinas, J. & Adell, J. 2020. Towards a contemporary vision of educational technology. *Digital Education Review***,** 240-268.

Castañeda, L., & Williamson, B., 2021. Assembling new toolboxes of methods and theories for innovative critical research on educational technology, 10.

Czerniewicz, L. 2010. Educational technology - mapping the terrain with Bernstein as cartographer. *Journal of Computer Assisted Learning,* 26**,** 523-534.

Daenekindt, S. & Huisman, J. 2020. Mapping the scattered field of research on higher education. A correlated topic model of 17,000 articles, 1991–2018. *Higher Education,* 80**,** 571-587.

Dede, C., Richards, J. & Saxberg, B. 2019. *Learning engineering for online education: Theoretical contexts and design-based examples,* New York, Routledge.

Everitt, B.S., 2019. *The analysis of contingency tables*, London, Chapman and Hall/CRC.

Farrow, R., Iniesto, F., Weller, M. & Pitt, R. 2020. *Research Methods Handbook v. 1.0* [Online]. GO-GN. Available: https://go-gn.net/wp-content/uploads/2020/07/GO-GN-Research-Methods.pdf.

Gorard, S. & Cook, T. 2007. Where does good evidence come from? *International Journal of Research and Method in Education,* 30**,** 307-323.

Grant, M. J. & Booth, A. 2009. A typology of reviews: An analysis of 14 review types and associated methodologies. *Health Information and Libraries Journal,* 26**,** 91-108.

Hew, K. F., Lan, M., Tang, Y., Jia, C. & Lo, C. K. 2019. Where is the "theory" within the field of educational technology research? *British Journal of Educational Technology,* 50**,** 956-971.

Ifenthaler, D. & Yau, J. Y. K. 2020. Utilising learning analytics to support study success in higher education: a systematic review. *Educational Technology Research and Development,* 68**,** 1961-1990.

Kiliç-Çakmak, E., Çebi, A., Mihçi, P., Günbatar, M. S. & Akçayir, M. 2013. A content analysis of educational technology research in 2011. *Procedia-Social and Behavioral Sciences,* 106.

Liberati, A., Altman, D. G., Tetzlaff, J., Mulrow, C., Gøtzsche, P. C., Ioannidis, J. P. A., Clarke, M., Devereaux, P. J., Kleijnen, J. & Moher, D. 2009. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: Explanation and elaboration. *PLoS Medicine,* 6.

Nortvig, A. M., Petersen, A. K. & Balle, S. H. 2018. A literature review of the factors influencing e-learning and blended learning in relation to learning outcome, student satisfaction and engagement. *Electronic Journal of e-Learning,* 16**,** 45-55.

Polanin, J. R., Maynard, B. R. & Dell, N. A. 2017. Overviews in education research: A systematic review and analysis. *Review of Educational Research,* 87**,** 172-203.

Raffaghelli, J. E., Cucchiara, S. & Persico, D. 2015. Methodological approaches in MOOC research: Retracing the myth of Proteus. *British Journal of Educational Technology,* 46**,** 488-509.

Ranking Cyd. 2020. *Ranking CYD* [Online]. Available: https://www.rankingcyd.org/info/universidad-oberta-de-catalunya.

Reeves, T. C. & Lin, L. 2020. The research we have is not the research we need. *Educational Technology Research and Development,* 68**,** 1991-2001.

Reeves, T. C. & Oh, E. G. 2017. The goals and methods of educational technology research over a quarter century (1989–2014). *Educational Technology Research and Development,* 65**,** 325-339.

Sangrà, A., Vlachopoulos, D. & Cabrera, N. 2012. Building an inclusive definition of e-learning: An approach to the conceptual framework. *International Review of Research in Open and Distance Learning,* 13**,** 145-159.

Selwyn, N., Hillman, T., Eynon, R., Ferreira, G., Knox, J., Macgilchrist, F. & Sancho-Gil, J. M. 2020. What's next for Ed-Tech? Critical hopes and concerns for the 2020s. *Learning Media and Technology,* 45**,** 1-6.

Wilcox, K. E. & Sarma, S. 2016. *Online education: A catalyst for higher education reform* [Online]. MIT Press. Available: https://jwel.mit.edu/assets/document/online-education-catalyst-higher-education-reforms.

Zawacki-Richter, O., Kerres, M., Bedenlier, S., Bond, M. & Buntins, K. 2020. *Systematic reviews in educational research: Methodology, perspectives and application,* Wiesbaden, Springer VS.

Zawacki-Richter, O. & Latchem, C. 2018. Exploring four decades of research in Computers & Education. *Computers and Education,* 122**,** 136-152.

