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A model for enhancing creativity, collaboration and pre-professional identities in technology-supported cross-organizational communities of practice

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Abstract

This research proposes that technology-supported cross-organizational (university-industry) Communities of Practice (CoPs), which are integrated into the Design Studies curriculum in Higher Education, can foster robust university-industry collaborations. These can help bridge the reported gap between the actual versus the expected soft skills and personae of young graduates transitioning to the creative industries today. CoPs are groups of people who share a common interest in an area of 'endeavor' and connect to co-create competence in that area through their practice.

This paper makes two overarching research contributions. First, it informs about the design, enactment, and evaluation of a student CoP in an undergraduate Design course which was expanded to include members from the industry as clients, alumni mentors, and expert evaluators. Drawing from rich empirical data, the paper explains the designed and emergent learning phenomena of CoP participation and its effects on the students' creative and socio-epistemic outcomes, as well as their pre-professional identities. Second, it presents a governance model with three sets of actionable guidelines, namely the *Set* (technology), the *Social* (collaborative), and the *Epistemic* (learning) components. The entire body of work validates the critical interlocking of these components to form a robust social learning model that appropriates the complex practices of cross-organizational CoPs in Higher Education Design studies.

Keywords Communities of practice · Technology configuration · HCI · Creativity · Collaboration · Authenticity · Identity · Governance model · Actionable guidelines

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1 Introduction

The motivation behind this work originates from the reported lack of graduates with critical job-appropriate skills that are suitable for today's creative and knowledge-based economies. These extend beyond subject-level knowledge to encompass skills like *creativity*, *communication*, *collaboration*, *critical thinking, technology literacy*, and *vocational relevance* among others (Becker et al., 2017; Chamorro-Premuzic, 2019; Leung & Bentley, 2017). However, the existence of a "widening gap between higher education outputs and industry needs and expectations" (Pelletier et al., 2022, p. 47) with regard to young graduates' soft and digital skills, is apparent across various fields (Alexander et al., 2019; Gürdür Broo et al., 2022; Karimi & Pina, 2021; Pelletier et al., 2023).

1.1 Background

The preparation of graduates with such a skillset is perceived as one of the major educational challenges of the 21st century, and an area in which universities are evidently unable to deliver (Mulgan et al., 2016; Thornhill-Miller et al., 2023). Insufficient communication, lack of relevance, uniformity, and concurrency between the industry and academia in terms of the objectives, approaches, and evaluation criteria that apply in each are the main reasons behind this skills gap (Karimi & Pina, 2021; Leung & Bentley, 2017; Oguz & Oguz, 2019; Pelletier et al., 2022; Turbot, 2015). This issue is particularly prominent in the *Digital Creative Industries* (DCIs) which are inherently linked to *creativity*, *collaboration,* and *technology literacy* as the key driving skills for *innovation* (Leung & Bentley, 2017; Nuccio & Mogno, 2023). The DCIs subsume all Design disciplines which, amongst others, include the fields of engineering, architecture, product, industrial, information, and interaction design (L. Dym et al., 2005; Pontis & Van der Waarde, 2020; Proctor-Thomson, 2013; Zimring & Craig, 2001). All of these aim to produce original solutions for real-world problems, adhere to human-centred philosophy, follow creative and iterative processes, rely critically on technology, involve technical and visual activities, and are heavily social and collaborative (Gabriel et al., 2016; L. Dym et al., 2005; Nguyen et al., 2016; Strobel et al., 2013).

1.2 Literature directions

In response to the aforementioned skills gap, recent literature suggests a paradigm shift toward the *challenge-driven* university, that addresses *authentic* problems, cultivates soft skills, and produces *innovative* outcomes (Chamorro-Premuzic & Frankiewicz, 2019). This shift can apparently be achieved through *technology-enriched*, *cross-disciplinary*, and *cross-organizational* (university-industry) collaborations, such as venture labs, entrepreneurial incubators, shared virtual talent networks, and curriculum-based industry partnerships (Pelletier et al., 2023; Pontis & Van der

Waarde, 2020; Singh Dubey et al., 2022). As such, the recent years have seen a slow rise of University-Industry Collaborations (UIC), which are nonetheless, still far from achieving "wide penetration in higher education" (Becker et al., 2017, p. 12).

1.3 Research framework

Guided by these directions, this research proposes a robust type of university-industry collaboration, drawing from the theory of *Communities of Practice* (CoPs) to support its objectives, design, and outcomes. Originating from Situated Learning and Cognitive Apprenticeship, CoPs is a social learning framework that sees a group of people with common interests and goals in a given field, connecting with each other to learn together, as the *situated* members of a common *practice* (Brown et al., 1989; Lave & Wenger, 1991, 1999a). This work suggests that *cross-organizational (university-industry)* CoPs that are integrated into the HE curriculum, can narrow the above-mentioned skills gap and boost graduates' employability and competitive advantage in the industry, by allowing rich university-industry interactions to take place early on in HE (Shreeve et al., 2010).

1.4 Research significance

This work extends CoPs with a *cross-organizational* dimension, to involve both members from the *academia* and *industry* (Kezar et al., 2017; Wenger et al., 2009). This proposition is grounded in evidence highlighting the enhanced *social learning* capabilities of CoPs, and their role in fostering professional identities across all disciplines in HE (DeChambeau, 2017; Gibson, 2019; Harvey et al., 2015; Irving et al., 2020; Jackson, 2016; Park, 2015; Pontis & Van der Waarde, 2020; Power & Armstrong, 2017; Pyrko et al., 2017; Tight, 2015; Townley, 2020). While some preliminary conceptualizations of the *cross-organizational* model exist, a sound theoretical framework to guide them, as well as, empirical evidence from their application and validation in real educational settings is still missing (Iskanius & Pohjola, 2016; Jackson, 2016). Importantly, there are no CoP studies with a focus on the particular *socio-epistemic and technology demands, goals*, and *practices* of a specific discipline (i.e. Design studies), versus a *one-fits-all* approach to CoPs (Amin & Roberts, 2008; Smith et al., 2017).

1.5 Research design & outcomes

This empirical work focuses on a pre-existing organic CoP of third-year university Design students, which was extended to involve industry members, namely, clients, alumni mentors, and evaluators. This allowed students and professionals to collaborate on industry projects based on *authentic* and *vocationally*-relevant requirements and practices, and receive feedback and evaluation from experts (Albats, 2018; Bhatnagar & Badke-Schaub, 2017; Ivascu et al., 2016; Lombardi, 2007).

The effectiveness of the *cross-organizational* CoP model was assessed by comparing *the epistemic*, *creative*, and *social* outcomes of the CoP participating—versus non-participating—students. Following this, a more in-depth investigation of the *technology adoption*, the *learning value*, and students' *identity* transformation helped classify both the effective and challenging elements of the *cross-organizational* CoP model. Consequently, this research synthesized an affordable and transferable set of guidelines, divided into three components: *epistemic* structure, *social* setup, and *technology* configuration, that can address the particular needs of CoPs in HE Design Studies.

While the entire research corpus consists of five individual studies, focusing on the design, enactment, and validation of the cross-organizational CoP, this paper focuses on delivering guidelines to assist CoP *stewards* in designing, managing, and evaluating similar learning environments toward related objectives. According to Wenger et al. (2009) the term 'steward' may reflect educators, researchers, instructional designers, or technologists who act as CoP administrators.

2 Theoretical background

2.1 Communities of Practice (CoPs)

CoPs is a social theory that sees learning as occurring informally, by living and interacting through participation in a community, steering rich meaning-making processes and diverse opportunities for learning. The activities in these processes are seen to assume 'meta-meanings' that constantly evolve, defined as the '*negotiation of meaning*' (Wenger et al., 2009; Wenger, 2010a).

CoPs have been extensively investigated with regard to their three 'constituents of coherence', *joint enterprise*, *mutual engagement*, and *shared repertoire* (DeChambeau, 2017; Johnston, 2016; Pyrko et al., 2017; Vangrieken et al., 2017). *Joint enterprise* refers to the common goals that CoP members pursue, *mutual engagement* refers to the active involvement and collective negotiation of meaning in the practice, and *shared repertoire* refers to a common vocabulary of terms, routines, and methods that members develop to speed up their practice.

Legitimate Peripheral Participation (LPP) is a concept reflecting *partial*, rather than full forms of participation, as a legitimate *mode of belonging* in the CoP. Specifically, observation and imitation of more competent others promote the gradual involvement and evolution of novices toward fuller forms of knowledge and competence. These bounded or internal forms of participation reflect the *local* dimension of participation in CoPs. (Lave & Wenger, 1999b; Wenger, 1998).

The *global* dimension in CoP theory refers to the participation of members in various other communities that may have *boundaries* but are still inter-connected, as "no community exists in isolation" (De Moor, 2015, p. 1). The social *history* and *reified* items of a CoP's practice derive from both *local* and *global* activities, through the *boundary encounters* of their members and the reified *objects* that are transferred across practices, what is known as *brokering* (Cobb et al., 2018; Hefetz & Ben-Zvi, 2020).

2.2 Modes of belonging and identity in CoPs

While participation in a CoP persists even in states of inactivity, *engagement* denotes *active* involvement in serving the joint enterprise (Wenger, 1998). Engagement involves a “kind of personal investment that makes for a vibrant community” (Wenger et al., 2002a, p. 36) and together with *imagination* and *alignment*, they comprise the three *modes of belonging* in CoPs. *Imagination* refers to projecting one’s self across time and space, extrapolating from the lived experiences in the community, while *alignment* refers to the coordinated efforts of members to align with the practice (Wenger, 2010c). All three are constitutive parts of *identity*, which according to Pratt and Back (2013) is not merely the sum of knowledge and skills, but an ongoing process of becoming – a *trajectory.*

2.3 Virtual CoPs

Wenger et al (2009) provided a technology framework for virtual CoPs (VCoP) involving four components: a) *tools,* software used for specific purposes, *b) features*—particular *tool* functionality and properties, c) *platforms*—collections of various tools, and d) *configurations*—the entire technological setup comprising all previous components (E. Wenger et al., 2009).

The VCoP framework proposes that *stewards* need to first, define the *orientations* (typical activities) of the community and then map these against *field-specific* epistemic activities, to define a CoP’s technology configuration requirements.

2.4 Socio-affective interactions in CoPs

Socio-affective factors have received considerable attention in CoP, Design, and HCI research in recent years (Heuer & Stein, 2019; Sanches et al., 2019). Socio-affective interactions are emotional externalizations (i.e. *familiarity, trust*) in social groups that critically impact learning. For instance, the fear of exposing personal weaknesses and being judged by others in a CoP – known as the ‘Virtual Panopticon’ (Rayner, 2012)—can cause feelings of vulnerability and lack of *intra-personal* (self) trust in learners.

Exclusive remote CSCL and CSCW communities may present serious *trust* issues (*intra* and *inter*-personal), as well as *conflict*, *competition*, and lack of *accountability*, due to insufficient face-to-face interaction (Nilsson, 2019). The role of technology is thus crucial, in creating effective socioemotional CoP workspaces which can facilitate natural interactions and simulate active co-present communication (Stephanidis et al., 2019).

2.5 Design-oriented CoPs

Due to their nature, the Design disciplines are integrally connected to *social* and *situated* learning (Brown et al., 1989). According to research (Shreeve et al., 2010, p. 128), an experiential approach to learning is critical to Art and Design education, as it enables the enactment of an "artist, designer or performer". A few examples from literature where CoPs facilitate such approaches in Design education indicate that they can provide enhanced opportunities for collaboration, knowledge sharing, assessment (Eriksson et al., 2021), skills development, and transferability of expertise to other domains, while forming professional identities and connections to the industry (Gibson, 2019; Jackson, 2016; Morton, 2012).

For instance, with regard to experiential learning, Gibson (2019, p. 32) explored the relationship between making, crafts, and learning in CoPs, affirming that "successful practical learning relies on community participation and the sharing of common values and goals", where individuals seek to belong and produce innovative artifacts in result. Innovation can evidently be accepted, only if is valued by the CoP it adheres to. Similarly, working with experts from the areas of Fine Art, Graphic Design, Design for Performance, and Fashion Product Design, Shreeve et al., (2010, p. 135) studied the characteristics, spaces, and fundamentals of effective teaching and learning. They found that CoPs can facilitate an understanding of "how to be a practitioner" through *socially situated* types of *meaning-making* in the practice, especially when these evolve through *legitimate peripheral participation*. Students initially participate peripherally, learning from various levels of expertise, and gradually develop their own creative insights and designer identities in the process.

In architectural studies, researchers argued that at the core of all Design disciplines lies the *studio*, which enables students to socially enact the professional activities of their CoP, focusing on *critiquing* and shared knowledge-building (Morton, 2012). *Evidently,* studio-based practice is seminal for mediating real-world relevance in a community of scholars, as a primary component of the industrial practice (Adams et al., 2016; Harvey et al., 2015). Likewise, strong communities can develop around exhibitions or workshops in education, generating better opportunities for Design assessment since this can "include more voices and build greater capacity for student learning" (Eriksson et al., 2021, p. 141).

Pontis and Van der Waarde (2020, p. 241) challenge existing Design pedagogical methods and advocate for using "the world as a classroom", encouraging student participation in the broader professional CoP, tackling real-world problems, receiving feedback from peers and experts, and observing real-life workplace interactions, to deepen "the understanding of how professional practice interacts with theory".

2.6 Knowledge gaps in CoP literature

Lea et al., (2005, p. 1) described CoPs as “one of the most articulated and developed concepts within broad social theories of learning”, with multiple applications in education. Respective empirical interventions recorded the benefits of CoPs in fostering *self-development*—mainly through *legitimate peripheral participation* (Stone et al., 2017; Woo, 2015), enhancing *reflective* skills (Rourke & Coleman, 2009), evolving the ability to network and *co-create knowledge* (Allee, 2000; Hildreth & Kimble, 2004), and steering *innovation* (Goodyear & Casey, 2015) and *professional growth* (Khalid & Strange, 2016).

However, to date, CoP research largely reflects *intra-organizational* incentives, focusing on either academic or industrial contexts, while *cross-organizational* CoP research is still limited (DeChambeau, 2017; Stone et al., 2017). We argue that at times when university-industry alliances are increasingly endorsed by academic institutions, the CoP-supported link between education and practice is a critical step for innovation that cannot be overlooked.

Based on the critical role of technology in cross-organizational settings, it is also crucial to report on effective technology configurations based on empirical evidence from their adoption by members in blended or virtual CoPs in HE, with both collocated and remote memberships respectively (Spagnoletti et al., 2015).

Lastly, the bibliography lacks concrete *governance mechanisms* for CoPs of a specific *social structure* (i.e. small-scale, closed, public), *scope* (i.e. academic, industry, cross-organizational), and *purpose* (i.e. learning, professional development), within particular *disciplines* (Amin & Roberts, 2008; Smith et al., 2017).

3 Methodology

3.1 Research questions

Cross-organizational CoPs in HE curricula require a holistic approach—a CoP ecology per se – to their design and evaluation. Drawing from underlying studies attending to the individual components of this ecology, this work *integrates* the sum of its findings to address two overarching questions:

> RQ1: What constitutes an appropriate *social*, *epistemic*, and *technology configuration* design for a cross-organizational CoP in HE Design studies based on empirical findings?
> RQ2: What are the practical governance mechanisms for a transferable cross-organizational CoP model in HE Design studies?

RQ1 is addressed in Section 3 which discusses the *design* of the cross-organizational CoP's main components, while Section 4 provides a summary of findings from the CoP's enactment and evaluation. While a full account of the outcomes of RQ1 is available in peer-reviewed publications (disclosed), in this paper, these outcomes merely serve to support the overarching research aim, that is, to extract a CoP governance model, in response to RQ2.

3.2 Participants

This research involved 38 third-year students in a Multimedia and Graphic Arts course in a university of technology (disclosed) who enrolled in two consecutive 3rd-year Web Design and Development (WDD) modules (13 × 180-min lessons per semester). The students were divided by registration into the Multimedia and Graphics directions, forming the experimental (**G1**, N = 21) and control (**G2**, N = 17) groups respectively. These groups were selected by the instructor of the course who was also the primary researcher in this work since they shared identical program structures, syllabi, and GPAs over years one and two of their studies. As such, convenience sampling (Patton, 2002) was employed. Students self-formed teams of approximately four-to-five people in both groups.

Ethical permission to run the studies was obtained from the university's department. The appropriateness of study methods was approved by an internal ethics committee. Further, all ethical considerations regarding data collection were addressed in signed consent forms by participants.

3.3 Research design

The entire body of this research followed a mixed methods (MM) multiphase design. Related evidence indicates that MM is highly appropriate for CoP studies,. Specifically, we sought to examine the *effects* of the cross-organizational CoP by measuring and comparing learning and creative outcomes through *quantitative* data and understanding the *experiential* dimensions of learning, through *qualitative* investigations of the emergent phenomena (B. Wenger-Trayner et al., 2019).

In this work, while both groups of participants followed precisely the same epistemic activities of the WDD module, only Group G1 actively participated in the CoP (experimental condition) (Section 3.2). Following a quasi-experimental research design for studies 2 and 3 (Table 1), we compared the groups' *epistemic, creative,* and *social* learning outcomes, and conducted more comprehensive qualitative investigations on the *technology* adoption, the *value creation* of learning, and *identity* transformation phenomena, working with the *experimental* group only, in studies 3 and 4. Study 2a was conducted for the purposes of validating the quantitative instrument used in Study 2.

Additionally, two frameworks were employed to guide the analysis of data. First, the ACAD framework which aims to generate knowledge on the design of complex learning networks to support learning designers with proactive information shaped by particular *technological* (SET), *instructional* (epistemic) and *social* parameters (Fig. 1).

Table 1 Multiphase research design: quasi experimental and qualitative study designs

CoP Studies	Participants	Semester
Study 1 (Epistemic design)	G1 (N=21)+G2 (N=17)	Semester 1 (WDD-1) 13-weeks
Study 2 (Social design)	G1 (N=21)+G2 (N=17)	
Sub-study 2a (Instrument validation)	Under/Post-graduate students (N=236)	
Study 3 (SET-technology)	G1 (N=21)	
Study 4 (Value Creation, Identity transformation)	G1 (N=21)	Semester 2 (WDD-2) 13-weeks
Study 5 (Guidelines Governance Model)	-	

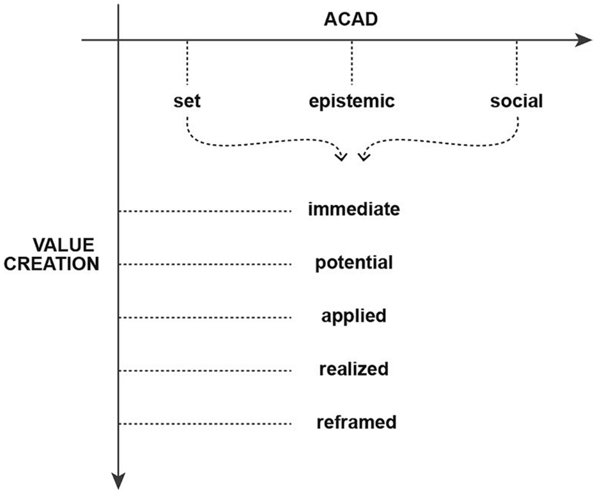

Fig. 1 Horizontal (ACAD) and vertical (VC) approaches to analysis

Aside of design, the ACAD framework (Fig. 2) was also employed as a *horizontal* approach to the analysis of the empirical data collected in this work (Goodyear & Carvalho, 2016). The second framework—Value Creation (Fig. 3) – was employed as a *vertical* approach to the investigation, aiming to gain a deep understanding of the value of learning in CoPs, attending to five dimensions (cycles) of learning (Wenger et al., 2011; B; Wenger-Trayner et al., 2019).

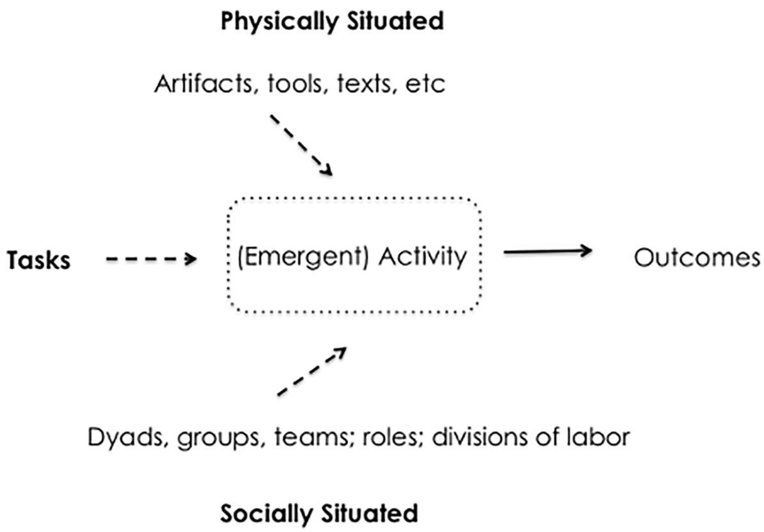

Fig. 2 Epistemically, physically/digitally, and socially situated activities and outcomes

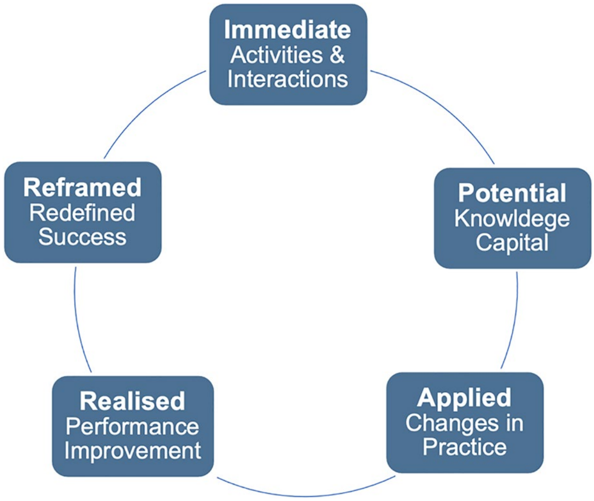

Fig. 3 Value Creation framework cycles

4 The cross-organizational CoP ecology

The proposed CoP model draws from the Activity centered analysis and design (ACAD) methodological framework to define and analyze the components of its learning ecology: the *social, epistemic, and technological* (SET) components.

4.1 Social component

An organic, self-formed social CoP became evident in G1 early on in the research. This had emerged amongst students, driven by their common status, purpose, and interests, since year 1 of their studies. The CoP in G1 was then extended by the instructor (acting as CoP steward), to also include members from the industry. The CoP members were (Fig. 4):

a) *Instructor* of the module
b) *Students*
c) *Floating facilitator*: final-year student acting as teaching assistant
d) *Alumni Mentors*: alumni designers (three in semester 1, two in semester 2), with two-to-three years of professional experience who provided regular feedback on student deliverables.
e) *Industrial Experts*: field professionals (three in semester 1, five in semester 2), with 6 + years of experience, responsible for evaluating the final websites, but were made accessible to students via a social network (SN) group from the semester start
f) *Industrial mentors* (clients): five local-industry organizations who assigned student projects and provided related resources and feedback

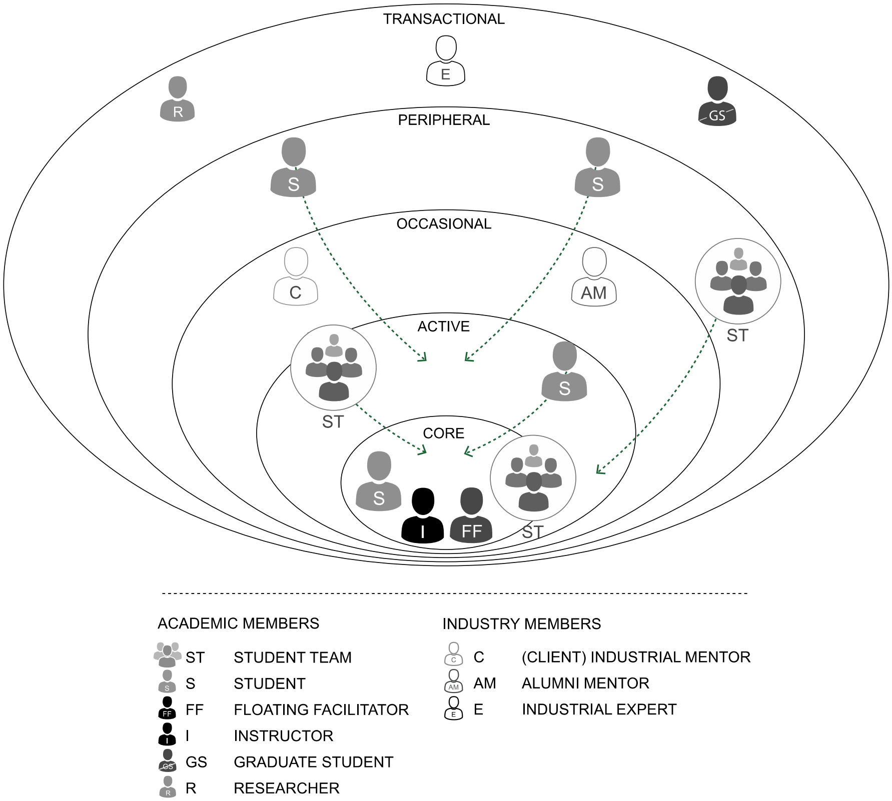

Fig. 4 Cross-organizational CoP social structure and levels of participation adopted from Wenger-Trayner's (2011) participation model

A full account of the various CoP roles and incentives is provided in published work (Mavri et al., 2020c).

4.2 Epistemic component

Five industrial mentors (clients) assigned different projects to different student teams in WDD-1, essentially, to design and develop websites addressing specific business needs (Table 2). Each project was developed twice, once by a team in the experimental (**G1**), and once by a team in the control group (**G2**). Both groups followed identical lesson structures, materials, and problem-based learning (PBL) approaches in class.

The thematic areas of instruction and classroom-based processes were designed to coincide with respective project deliverables, to be reviewed by the CoP's alumni and industrial mentors. This applied to **G1** students only, whereas students in **G2** engaged in their normal academic activities. In semester 2, the **G1** students advanced their projects further, while sustaining their CoP memberships.

Table 2 Experimental and control group teams structure, authentic projects and industrial CoP membership

Project / client domain	Law Consultancy	Non-profit	Sports Management	Property Development	Investment Services	Industrial members	Gender
Team	A	B	C	D	E	Alumni mentors	2 female 1 male
Experimental (CoP) (G1) N = 21	4 female	1 female 3 male	4 female	2 female 3 male	3 female 1 male	Industrial experts Industrial mentors (clients)	3 male 3 female 2 male
Control (G2) N = 17	4 female	5 female	5 male	3 female	-		

A full account of the learning and instructional design can be found in parallel work (Mavri et al., 2021a).

4.3 Technology (SET) component

The SET component reflects the *physical*, *digital,* or *blended* learning setting that hosted the learning activities of the CoP (Carvalho & Goodyear, 2014). In this work, the emphasis was on ensuring that the *technology configuration* facilitated vital Design-oriented CoP interactions (communication/collaboration/visual/technical activities). The configuration strategy was formed based on *internal* and *cross-organizational* objectives, like software/tool availability for all members (i.e. free/low-cost/subscription-based), suitability for WDD epistemic *orientations* (Section 2.3), tool familiarity (i.e. tools used by the organic CoP), and ease-of-use (i.e. conventional functionality) for all CoP members.

Figure 5 presents the resulting technology configuration, categorized into the '*team-based*', '*community-wide*', and '*single-user*' contexts.

In this work, with the exception of Google Drive, Docs, and Sheets, all tools in the *Team* and *Single-user* context are classified as *Creativity Support Tools* (CSTs) since they support Design activities that generate innovative outcomes (Gabriel et al., 2016).

Extensive reports of the CoP's *orientations*, *technology configuration*, and *adoption* results are presented in parallel work (Mavri et al., 2020a).

5 Data collection, analysis, findings (all studies)

The entire body of this work gathered quantitative data from the WSCMI instrument (Zeng et al., 2009) (Table 6), Cumming et al.'s (2016) feedback coding scheme (Table 11), students' final exams scores (Table 7), system logs, and communication frequencies (Table 10), as well as extensive qualitative evidence, from pre, during and post-intervention focus groups, one-to-one semi-structured

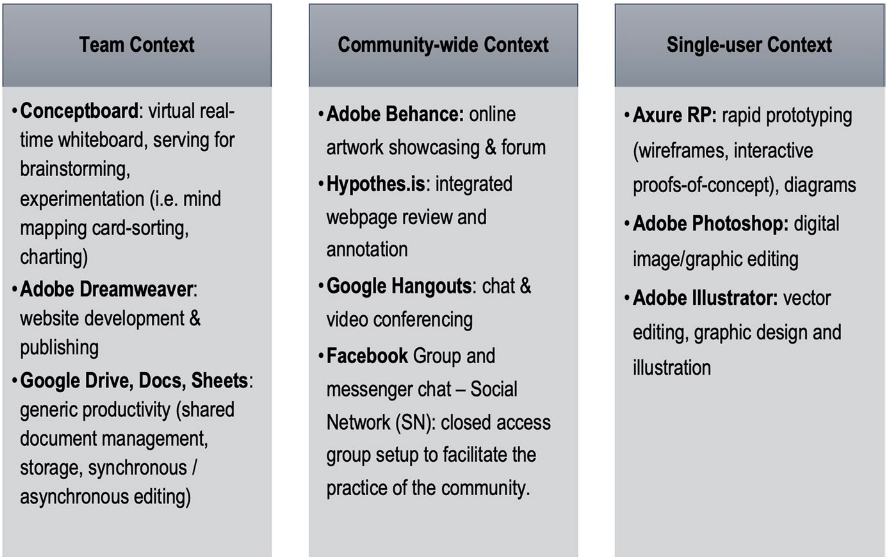

Fig. 5 Design-based CoP Technology configuration

interviews, field-notes, SN group posts and chat logs (Table 3). Quantitative data underwent statistical processing and independent samples *t-tests* were conducted to examine mean differences between the two groups (Tables 8 and 9). Qualitative data were transcribed and analyzed employing either *inductive thematic* or *priori codebook*-driven analysis approaches (Table 11) (Braun et al., 2019; Saldaña, 2015).

Qualitative findings from all studies extracted overall strong participation levels from – primarily – learners—and external CoP members through the abundant learning and creative collaboration exchanges that emerged from positive *technology-adoption* findings, in both *within-team* and *community-wide* contexts. Students were evidently "using technology to learn together" (Wenger et al., 2009, p. 41). They also valued their interactions with CoP experts as possessing significant real-world value, particularly focusing on the systematic feedback which urged them to rethink their work strategies, processes, and creative outcomes, without compromising quality and deadlines.

Findings also revealed that CoP technology configurations should uniformly facilitate various media channels for communication (audio/video/chat/share-screen), different user roles and privileges, and importantly, interoperability between SNs and productivity tools through common access and functionality.

Results also denoted a substantial shift in learners' perceptions of achievement and reframed imperatives for learning and professional development. The CoP had evidently encouraged them to adopt a performance-driven—rather than a strategic (grades)—approach to learning. This signifies transformed learner *identities* into a pre-professional status (Jackson, 2016), driven by increased awareness of their prospective transition into professional practice.

Table 3 Data collection methods

		Group1	Group2
Semester 1 (phase 1)			
Interviews	10 participants (N = 253 min, N = 8,095 words)	✓	
Focus Groups	5 teams (N = 21 participants) × 3 sessions (N = 457 min, N = 14,357 words)	✓	
Observation notes	Instructor (N = 2,396 words)	✓	✓
ASCC	38 students	✓	✓
WSCMI	38 students + 38 evaluators	✓	✓
Final exams	38 participants	✓	✓
Behance feedback posts	5 teams (N = 21 participants), 3 alumni mentors, 5 industrial mentors (N = 101 posts, 9,977 words)	✓	
Email communication	G1 N = 54 email threads G2 N = 25 email threads (team-based)	✓	✓
	G2 N = 14 email threads (with alumni mentors)	✓	
Artifacts in Conceptboard & Google Drive	N = 1393 items (artifacts, chats, notes, boards)	✓	
Semester 2 (phase 2)			
Interviews	8 participants (N = 360 min, N = 12,717 words)		
Focus Groups	5 teams (N = 21 participants) × 1 session (N = 318 min, N = 18,498 words)		
Observation notes	Interviewer		
Facebook group timeline (SN)	N = 205 posts		

In terms of quantitative findings, the evaluation scores of learners' creative outcomes (websites) and conceptual knowledge gains (exams) revealed statistically significant differences in favor of the G1 (experimental) group, with a medium to large effect size (Cohen, 1992) (Table 8). Likewise, the communication frequencies in *learner-instructor interactions* of group 1 doubled the amount of those in group 2, denoting greater engagement in learning (Table 10). Lastly, feedback

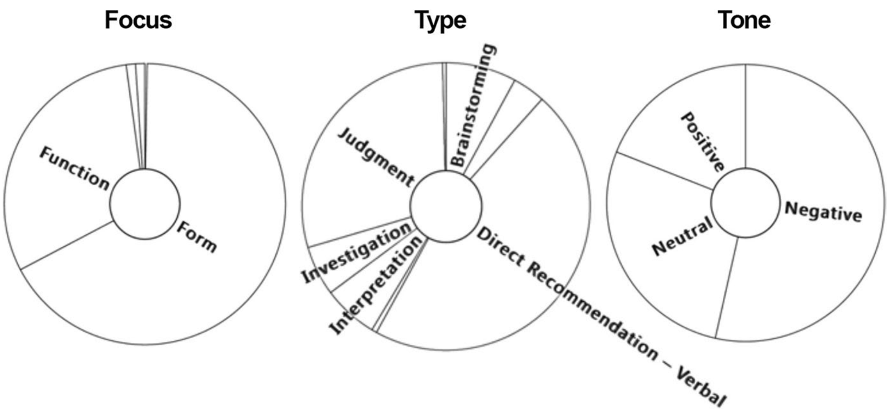

Fig. 6 Coding references charts

findings (Table 11) presented *negative* feedback as a significant predictor of lower creativity scores, and *neutral* feedback as positively correlated to higher creativity scores, suggesting that a moderated (*plain*-versus-*negative*) approach to feedback can yield improved outcomes in cross-organizational CoP contexts (Fig. 6).

A full account of the data collection and analysis processes, as well as, respective findings is published in various parallel studies (Mavri et al., 2020b; Mavri et al., 2021a, b).

6 Results: Design implications

Building on the research findings, this section provides a model, that is, a collection of actionable *design guidelines*, grouped under the three ACAD components: *Set* (technology), *Social*, and *Epistemic*. The themes and guidelines are supported by empirical evidence from the studies to help the reader gain better contextual understanding. Their purpose is to locate the *effective* and *challenging* dimensions that warrant attention during the *design*, *governance,* and *evaluation* stages of a CoP's life.

Table 4 presents the three sets of guidelines in the cross-organizational CoP model and the following sections discuss these extensively.

6.1 Set design implications

Based on the *technology configuration* (Set) and adoption findings, a generic guideline for CoP stewards is to:

> *SE1. Integrate member-preferred social networks (SN), field-specific creativity support tools (CSTs), generic productivity, and online showcasing tools in the CoP technology configuration*

As explained (Section 2.3), technology configuration decisions should be informed by a solid understanding of the community's *orientations* and *cross-organizational* needs, to cater for different roles and activities in the CoP. Evidently, tool availability, ease of use, and familiarity are key factors for the configuration, as CoP members do not typically "live in" field-specific tools—CSTs—or community platforms, for example. Empirical evidence indicates that their day-to-day activities typically transpire on productivity tools, communication/collaboration apps, and importantly, SNs. These should thus inform respective configuration design decisions.

The next sections present targeted guidelines for *Design*-oriented CoPs that rely heavily on *practical* (*technical*) and *visual design* communication in CSCL and CSCW settings.

6.1.1 Technical and design-oriented communication: Practical and socio-emotional considerations

Practical considerations As it stands, *technical* communication in design-oriented CoPs relies on tools that facilitate *reviewing* and *debugging* of programming code in shared environments.

The configuration should thus employ tools with *live-editing* and code *debugging* facilities, that are visually differentiated from natural language text (i.e. conversational data). This is typical of technical Q&A sites, like 'Stack Overflow', that facilitate code-formatted *snippets* that can be edited and executed within the platform (Mamykina et al., 2011; Yang, 2016). Stewards can proactively incorporate such functionality through relevant APIs into the CoP's platform (i.e. SNs) to:

SE2. Integrate effective technical Q&A interface capabilities, like code snippet sharing, execution, and debugging within the social CoP platform

The ability to *tag* posts can also help build a searchable 'code' index. Additionally, *voting* systems based on code correctness, generating *scores* and *badges* for users on their SNs, can help elevate interest and also provide statistics for evaluation purposes. Hence, the next guideline:

SE3. Integrate automatic or manual gamification features in the social CoP platform to promote student interest and engagement in the practice

It is equally important that members are encouraged to follow ground rules for *natural* and *technical* writing, as the **following** guideline suggests:

SE4. Guide members to make use of appropriate language for effective natural and technical communication in the CoP platform

Class-based PBL practices can train students accordingly; following short seminars on *technical* communication, students can practice their technical writing on specific tasks and undergo peer reviews based on their writing's conciseness and communicational aptitude.

Socio-emotional considerations The CoP's platform should foresee the occurrence of socio-emotional phenomena that may hinder learning, particularly, for 'underpowered' learners who often tend to make unhealthy comparisons between themselves and peers. Such phenomena can be minimized by on-demand *modular visibility* for certain interactions, such as *one-to-one, one-to-team, team-to-team,* and *team-to-community*, during the practice. Implication SE5 below incorporates two sub-implications for: a) *activity-driven* and b) *permissions-driven* modularity:

Table 4 Design implications for Cross-organizational Design-based CoPs

1	**SET**
SE1	Integrate member-preferred social networks (SN), field-specific creativity-support tools (CSTs), generic productivity, and online showcasing tools in the CoP technology configuration
	Technical & Design-oriented communication: practical and socio-emotional considerations
SE2	Integrate effective technical Q&A interface capabilities, like code-snippet sharing, execution, and debugging, within the social CoP platform
SE3	Integrate automatic or manual gamification features in the social CoP platform to promote student interest and engagement in the practice
SE4	Guide learners to make use of appropriate language for effective technical communication in the CoP platform
SE5	Support modular visibility to accommodate various ad-hoc CoP interactions, both from the initiating & the target member's perspectives:
	SE5.1 Provide on-demand activity-driven permissions
	SE5.2 Provide on-demand role-specific permissions
	Visual design-oriented interactions
SE6	Aim to enhance workspace awareness in terms of peers' identity, position & activity, particularly in visual CST workspaces
SE7	Integrate various channels for multimodal communication in visual CST workspaces
	Interoperability
SE8	Enable interoperability between CSTs, SNs, generic productivity, and other tools in the CoP's technology configuration
2	**SOCIAL**
	Power relations: trust, competition & accountability
SO1	Aim for an even distribution of power through the balance of trust, competition & accountability in the CoP
SO2	Empower external CoP members with compound and in-depth information on their purpose and role, as well as the other members in the practice
	Interpersonal (peer trust)
SO3	Schedule regular work crits with students for constructive peer review, commencing early on in the project cycle
SO4	Assign different industry projects and clients to different CoP teams, ensuring that they require same-level subject knowledge, creative adeptness & technical competence
	Intrapersonal trust (self-efficacy)
SO5	Aim for mixed-competence teams to form the CoP's working subgroups
SO6	Aim for community-wide face-to-face interaction early on and throughout the life of the CoP in order to boost online participation
	Accountability
SO7	Limit the size of the CoP to enhance member accountability
SO8	Highlight the incentives, purpose & responsibilities of each CoP role at the start & regularly throughout the life of the CoP
3	**EPISTEMIC**
	Time
EP1	Invite community-wide participation in the design of the learning ecology prior to its enactment
EP2	Introduce visual representations to simplify the epistemic design and clarify its practical implications early on in the life of the CoP
EP3	Allow for sufficient time to pilot-test the epistemic design prior to the commencement of critical CoP-based learning practices

Table 4 (continued)

EP4	Plan the academic curriculum to coincide – thematically and temporally—with CoP-based activities
	Feedback
EP5	Aim for regular feedback and evaluation of student work from expert CoP members to enrich the academic feedback process
EP6	Proactively negotiate the focus, amount and tone of feedback with external CoP members
EP7	Articulate comments appropriately to encourage reciprocal feedback activity in CoP-wide settings
	The purpose of expert CoP members
EP8	Invite industry CoP members with various degrees of expertise to provide briefs, insights, evaluation, and feedback to students
EP9	Recruit recent graduates for the role of alumni mentors in the CoP
EP10	Aim to share expert trajectories and 'inside' information about the industrial practice
EP11	Always include real industry clients & authentic projects to guide the CoP-based activities

SE5. Support modular visibility to accommodate various ad-hoc interactions, both from the initiating and the target member's perspectives

The CoP platform/tool should offer selective *initiator visibility*. 'Initiator' is the person who starts an activity (i.e. question, task, artifact creation), and can do so by using their *name*, *team name,* or *anonymously* (Table 4). This prevents the exposure of personal weaknesses, where preferred, while sustaining flow in the practice.

On the other hand, the platform/tool should also afford selective *target visibility*, that is, making activities visible only to specific members. For example, a student can post a question to a specific *classmate*, an *alumni mentor,* and the *instructor*. Thus, communication becomes adaptive and fine-tuned to the members' needs. The visibility feature can also include options such as *activity and role* permissions (Table 5). The interface should therefore:

SE5.1. Provide on-demand activity-driven permissions

This allows *initiators* to grant *targeted* users (i.e. collaborators) *edit, view*, *review*, and/or *collaborate* permissions, for a specific workspace (i.e. canvas#3) or a particular artifact (i.e. 'top menu'). These permissions can bind to a preset index of *user roles*, to build customized access (Table 5) as per the following guideline:

SE5.2. Provide on-demand role-specific permissions

This helps minimize intrusion (i.e. overwrite, delete) in CSTs and other tools.

Both SE5.1 and SE5.2 guidelines aim to provide a combined matrix of *initiator* and *target visibilities*, linked to *activity permissions (edit, comment,* etc.) for specific user *roles* to facilitate the members' ad-hoc needs. This creates a fluid, aggregated, multi-visibility, multi-activity, and multi-role environment, eliminating the need for separate tools (Table 5).

Table 5 Modular visibility scheme: initiator & target visibility, activity & role permissions matrix

Initiator visibility	**Target visibility**	
Visibility settings	**Activity permissions** *Workspace* OR *Artifact* level	**Role permissions** *Workspace* OR *Artifact* level

☐ Member name
☐ Team
☐ Class / group (anonymous)
☐ CoP (anonymous)
	☐ Edit
	☐ View
	☐ Review (Q&A)
	☐ Collaborate
	    ☐ Chat
	    ☐ Stickies
	    ☐ Voice Call
	    ☐ Video Conference
	    ☐ Screen Share
	    ☐ Point
	☐ None
		☐ Admin
		☐ Team
		    ☐ Team Leader
		    ☐ Member 1 (name)
		    ☐ Member 2 (name)
		☐ Group (class)
		    ☐ Student 1 (name)
		    ☐ Student 2 (name)
		    ☐ Student 3 (name)….
		☐ Community
		    ☐ Alumni Mentor
		    ☐ Industrial Expert
		    ☐ Industrial Mentor (client)
		☐ Public

For clarification purposes, we offer an example scenario whereby an author (*initiator* visibility) can label an *artifact* under their name or anonymously. For *target visibility*, they can choose to assign *review* permissions for all *alumni mentors*, *edit*, *chat,* and *voice-call* permissions for *team members* 1 and 2, and *view permissions* for *class-wide* access. Likewise, a *team leader* can grant a specific *target* member *view* permissions for a large *workspace* area (i.e. entire team's canvas), and *edit* permissions for a particular artifact in that workspace.

Visual design interactions The following guidelines focus on *visual* design interactions (i.e. 2D/3D drawing, diagraming, prototyping) that are inherent in Design-oriented CoPs. They mainly concern collaboration in *synchronous* CSTs and address the topic of *workspace awareness* (awareness of others' presence and activities) in shared virtual spaces (Gutwin et al., 1996).

Insufficient *workspace awareness* can be the cause of *overwrites*, *deletions, or duplicated* work in shared CSTs (Forghani et al., 2014). This often generates an excessive sense of ownership, individualistic behaviors, mistrust, and lack of accountability in the CoP practice. Interfaces should instead facilitate true immersion and full awareness of shared activities in the CoP's virtual spaces (Gabriel et al., 2016). The CoP's technology should:

SE6. Aim to enhance workspace awareness with regard to the peers' identity, position, and activity, particularly in visual CST workspaces

This should be intuitively 'detected' (lightweight information gathering) without added physical/mental overhead (Gutwin et al., 1996). In practical terms, CoP platforms should natively present others' activity (i.e. displaying labeled *user cursors* moving in real-time). Additionally, artifacts' state of edit can be labeled (i.e.

‘*in-progress*’, ‘*completed’*), to allow/prevent changes by others. Synchronous multi-channel communication (i.e. chat, voice, video conferencing, screen-sharing, remote connection) can also provide supplementary coordination support, according to the following guideline:

SE7. Integrate multiple channels for multimodal communication in the CST’s visual workspace

Interoperability CoP participation should allow its members to work with *spatially* and *relationally* proximal elements, be it visual/technical artifacts, Q&As, messages, SN posts, calendars, and resources. This poses a number of *governance* challenges in CoPs. Managing various tools/platforms, for handling such elements:

a) requires time and effort, being equally overwhelming for CoP stewards and members
b) increases redundancy (i.e. repeated data in different tools).
c) diffuses participation across tools, leaving some tools unpopulated or underused, known as “practice intangibility” (Probst & Borzillo, 2008, p. 343).

CoP stewards should therefore aim to:

SE8. Enable interoperability between CSTs, SNs, generic productivity, and other tools in the CoP’s technology configuration

On a practical level, this synergy requires technical knowhow for employing APIs to inter-connect applications. However, the CoP’s practice has a lot to benefit from a consolidated platform offering universal access, field-specific and generic productivity functionality (i.e. CSTs.), shared resources, and common *login* and *navigation*, ensuring *spatial* and *relational* proximity.

6.2 Social design implications

6.2.1 Power relations: Trust, competition, and accountability

Power equates the ability to define and claim knowledge in the practice; in short, *power* and *knowledge* imply each other in CoPs (Farnsworth et al., 2016). As *power* entails predominance in the meaning-negotiation processes, it is often contingent on the degree of participation and accountability in CoPs. Power asymmetries often surface in CoPs, both in their *internal* and *external* interactions. Cop stewards should:

SO1. Aim for an even distribution of power through the balance of trust, competition, and accountability in the CoP

Primarily, the power of external members (i.e. *alumni* and *industrial* mentors) in defining *competence* in the practice can be compromised due to insufficient contextual information on the internal practice. CoP stewards should:

SO2. Empower external CoP members with compound and in-depth information on their purpose and role, as well as about the other members in the practice

Adequate information like comprehensive requirements, expected academic outcomes, feedback focus, and rich contextual information (team setup, member roles and responsibilities, detailed communication plan, etc.) should be provided to external mentors, early on in the practice. Learners could also be responsible for supplying this information, overseen by the CoP steward, possibly, by transforming this into an assessed deliverable.

Likewise, power may unintentionally accumulate in the hands of a few members with more interest and motivation in learning and community-building intentions. Related theory posits that while a strong core group is necessary for driving community flow, it can also be steered to encourage—not intimidate—others. Next, we review guidelines that aim to manage such *power*, *trust,* and *accountability* imbalances*,* as the key social phenomena extracted from our analysis.

Interpersonal (peer) trust Lack of *interpersonal trust* involves doubting others' intentions, expecting opportunistic behaviors, and unhealthy competition (Hsu et al., 2007). This type of 'moral hazard' reflects some members well-intendedly sharing their work and others taking the opportunity to 'steal' ideas instead. Our findings suggest that *early CoP-wide* peer reviews on project work can help alleviate mistrust. CoP stewards are encouraged to:

SO3. Schedule regular synchronized deliverable reviews for peer teams commencing early on in the project cycle

A *full-transparency* approach lessens the chance of 'copying' work after it is publicly scrutinized and promotes honesty instead. It helps eliminate sustained secrecy—often followed by surprising revelations (i.e. hiding work until it's fully completed), a strategy practiced by competitive students. It also ensures that learners practice evidence-driven constructive and unbiased feedback, that requires sound subject-level knowledge and metacognitive aptitude, which are critical attributes for *pre-professional identity* development.

To avoid competitive comparisons and antagonistic behavior between teams, different clients and projects can be assigned to each team:

SO4. Assign different industry projects and clients to different CoP teams, ensuring that they require equal subject-level knowledge and technical competence

The instructor should ensure that different briefs are attuned to same-level requirements, regardless of their thematic foci. This also infuses diverse 'industry-academia' information streams into the practice, perceived as 'highly interesting' by learners.

Intrapersonal trust *Intrapersonal (self) trust*—linked to self-efficacy—is influenced by *interpersonal trust*, both associated with relations of *power* (Broom, 2015). Self-efficacy refers to personal beliefs about one's aptitude to perform and generate. More academically competent members typically present higher self-efficacy levels, sound awareness of their public status, and active participation in the practice. In contrast, previous embarrassing or intimidating events may discourage future participation. To mitigate such issues, stewards should:

SO5. Aim for mixed-competence teams as the CoP's working subgroups

Teams generally tend to operate as entities of a collective identity. However, self-formed teams often end up with a one-sided (high/low) 'accumulation' of competence, since 'sameness' is favored, which is reflected in the CoP participation (Tereshchenko et al., 2019). Instead, mixed-competence/attainment teams can benefit learners on the 'lower end' through their interactions with more competent teammates, enhancing motivation and gradually empowering them to become full CoP participants.

Another way to foster *inter* and *intra*-personal trust to boost participation, particularly in blended communities, is to encourage sufficient *face-to-face* (offline) collaboration (Booth & Kellogg, 2015). Specifically, stewards should:

SO6. Aim for community-wide face-to-face interaction early on and throughout the life of the community in order to boost online participation

Co-located interactions can also support *explicit* and *implicit* knowledge co-creation in the form of accidental information 'spill-overs' between teams (i.e. during class, tutorials, break times), which are more unlikely to occur online. Likewise, *trust* has a lot to gain from *geographical proximity* between internal and external CoP members. Close proximity provides comprehensive social cues and helps contextualize the requirements, *feedback,* and overall communication between students, mentors, and experts. These can trigger more spontaneous behaviors on behalf of learners and encourage higher engagement levels in the CoP practice.

Accountability *Accountability* is a constitutive component of CoP practice, driven by the members' sense of *joint enterprise* and *mutual engagement*. This aligns with the degree of competence in the CoP (increased competence equals higher accountability). It is also intertwined with *trust* and *power* in the community and suffers more in *exclusive online*—rather than blended—CoPs (Nilsson, 2019). The following guideline can help improve *accountability*, avoiding one-sided *power* accumulation:

SO7. Limit the size of the CoP to enhance member accountability

Individualistic tendencies and lack of accountability, cannot be easily 'hidden' in smaller social groups with sufficient face-to-face time, as these tend to generate healthier 'pressures' of participation (Nilsson, 2019). By contrast, *accountability* can easily get *diffused* in larger or exclusive online communities. The next guideline follows Wenger's (2002b) rationale for dividing larger communities into subgroups based on *location* or *subject*, to help accountability and participation:

SO8. Highlight the intended responsibilities of each CoP role at the beginning and regularly throughout the life of the CoP

Based on this work's findings, the role, goals, and responsibilities of CoP members often get subdued by the complexity and obligations of everyday *work-life* and their *multi-memberships* across a landscape of practices (Wenger, 2014). A sustained scheme to remind members of their benefits, contributions, and responsibilities in the practice can boost accountability (Borzillo, 2017).

6.3 Epistemic design implications

Epistemic guidelines involve the design of tasks that guide the *learning activities* and *outcomes* (Goodyear & Carvalho, 2016). The three prominent themes under this component concern *time*, *feedback*, and the *roles* and *purpose* of *mentors* in the CoP.

6.3.1 Time

Time is fundamental in CoP-based learning. Wenger perceives the transformation of members' identities as learning that happens "in time and space and identity itself is a time/space concept" (Farnsworth et al., 2016, p. 11). While *time* can evolve knowledge and competence in the CoP practice, it can also hinder learning, if not effectively managed.

An initial epistemic time/task plan, should be collectively decided between CoP members to *guide* the real-life CoP learning activities that ensue (Goodyear & Carvalho, 2016). All members should fully understand the time/task plan and align it to their practice, work styles, preferences, limitations, deliverables, and schedules. CoP stewards should:

EP1. Invite community-wide participation in the design of the learning ecology prior to its enactment

This step is crucial as it primarily helps educators, experts, and students co-define their learning ecology, which consists of tasks, people, tools, and places, as the key components of the practice (Novakovich et al., 2017).

In line with the ACAD framework, this process can be visualized through representations (i.e. network diagrams) to enable better comprehension. Aside from being inherently linked to the Design practice, these serve as *reified* artifacts to guide members throughout the practice. Stewards should:

EP2. Introduce visual representations to simplify the epistemic ecology and clarify its practical implications early on in the life of the CoP

It is equally important that this ecology is pilot-tested prior to its enactment, to uncover possible issues and allow for early co-configurations (collective adjustments) to serve the practice. It is thus reasonable to:

EP3. Allow for sufficient time to pilot-test the epistemic ecology prior to the commencement of critical CoP-based learning practices

Time management is significant in achieving sound epistemic outcomes through scheduled interweaving of the curriculum and CoP practice to ensure that their activities and objectives coincide. For instance, within the WDD context, academic lessons on GUI design should timely precede relevant deliverables (GUI prototypes) to be reviewed by alumni mentors. Likewise, practicing time-management methods (i.e. Gantt-charts) should precede the delivery of the project-plan from students to their industrial mentors, as the following guideline suggests:

EP4. Plan the academic curriculum to coincide – thematically and temporally—with CoP-based activities

6.3.2 Feedback

A primary goal of the cross-organizational model is to provide students with the experience of authentic industry feedback (from alumni and industrial mentors); hence the following guideline:

EP5. Aim for regular feedback and evaluation of student work from expert industrial CoP members to enrich the academic feedback processes

This process may naturally result in a large volume of comments, which are often ambiguous or conflicting, yet, representative of future real-life scenarios. Nonetheless, this work's findings indicated that feedback should be 'curated' to ensure that its *focus*, *volume*, and *tone* align with the epistemic objectives of the module. CoP stewards should:

EP6. Proactively negotiate the focus, amount and tone of feedback with external CoP contributors

Instructors should outline *feedback* guidelines in advance, to define the thematic *focus* (visual/technical), *volume* (word range, single/multiple mentor reviews per team), and *tone* (neutral recommendations). To encourage engagement, feedback should be articulated so as to invite student responses and be visible to the entire CoP for others' public reference, as the next guideline suggests:

EP7. Articulate comments appropriately to encourage reciprocal feedback for CoP-wide access

6.3.3 The purpose of expert CoP members

The role of external CoP members is critical in cross-organizational CoPs. This work has inferred that they can: a) enhance identification with the CoP's joint enterprise, b) enrich the evaluation processes with authenticity through their *feedback*, and c) enable *brokering* by importing *boundary elements* from different CoPs (Wenger, 1998). The next recommendation applies to all external roles:

EP8. Invite industry CoP members with various degrees of expertise to provide briefs, insights, evaluation, and feedback to students

This guideline should be practiced in collaboration with the module/course instructor to orient external members toward the focus of the CoP.

Alumni mentors Wenger (2014) posited that CoPs aim to decrease the distance between *masters* and *novices,* unlike traditional *apprenticeship* theories. Perceiving masters, as the 'big figures' can create a wide competence gap and compromise learning. Instead, mentors who are 'only slightly ahead' are more accessible for assistance. Novices can gradually co-create competence in practice, by negotiating more *proximal* meanings. CoP stewards should aim to:

EP9. Recruit recent graduates for the role of alumni mentors in the CoP

The word *recent* has both *temporal* and *relational* dimensions. The *recency* between alumni mentors and learners reflects *relational proximity*—how individuals relate based on affinity and similarity (Moodysson & Jonsson, 2007). Both roles share similar backgrounds, epistemic foci, and instructional experiences. On the contrary, the longer the time since graduation, the wider the *relational* gap, and the less the alignment in the ways o*f knowing* (Wenger, 2010b).

Industrial experts Rather than distant symbols, industrial experts should be accessible learners, to promote identification and cultivate the process of *imagination* and *alignment* with the *global* practice (industry). Novices should have *legitimate* access to the experts' backgrounds, trajectories (university-to-practice), and real work-life experiences, as highly valued inside-information (Morton, 2012). Stewards should:

EP10. Aim to share expert trajectories and 'inside' information about the industrial practice

This can become a transformative process of the learners' *identification* with expert trajectories, to pragmatically ground them in both the favorable (achievements and successes) and unfavorable (challenges and burdens) events involved in the process.

Industrial mentors (clients) Real-life *clients* are essential for cross-organizational CoPs, not just for assigning authentic projects, but also providing diverse industry information. Their feedback may not abide by Design terminology, and it is often messy, negative, or conflicting with theory. Learning to manage, counteract, and factor this back into the work, is an important mitigation skill for students. Community stewards should seek to:

EP11. Always include real industry clients and authentic projects to guide the CoP-based activities

6.4 The cross-organizational CoP model

The model comprises a total of three levels of detail:

- Level 1: Summary-level (current section)
- Level 2: Actionable guidelines by component & theme (Section 6)

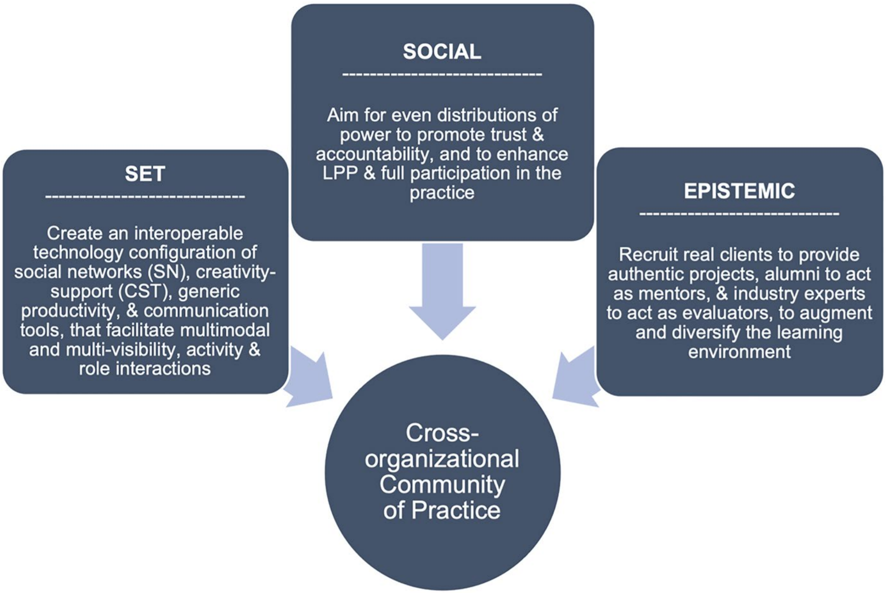

Fig. 7 The Cross-organizational CoP governance model. Own work

- Level 3: Extended version: includes guidelines associated with respective findings, bibliographic evidence, proposed instructional interventions, and evaluation measures for similar CoP-based ecologies, published online (Mavri, 2021).

All three levels provide structured guidance to educators and researchers for integrating cross-organizational CoPs in HE Design and similar studies (Fig. 7).

7 Discussion

This section discusses findings in relation to the research questions of the study as follows.

RQ1: What constitutes an appropriate *social*, *epistemic*, and *technology* configuration design for cross-organizational CoPs in HE Design studies based on respective outcomes?

This study addresses the lack of evidence on the design of cross-organizational CoPs in HE, responding to the call for CoP research that is localized to specific disciplines such as the Design and adjacent fields, versus a 'one-fits-all' approach (Hsu et al., 2007).

Five individual studies synthesized the entire body of this research, capturing, triangulating, and explaining the *designed* and *emergent* learning phenomena. These reported on a) the Design and critical interlocking of the *technological*, *epistemic*, and *social* components that comprise an appropriate ecology for the complex practices of Design-oriented CoPs (Section 4), b) the significantly enhanced (actual and perceived) learning outcomes (creative collaboration results, conceptual knowledge gains, feedback value), c) the positive shift in learners' perceptions of achievement and their reframed Design-oriented aspirations, and d) the transformation of learners' identities into their pre-professional and professional statuses (Jackson, 2016), encouraging effective industry transitions and enhancing employability.

As such, this work contributes *a first-time* design and validation of the cross-organizational CoP model to the growing community of researchers and practitioners involved in *university-industry* collaborations. It focuses on *curriculum-integrated* CoPs that aim to promote *collaboration, creativity,* and *real-world vocational relevance in* HE Design studies (Albats, 2018; Ivascu et al., 2016).

RQ2: What are the practical *governance mechanisms* as part of a transferable *cross-organizational model* for CoP-based learning ecologies in HE Design studies?

The second research objective concerns *governance mechanisms* for CoPs in specific epistemic areas in HE which aim to cultivate creativity, collaboration, real-world vocational relevance, and pre-professional identity development. Section 6 presents an exhaustive analysis of the three guideline sets of the governance model. Next we critically discuss each of these based on their contributions to and interactions with foundational CoP theory and related research.

7.1 Set guidelines

The *Set* component themes concern *socio-emotional* factors in technology-supported CoPs, as well as considerations for Design-based practices, specifically *technical and visual (practical)* communication. *Interoperability* is also an important dimension of this component.

Practical considerations concern *field-specific* functionality and usability guidelines, to enable efficient *technical communication* in SNs and *visual interaction* in CSTs (*SE1*). While these issues were formerly addressed by the literature (Dillenbourg et al., 2009; Gutwin et al., 1996), this work contextualizes them to CoPs. It provides empirical CoP evidence and guidance on facilitating *multi-channel* communication (*SE7*), multiple *roles, permissions,* and *visibility* options (*SE5*), and increased *workspace awareness* (*SE6*) across tools used in a CoP.

The Set component also addresses and counteracts previous findings on the *resistive type of agency* by anyone (human) and anything (non-human, i.e. tools & platforms) in the community (Novakovich et al., 2017). 'Non-human' forms of resistance reflect *usability* barriers that can hinder CoP practice, addressed by respective guidelines (*SE2*). 'Human' forms of *resistance* may be triggered by fear of vulnerability and exposure (Brass & Mecoli, 2011; Waycott et al., 2017), criticism (Baek et al., 2008), unhealthy self-comparisons (Crossouard & Pryor, 2008), and competitive or dishonest intentions (Chang et al., 2008), lack of authorial identity (Dennen, 2016; Waycott et al., 2017), and language/communication barriers (Huang et al., 2016), all previously reported in CSCL/CSCW literature.

The value of these guidelines lies in their potential to bolster the three constitutive *dimensions of coherence* in a CoP – namely: a) *mutual engagement,* that is, to support the full complexity of 'doing things together', b) *joint enterprise,* that is, to use tools that allow for this to be safely – yet—flexibly negotiated, and c) *shared repertoire*, that is, to expedite the development and effective use of a shared vocabulary (language, resources, patterns) amongst members of a virtual practice (*SE3-SE4*) (Wenger, 1998).

The guidelines aim to achieve this through a flexible, modular, and interoperable technology (*SE8*), integrating generic productivity, field-specific tools, and SNs to create the 'digital habitats' that CoP members can 'live in' during their practice (Wenger et al., 2009). These can facilitate *narrow* or *wide* modes of interaction, for *team-based*, *community-wide* (local), and *public* (global) settings, based on preference. In this way, they equally empower the *local* (learners, faculty, alumni mentors) and *global* (industrial experts, clients) CoP members to build and sustain agency in their practice.

From a theoretical standpoint, the Set component's contribution is manifold. First, it actively enables Wenger's (1998) critical *local/global* duality and acknowledges its *balance* as vital for cross-organizational practice. Secondly, it safeguards a powerful *polarity* in CoP theory (Section 2.3)—*synchronous/asynchronous* participation—which caters for "togetherness and separation across time and space" (Wenger et al., 2009, p. 14), allowing fluent meaning-negotiation processes, in real-time or asynchronously. Thirdly, it fully aligns with recent advancements in HCI research that value the affective dimensions of *people-technology* and *people-people* interaction, as critical in CSCL and CSCW settings (Heuer & Stein, 2019; Sanches et al., 2019).

7.2 Social guidelines

The *Social* component guidelines involve the management of *power* originating from the level of *knowledge* and *competence*, *identification* with, and *accountability* toward the CoP. This has a significant impact on the members' levels of *trust* and *competition*.

Power relations are bound to emerge in CoPs. Yet this work, unlike Fox's (2000), does not perceive them as 'conflicts', but rather, as *asymmetries* that may 'silence certain voices' in the *local-to-local-to-global* relations. These warrant attention from CoP stewards. As such, this set acknowledges the criticality of providing *global* members with in-depth information about the *local* practice. On the one hand, this grants them enough power to *drive* the meaning-negotiation processes, and on the other—as Fuller et al. (2005) posit—it allows them to benefit from the fresh insights of the CoP's novice members (*SO2, SO6, SO8*).

All the same, and in line with prior research which acknowledges the probability of *local-to-local* power asymmetries (Cundill et al., 2015; Smith et al., 2020), the model proposes ways to constructively avoid one-sided participation from a core learner group. This tends to dominate the *meaning-negotiation* and *knowledge-creation* processes in the CoP (*SO1*). Similar to educational and organizational CoP findings, this work locates the complex and uneven distribution of power in the *trust* structures of a CoP (Stroupe, 2014). It has therefore synthesized a subset of guidelines (*SO3-SO7*) that target both *inter* and *intra-personal trust*, to reduce *competition,* and support the *peripherality* of members in evolving into fuller forms of participation.

The cross-organizational model follows and strengthens Wenger's (2013) call to design for balance in CoPs. The aim of CoP stewards, in this case, is not to demolish *power*. Instead, the aim is to prepare for it, prevent it from 'blocking' voices that deserve to be heard, and moderate it to encourage members in making their own claims to competence, creating *healthy* opportunities for learning (Wenger, 1998).

7.3 Epistemic guidelines

The *Epistemic* component themes reflect the criticality of *time* in the a) co-evolution of knowledge, b) the transformation of learners' *identities*, c) the importance of *feedback* as a *boundary* object that enriches the local practice, and d) the *boundary relationships* between learners and experts in the CoP, which instill the three modes of belonging: *engagement, imagination, and alignment*, in learners, as prospective graduates.

With regard to *time*, the model takes into account the distinct *thematic* and *temporal* differences between instruction and CoP-based learning – a *part-academic*, *part-professional* process and – agreeing with Morton (2012) – it advises a form of organized *synchronicity* (*EP4*). In doing so, it concedes with foundational CoP theory which advocates the *early* involvement of CoP members in the design and testing of a CoP's epistemic ecology (*EP1-3*) (Wenger et al., 2002a). Moreover, it draws from the ACAD framework to propose: a) the *collective needs* analysis and careful planning of the 'chain of operations' that are likely to develop in practice, *before* the practice, and b) the creation of *visual representations* (versus abstract conceptualizations) to clarify the components and epistemic activities of the cross-organizational CoP, *prior* to its practice.

Equally important, the *feedback* guidelines (*EP5-EP7*) in this component constitute the backbone of the cross-organizational model. They respond to Boud's & Falchikov's (2006, p. 400) call for reconceptualizing "the place of assessment in learning beyond the academy", that is diversified by the perspectives of "parties external to the educational institution". While this generates rich learning prospects, the *feedback* that ensues is often complex and requires more intense *metacognitive* action and *meaning-negotiations* from learners (Novakovich et al., 2017). While in agreement with Jackson (2016) in that these actions are critical for students' evolution into reflective practitioners, respective guidelines recommend moderating the feedback to leverage its full learning potential.

The cross-organizational model also foresees and cultivates two types of *boundary* relations in the CoP, *distant* and *narrow*, based on their level of proximity. Industrial mentors (clients) for instance, are epistemically *distant* to other members in the CoP since they themselves are not designers. Yet, they share 'boundary' information (i.e. culture, goals, perspectives) and *reified* objects (i.e. documents, vocabularies, formulas) from their own practices. On the other hand, *narrow proximities* reflect epistemically closer members (i.e. Design practitioners/scholars), these being, the *mentors* and *experts* in the CoP.

Still, these may also have various sub-levels of proximity. Alumni mentors, for instance, are more *proximal* to undergraduate students, since they too are recent graduates. They are also proximal from a *generational* (age) and *relational* (perspective) outlook, as opposed to industrial experts. This follows Wenger's (1998) foundational conceptualization of a CoP's learning value, which sees members with proximal *epistemic* and *generational* characteristics making smaller leaps of effort to learn together. By contrast, industrial experts – though *epistemically* proximal—reside further away on the *generational* and *relational* axis, and are thus more distant in the learners' day-to-day CoP practice (Wenger et al., 2011).

As such, the *EP8-11* implications corroborate, enact, and expand the CoP theory through the *cross-organizational* dimension, by introducing a blend of *multi-generational* and *multi-relational* proximities that generate various boundary encounters in the practice (Culver & Bertram, 2017). The model aims to help learners form a mental matrix of the different entangled practices, roles, and competences involved in their wider CoP ecology. In agreement with Wenger and Trayner (2016), it also highlights other possible trajectories, helping them gain a sense of their own purpose and orientation within a landscape of practices.

The sum of these guidelines align well with Jackson's (2016) work which focuses on the role of complex CoPs in the development of learners' *pre-professional identity* early on in university. Identity thus begins its journey in its purely academic form and evolves into its broader professional dimension, through the rich boundary experiences gained in a cross-organizational CoP practice (Farnsworth et al., 2016; Novakovich et al., 2017).

7.4 Model transferability

The proposed governance model in this work provides targeted recommendations for educational CoPs, which are attuned to the *socio-epistemic* and *technological* dynamics of *Design*-based communities with a cross-organizational scope, to support the entry and epistemic development of learners in the Design disciplines (Amin & Roberts, 2008; Smith et al., 2017).

However, each CoP intervention may be subject to its particular intra-disciplinary conditions and characteristics. While different fields like architecture, computer science, and HCI, may not follow identical methodologies or tools, they share foundational similarities, making the guidelines readily adaptable to adjacent Design settings (Bhatnagar & Badke-Schaub, 2017; Zimmerman & Forlizzi, 2014). At the same time, the fact that our *findings* and *guidelines* confirm and align with those of others in the literature (Borzillo, 2017; Novakovich et al., 2017; Waycott et al., 2017), even within seemingly different genres of CoPs, reinforces their transferability into other domains and contexts. Nonetheless, further research and adaptations are needed for cases of *distant transfer* to leverage the model's full potential within specific disciplinary learning settings.

Lastly, to fully empower prospective CoP stewards with full clarity on how to adopt, steer, and evaluate the cross-organizational model in their own contexts, this research delivers both *specificity* and ample room for *customization*, to accommodate the practices of different disciplines. An extended online model version (Section 6.4) (Mavri et al., 2021) provides rich examples and ideas of *practical instructional interventions*, *methods* for measuring student performance and model effectiveness*, and available technology tools*, with a broad range of applicability to various CoP practices.

7.5 Conclusion

This work presents research that is interdisciplinary, drawing on diverse theoretical and empirical evidence from fields such as learning and instruction, social psychology, educational technology, Human-Computer Interaction, 21st-century soft and digital skills that are integral to Design education, as well as innovation strategies through university-industry collaborations.

From a theoretical perspective, it advances the CoP conceptualization into a cross-organizational CoP model, following its design, empirical enactment, and evaluation of its impact on learning in HE. It also employs CoPs as a robust social learning framework, to guide the university-industry collaboration initiative it proposes. This is reportedly missing from the literature since most of the existing UIC studies adopt frameworks from organization-based research to frame their design and evaluation (Albats, 2018; Etzkowitz & Ranga, 2015; Scandura, 2016).

From a practical perspective, this work integrates the abovementioned conceptualizations, theories, literature directions, orgamizational spheres and disciplines into a "coordinated and coherent whole" (Choi & Pak, 2006, p. 351). In doing so, it designs a robust learning ecology, analyzes and explains the emergent CoP-based learning phenomena, and derives practical governance mechanisms for use in similar incentives. Consequently, it offers an affordable and transferable cross-organizational CoP model to assist instructors, technologists, researchers, and practitioners who wish to adopt it to enhance their learning environments in HE.

Limitations The research presents limitations with regard to *external* validity. Due to the small number of participants and localized nature of its sample (sample of convenience), it is difficult to generalize findings to the population of interest, that is, students in Design courses. That said, there is greater confidence in its *ecological* validity (i.e. transferring to different settings within adjacent disciplines), since the studies occurred in *natural* (classroom), versus *controlled* environments, the stimuli under investigation (i.e. websites, epistemic outcomes) were naturally occurring and concrete—rather than abstract and arbitrary. Additionally, the participants' behavioral responses were representative of the real world, since the score-based tools employed (i.e. scales, questionnaires) are used extensively in real-life situations (Gouvier & Musso, 2014).

Future work There is much room for enhancing the research's trustworthiness and impact with future studies. Indicatively, while the Design disciplines share a high level of resemblance, further research into the learning environments of *specific Design sub-disciplines* can validate and augment the cross-organizational CoP model with more targeted information. Exploring cross-organizational CoPs in *multi-disciplinary* and *diverse international* or *cultural* settings can also shed light on the intricate socio-technical and socio-emotional learning dynamics of such CoPs. Lastly, the pandemic situation and similar circumstances have underscored the need to explore *exclusively online cross-organizational CoPs*, where physical presence is not possible.

Appendix I

Table 6 Web Site Creativity Measurement Instrument (WSCMI)

1. Aesthetically appealing design	1. Artistic 2. Colorful 3. Energetic 4. Beautiful 5. Fascinating 6. Entertaining 7. Engaging 8. Attractive 9. Favorable 10. Desirable
2. Interactive design	11. Interactive 12. Animated 13. Multimedia-available 14. Dynamic
3. Novel and flexible design	15. Original 16. Appealing 17. Flexible
4. Affective design	18. Stimulating 19. Pleasing 20. Delighting 21. Exciting
5. Important design	22. Relevant 23. Important 24. Crucial
6. Common and simple design	25. Infrequent 26. Rare 27. Sophisticated
7. Personalized design	28. Personalized

Table 7 Examples of three types of questions to assess conceptual knowledge

Short answer questions	
• Which graphics file type would you choose, if you had to optimize a full-color image with multiple gradients, to achieve a lossless image compression for the web and why? • Please explain the two main advantages of using a <label> tag rather than plain text in HTML forms.	
Multiple choice questions	
• Please select two of the following options, which reflect correct syntax for the label tag in an HTML form:	a. <label id='student'> long description </label> <textarea id='student'> text </textarea> b. <label> long description <textarea id='student'> text </textarea> </label> c. <label> long description </label> <textarea id='student'> text </textarea> d. <label for='student'> long description </label> <textarea id='student'> text </textarea>
Long answer - Essay type questions	
a. Explain the concepts of a) 'grid-based' and b) 'above the fold' design. b. Discuss how these translate to design heuristics for the web.	

Table 8 Comparison of website creativity evaluations' (WSCMI) independent samples t-test for experimental and control groups

	Experimental			Control			t	d.f	P	Cohen's d
	N	Mean	S.D	N	Mean	S.D				
Aesthetically appealing design	167	3.89	1.28	143	2.97	1.60	-5.46	271.03	< 0.001	0.628
Interactive design	173	4.30	1.20	144	3.30	1.51	-6.37	270.15	< 0.001	0.727
Novel and flexible design	173	4.00	1.27	144	2.97	1.50	-6.52	281.67	< 0.001	0.742
Affective design	170	3.76	1.30	144	2.73	1.60	-6.21	274.80	< 0.001	0.710
Important design	173	4.22	1.17	143	3.47	1.61	-4.66	253.58	< 0.001	0.535
Common and simple design	172	3.45	1.31	144	2.81	1.34	-4.23	301.63	< 0.001	0.478
Personalized design	173	4.01	1.52	143	3.28	1.72	-3.91	286.39	0.001	0.444
Overall mark	173	5.77	1.67	144	4.34	2.26	-6.31	258.22	< 0.001	1.223

Table 9 Experimental and control group exam scores' independent samples t-test

	Experimental			Control						
Exam scores	N	Mean	S.D	N	Mean	S.D	t	df	P	Cohen's d
	20	66.95	13.04	17	55.71	3.92	-2.33	35	.025	1.167

Table 10 Frequency of communication in experimental and control groups

	Faculty members			Alumni mentors			Industrial mentors	
Group	Project	Team emails (threads)	Team emails (unique)	Alumni mentors Emails (threads)	Alumni mentors emails (unique)	Behance feedback posts	Client emails (threads)	Client emails (unique)
Exp (CoP)	1	10	20	3	5	27	8	10
	2	9	23	2	12	21	6	15
	3	9	37	3	13	24	10	24
	4	7	20	2	6	26	1	1
	5	19	47	4	9	27	4	8
	Total:	54	147	14	45	125	29	58
Control	1	1	1	n/a				
	2	11	42					
	3	8	16					
	4	5	13					
	Total:	25	72					

Table 11 Feedback coding frequencies

	Instances	Percentage
FOCUS	376	30.4%
FOCUS\Form	252	20.4%
FOCUS\Function	115	9.3%
FOCUS\No Code	4	0.3%
FOCUS\Representation	4	0.3%
TYPE	517	41.9%
TYPE\Brainstorming	41	3.3%
TYPE\Comparison	19	1.5%
TYPE\Direct Recommendation – Verbal	240	19.4%
TYPE\Direct Recommendation – Visual	0	0
TYPE\Free Association	3	0.2%
TYPE\Identity Invoking	0	0
TYPE\Interpretation	32	2.6%
TYPE\Investigation	29	2.3%
TYPE\Judgment	151	12.2%
TYPE\Process Oriented	2	0.2%
TONE	342	27.7%
TONE\Negative	183	14.8%
TONE\Neutral	94	7.6%
TONE\Positive	65	5.3%
Total	1235	

Abbreviations ACAD: Activity-centered analysis and design; CoP(s): Community(ies) of Practice; CSCL: Computer-supported collaborative learning; CSCW: Computer-supported collaborative work; CSTs: Creativity Support Tools; HE: Higher Education; HCI: Human-Computer Interaction; LPP: Legitimate Peripheral Participation; MM: Multiphase Design; Q&A: Question & Answer; RQ: Research Question; SN: Social Network; UIC: University-Industry Collaboration; VCoP: Virtual Community of Practice; VC: Value Creation; WDD: Web Design and Development

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Declarations

Conflict of interest None.

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