



# Disconnected Connections of Learning Beyond Formal Schooling Through Human–Computer–Human Interactions

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## Abstract

This article originated from a working group on “Learning beyond formal schooling through human–computer–human interaction (HCHI)” convened at the UNESCO EDU-SummIT 2023 in Kyoto (Japan). A polylogue approach was adopted by engaging eight co-authors whose diverse perspectives culminated in propositions that addressed the pivotal question: How should the connections between formal, non-formal, and informal learning be considered in a digitally mediated world? Formal learning is typically structured, organized and chronologically arranged institutional learning, whereas informal learning is associated with everyday learning across contexts throughout one’s life, and non-formal learning is a hybrid of these forms of learning. Considering the growing prominence of informal and non-formal learning in a digitally mediated world, the evolving learning ecosystem calls for a recalibration of the emphasis on formal learning. In this regard, HCHI has the potential to mediate human–human interactions, thereby bridging formal and informal learning. Our articulated position is to preserve the distinct boundaries and inherent complexities of each type of learning while creating opportunities or ‘bridges’ to authentically draw on the processes of each through meaningful actions. The polylogue yielded three propositions to bridge the connections between formal, non-formal and informal learning spaces in a digitally mediated world: (a) formal education institutions can establish strategic alliances and collaborations with learning organizations beyond the formal educational system, (b) the creation of digital learning communities within formal and non-formal spaces exemplify a paradigm of operation in an unregulated, student-centric cohesive space where the educator is a co-participant, (c) the recognition of the value of informal learning experiences by formal education institutions is critical, with emphasis on the learning process rather than the product.

**Keywords** Human–computer–human interaction · Informal learning · Non-formal learning · Connected learning

## 1 Article Premise

Human–computer–human interaction (HCHI), understood as the communication and interaction between humans mediated by digital technologies, is an essential feature of today’s digital world. HCHI is not new and has been evident in ‘informal’ online learning communities through social media channels since the beginning of the World Wide Web. Online education, as a more standard or ‘formal’ approach to HCHI, gained large-scale adoption during the pandemic. What is interesting now is the blurring of boundaries of learning between formal learning, informal learning, and non-formal learning driven by teachers, students, and even systems to potentially revolutionize how education is carried out. From an educational perspective, this polylogue explores and evaluates the potential gains, opportunities and risks originating from these social, technological, and economic trends. This article represents a joint intellectual effort in this direction, originating from a working group on “Learning beyond formal schooling through human–computer–human interaction” convened at the UNESCO EDUSummIT 2023 in Kyoto (Japan). There are three parts to this article. *Part 1* provides the conceptual position that emerged from the EDUSummIT exploring formal, non-formal and informal learning and the nature of an evolving learning ecosystem. *Part 2* provides a professional dialogue by authors on three elements which further explore the conceptual position, these being, the influence of regulation, student approaches and a teacher’s role. *Part 3* provides synergies as representations of collective wisdom to present tensions and realities of what is understood as ‘Learning beyond formal schooling in the digital era.’

## 2 Part 1- Conceptual Position on Learning Beyond Formal Schooling

In a digital era where boundaries for learning are blurring, this article responds to seek more understanding by examining: *How should the connections between formal, non-formal, and informal learning be considered in a digitally mediated world?* In responding to this question, this section will address two major learning dynamics associated with learning beyond formal schooling: forms of learning- formal, non-formal and in-formal learning, and human–computer–human interaction (HCHI) uncovering the nature of an evolving learning ecosystem (see other models of learning ecosystems such as Nguyen & Tuamsuk, 2022). This forms the basis for which the authors engage in a polylogue to further respond to the research question and come to deeper insights into learning beyond formal schooling in a digital era.

## 3 Defining Formal, Non-Formal, and Informal Learning

From a review of the literature, including existing definitions by Johnson and Majewska (2022), there is greater consensus on definitions of formal and informal learning than non-formal learning. Formal learning tends to be aligned with organized and temporally defined periods of institutional learning, while informal learning is used to describe everyday learning across contexts throughout one’s life (Johnson & Majewska, 2022). Often, informal learning does not take place under the explicit premise to learn something in compliance with a given curriculum; rather, informal learning is situated in the context

of non-educational activities with its own corresponding goals and exigencies (Johnson & Majewska, 2022). The notion of non-formal is more fluid and less distinctive. “Non-formal learning is a hybrid of the other forms of learning, meaning that it is in the interaction of formal and informal elements that non-formality attains its special character” (Johnson & Majewska, 2022, p. 4).

Drawing on the history of pedagogical thinking (Shulman, 1986), this suggested understanding of informal learning resonates with the notion of “collateral learning” coined by Dewey (1938). In pedagogical literature, guided field trips or museum visits as extensions of school-based learning have been put in the context of informal learning (e.g., Cox-Petersen et al., 2003; Martin, 2004). There is no direct contradiction as long as the informality is attributed to the environment (such as a museum) and not to the organizational context of the learning activity, which would be the school for many guided museum visits. It is, however, interesting to see those definitions originating from a political and societal perspective resulting in a narrower framing of informal learning as compared to the discourse in STEM learning. In our argumentation, we adopt the narrower view of informal learning by excluding cases in which informal learning would be conceived and organized as an extension of schooling activities. The intermediate notion of non-formal learning would still allow for subsuming such cases (cf. Eshach, 2007).

Based on these definitions by Johnson and Majewska (2022), we have adopted a quite restrictive definition of informal learning that allocates it largely outside the practices of organized educational systems. According to this definition, informal learning would not take place within educational institutions, nor would it follow a predefined curriculum and prescribed learning goals. Whereas non-formal learning is a less restrictive modality allowing us to use it as a “bridge concept” that can subsume different types of transfer and exchange of ideas between these two practices.

## 4 Human–Computer–Human Interaction

The domain of Human–Computer Interaction (HCI) predominantly examines the relationship between humans and technology. The HCI domain initially emphasized user-friendly design and efficient interaction with technology (Meen et al., 2023). As interpersonal communications become technologically mediated, human computer human interaction (HCHI) emerges, offering a nuanced perspective on how technology acts as an intermediary, reshaping human relationality. Roberts (2019) pinpointed the transformation from the user-focused approach to an interconnected framework encompassing HCHI. This shift is not merely technological but sociocultural, where digital devices are not just tools but active participants in shaping human discourse.

In this shaping of human discourse through computer interfaces, metaphors and analogies are used as they are an integral part of human language for understanding; they are used to explain something that is unfamiliar. In HCHI, metaphors (e.g., using “desktop” to describe a computer interface) play a central role that provides the cyberspace a structure that is similar in some way to aspects of a familiar entity of own behaviours and properties. The interface metaphors enable people to know what to do at an interface (Roger et al., 2023).

The digital world offers an unparalleled platform for self-expression. Goffman’s theories (1956) about how people assume roles they use in their daily interactions with others serve as a theoretical foundation, but the digital age adds layers of complexity

(Papacharissi, 2010; Prestridge et al., 2023). Papacharissi (2010) highlighted the tension between authentic identity and the polished online personas individuals create. McKenna Lawson (2022) further expanded this by examining the societal implications of curated digital identities, especially regarding mental health and societal expectations. HCHI represents more than an interaction modality, rather it implores digital interplay and an individual's re-identification.

Digital communication's absence of traditional paralinguistic cues necessitates novel modes of expression. Walther's (1996) "hyperpersonal communication" suggests that online exchanges, paradoxically, might offer deeper interpersonal connections than face-to-face interactions. Baym (2015), and Nguyen and Johnson (2022) explored the symbolism and semiotics of emojis and GIFs. Their work suggests these digital symbols are not mere replacements but evolve into complex communicative constructs in their own right, aligning also to Kaye et al.'s (2023) view of emojis as 'social indicators' to help support effective interpersonal relations. Digital platforms, once passive tools, now resonate as vibrant sociocultural microcosms. Rheingold (1993) observed early online communities, identifying unique norms and rituals. Jenkins (2006) later postulated these platforms as "participatory cultures," emphasizing user agency and collaborative content creation. Kor-Sins (2021) analyzed how platforms such as Twitter and Reddit develop their unique cultures, norms, and linguistic subtleties, while Hiebert and Kortess-Miller (2023) identified Tik Tok as a platform for supporting gender and sexual minority youth social media cultures. Both symbolism and social discourse are key tenets of cultural representations that are creating varying interactions digitally.

Amidst digital anonymity and the emergence of digital culture, how do users establish trust? Luhmann's foundational work on trust (2000) set the stage for McKnight and Chervany (2001) to delve into the dynamics of online trust cultivation and present a holistic understanding of digital trust. It encompasses factors such as platform credibility, user reviews, shared digital histories, and interface design, emphasizing the multidimensional nature of trust in digital spaces. Technology's pervasive reach prompts a myriad of ethical dilemmas. Boyd and Crawford (2012) initiated dialogues around the ethics of big data, data privacy, and user consent. Subsequent discussions by Miller (2019) scrutinized the boundaries between AI-mediated interactions and genuine human engagements, probing the potential for manipulation, misinformation, and the erosion of genuine human connection. The advent of advanced AI systems further complicates the landscape. As systems grow in sophistication and integration into everyday platforms, they blur the lines between genuine human interactions and AI-mediated exchanges (see Rubin et al., 2024). Exploratory works by Miller (2019) have initiated this discourse, suggesting that future endeavours in HCHI will grapple with AI's role in shaping, facilitating, and sometimes even mimicking human relationships.

Moving onto HCHI in learning can be described as pervasive but recognisable. In formal learning environments characterized by organized educational settings such as schools and universities, HCHI's implications are deeply embedded. The digitalization of education has led to the emergence of platforms like learning management systems and virtual classrooms, which fundamentally alter the nature of student–student and student–teacher interactions (Ahn & Clegg, 2018). Underpinned by HCHI principles, these platforms influence knowledge construction, pedagogical approaches, and skill development within a tech-augmented setting. While technological advancements in formal education can democratize access and foster a sense of community, they also present challenges like potential detachment or engagement deficits in virtual spaces. Grasping

the nuances of HCHI is pivotal to ensuring that technology enriches the learning journey and fortifies genuine human connection within formal educational realms.

## 5 Connecting Informal Learning and HCHI

Within informal learning, characterized by spontaneous and unstructured learning episodes outside traditional academic confines, HCHI's significance is paramount. Platforms like discussion forums, social media, or virtual environments anchored by HCHI are pivotal in knowledge dissemination and skill acquisition (Clubb, 2007). The design and user-friendliness of these platforms guide the learner's journey, dictating how knowledge is accessed and assimilated (Meier, 2021). While digital platforms democratize knowledge access and foster global community interactions (Gonçalves & Oliveira, 2021), they also introduce challenges like information oversaturation and potential misinformation (Roberts & Qahri-Saremi, 2023). As informal learning pathways become more prevalent, harnessing HCHI's insights ensures that technology augments genuine learning and fosters meaningful human interactions.

In summary, HCHI has been represented as shaping human discourse while offering the emergence of new digital cultures. In formal, non-formal and in-formal contexts HCHI is modulated by digital discourse through the interaction with digital tools affecting relationships, communication patterns and the learning process itself. HCHI based tools and platforms modulate learner-facilitator and learner-peer interactions, directly influencing the learning experience (Lai et al., 2013). Although digital platforms can expand access to learning resources and foster global interactions, challenges like ensuring depth of engagement and overcoming technological barriers remain (D'Mello, 2021). As the popularity of informal and non-formal learning avenues surges in a digitally-driven world, understanding HCHI becomes essential to maximizing the potential of technology in enhancing human-centric interactions.

There are a variety of social practices based on and enabled by HCHI and communication technologies that are important and relevant sources of informal learning. Examples of such practices are productive online communities such as the community of Wikipedia authors or communities of Open Source software developers. These communities not only trigger individual learning but also contribute to innovation in industry and society (Dahl-ander et al., 2008). The participation of volunteers in scientific exploration and research, called "citizen science" (Roe, 2021), has traditional antecedents such as astronomy clubs or bird-watching associations. Yet, today citizen science activities are much broader and more numerous, enabled by online participation and data collection and sharing in networked communities such as SciStarter, Zooniverse or EUCitSci. Evidently, this is another important source of informal learning (Aristeidou & Herodotou, 2020; Jennett et al., 2016). This extends to civic engagement enacted in social media spaces, which has been identified as an important factor in the socialization of young and older adults (Feng et al., 2024; Loader et al., 2014).

The learning practices described above as informal learning are highly innovative and stimulate collaborative knowledge building in a community. There is an absence of a curriculum as a potential deficit of informal learning with respect to systematizing and interconnecting the application-specific knowledge and skills with the general body of knowledge and its agreed-upon structure. This calls for (re-)connecting existing "independent" informal learning experiences with structured education and this is still an open issue. In

this endeavor, informal learning experiences may also be considered as triggers of curriculum revision and modification. A related question with immediate practical consequences is the recognition of knowledge and skills acquired through informal learning activities in terms of certified competencies. This is the “accreditation” challenge that has been discussed for open learning formats based on digital participation and learning with open online materials (McGreal et al., 2014).

## 6 The Nature of an Evolving Learning Ecosystem

Based on the above conceptual understandings and our initial deliberations at the EDU-SummIT 2023 in Kyoto, an exploration of an evolving learning ecosystem illustrates the emerging relationship between formal, non-formal and informal learning through HCHI. The current educational landscape is predominated by formal learning, at least in K-12 and higher education settings. There is a premium placed on national, local, and institutional regulation, including curricular content, modes and methods of delivery, and certification of students’ attainment and competency. Non-formal and particularly informal learning, though complex but powerful concepts, fit less well into restricted curriculum models, and rely more on self- or community co-regulation.

Learning involves holistic experience, not just the intended, but also the unintended and accidental, including the attitudes and non-verbalized insights generated through how we learn, as a rhizomatic action (Bogiannidis et al., 2023) that not only blurs the boundary of formal, non-formal and informal learning but also has no obvious beginning and end.

Connecting formal, non-formal, and informal learning is not a trivial task. In considering the possibilities inherent in an evolving learning ecosystem, questions arise about regulation, student approaches and teacher role. Using these three elements we need to ask, whether and how formal education can (or should be) transformed to include non-formal project-based learning inspired by informal practices. This would imply overcoming disciplinary boundaries and constitute new synergetic learning experiences. This disconnected connection of formal, non-formal and informal learning may enable new ways of thinking and re-shape how learning is considered but it may also be counter-productive and reduce the actual potential within each learning domain.

## 7 Part 2- Provocating Professional Dialogue on an Evolving Learning Ecosystem

To examine an evolving learning ecosystem of the connections between formal, non-formal and informal learning through HCHI a polylogue was considered an appropriate methodology as it allowed for multiple authors from different cultural backgrounds to draw upon their own educational expertise in the field of connected learning and have their contributions equally considered (Egbai & Chimakonam, 2019). Following a similar process outlined by Markauskaite et al., (2022) of collective knowledge making in post digital dialogues, eight co-authors individually contributed their known paradigms before coming to a shared understanding through a unified response to the major research question: *How should the connections between formal, non-formal, and informal learning be considered in a digitally mediated world?* The use of dialogue as a mechanism for both self-reflection individually and group co-construction with many (stakeholder’s) cultures was

foundational to this polylogue. A polylogue carried out through dialogue can be characterized by “tolerance, critical concession, unbiased accommodation, creative consensus and de-othering” (Egbai & Chimakonam, 2019, p. 177) which was considered as an essential pathway for bringing many and varied schools of thought productively together.

We believed this methodological approach to gathering professional insights to be the most valid and representational of both an individual authors’ perspective as well as the emerging collective wisdom of the group. The authors came from multiple cultural contexts for teaching and learning and varied widely in their own educational and professional journeys. What unified the collective was a research background in learning technologies and specifically how learning is mediated by digital tools through and across various (informal-non-informal) spaces. Egbai and Chimakonam (2019) emphasize that intercultural engagement in the form of dialogue and polylogues seek to create a collective knowledge economy. For a shifting or evolving concept of a digitally enabled learning ecosystem, the ability to represent one’s stance or philosophical position is required before a systematic organization of collective sensemaking. In other words, each voice needed representation to provide an informed and intercultural manifestation.

The process for our polylogue involved three stages. The first stage set out to develop a community of researchers by coming together online in a ‘first-step’ brainstorming meeting then in a physical meeting in Japan in 2023 at the EDUSummit 23 in Kyoto. Both the online and physical meeting involved group activities, whole group sharing sessions and the development of co-constructed artifacts. This initial stage sought to build a tolerance and recognition of each researcher’s background, cultural context, and research interests in our field of connected learning. Only one of the co-authors was unable to attend this stage. The major artifact that emerged from this stage was a conceptualisation of the nature of an evolving learning ecosystem presented in Part 1. This brought together our initial ideas on formal, non-formal and informal learning and HCHI. This became a focal point of our polylogue.

The second stage built on these initial ideas as foundations for more robust and in-depth exploration of the evolving learning ecosystem. To investigate, question, clarify and critique our first collective wisdoms, in the second stage we chose to give voice to individual thought to fully consider each researcher’s perspective and further capture cultural meanings. Each author was asked to respond to three questions independently in a separate document emailed by the first author and sent back only to the first author. The second stage built on initial ideas as foundations for more robust and in-depth exploration. While discussing a learning ecosystem as evolving, three elements were central to how the connections between the learning spaces though HCHI may or may not occur. These three elements were: (1) the influence of regulation; (2) student approaches; and (3) educator’s role.

Based on these three elements each author was asked to independently provide a short response of 600–800 words to the following questions:

- Q1. Who should regulate whose learning?
- Q2. How do learners shape and navigate learning in a digital realm?
- Q3. How must the roles of educators and knowledgeable others be redefined in digital learning ecosystems?

The third stage involved a synthesis of individual responses by the first two authors with a third author checking for trustworthiness (Guba & Lincoln, 2005). The first two authors constructed a summary of responses for each question, these were presented back to the authors for confirmation and/or changes. From this summary the three authors examined the data further to establish synergies and relationships, with the first author establishing

the major themes followed by further analysis by the other two authors, back and forth, until agreement was achieved. The emergence of all themes and their representation were then presented to all authors collectively and discussed. For author individual contributions and for discussion of themes, two communication mechanisms were created. Firstly a shared folder housed all paper materials and an email communication list was created for on-going conversations and contributions for refinement and validation of collective insights. As the authors were on different time zones and as their work schedules varied, a simple, open and familiar communication medium was required. Once findings were agreed, a representational model was then constructed which responded to the major research question and again was presented to all authors posted in the shared folder and discussed through email.

In the following findings section the eight author contribution summaries are presented (see Table 1). There was no sharing of individual contributions until the final presentation of themes to the group. This process and the publishing of each author contribution in full was undertaken to provide a transparent process to the research community of the polylogue and to further validate trustworthiness of the data. As such in the following findings section, each authors' contribution is presented followed by a discussion of the findings that were collaborative validated.

## 8 Findings

A supplementary file has been provided which presents each of the eight authors' contributions to the three questions posed-in full. These are presented in no particular order.

In our authors' individual responses to considering the ways of thinking that surround formal, non-formal and informal learning and HCHI, Table 1 represents a summary of their responses, articulating the key concepts driving their view of learning in a digital realm. The three elements of regulation; student approaches and educator's role are unpacked through responses to the questions.

Three elements were examined individually that underpin an evolving learning ecosystem of the connections between formal, non-formal and informal learning through HCHI: the influence of regulation; student approaches to learning; and an educators' role. Each of these will be discussed, considered here as unravelling a concept:

*Unravelling regulation:* Regulation was considered by the authors in terms of learning- learning that can be assessed equally with learning which cannot be assessed such that Charoula wrote "online and open learning platforms has introduced a level of flexibility and accessibility" that challenges the traditional boundaries of education (represented by Charoula; Eugenia; Ayoub); learning as a shared responsibility such that "learning is a shared responsibility between learners and knowledgeable others in diverse socio-cultural ecosystems" stated by Michele (represented by Michele; Ulrich, Ferial); and learning as self-regulated, such that learners "needed to attain self-regulation" stated by Brendan (represented by Brendan, Shesha). These positions on learning then drive regulation to be considered, respectfully as, external, community and self-regulated.

*Unravelling student approaches:* All authors gave importance to authentic, real learning approaches that require critical thinking in the form of civic action orientated work. This was evident through emotional responses that drive commitment and complexity to the task, such as lifting to passionate learning that leverages co-deisgn and collaborative knowkedge building, personalisation, and self-awareness (represented by Michele,



**Table 1** Summary of author responses to 3 questions

Authors	Q1. Who should regulate whose learning?	Q2. How do learners shape and navigate learning in a digital realm?	Q3. How must the roles of educators and knowledgeable others be redefined in digital learning ecosystems?
Charoula	The need to effectively negotiate the balance between regulation and autonomy in the digital age, regulatory bodies must adopt a nuanced approach that takes into consideration quality, flexibility, equity, and lifelong learning, while addressing data privacy, security, and feedback from various stakeholders	Self-directed personalisation that leverage resources and tools in digital platforms for social mediated peer engagement; one-size-fits-all traditional curriculum learning and institutional resistance to digital technologies can be a hindrance	To facilitate exploration, curate content, mentor and coach to provide personalized support; as well as providing expertise and industry relevant knowledge and facilitate networking opportunities
Eugenia	Formal education has not been the only source of knowledge for decades and should only legitimize/certify what has been learnt	Solving real problems through interdisciplinary and multidisciplinary approaches ensures critical thinking and curiosity	Different mindsets exist. Changing mindset to co-creator and guiding mentor
Michele	Learning is a shared responsibility for equitable and inclusive participation where learners co-design and conduct peer review. Design-based research can be used to optimize the learning ecosystems	Passionate learning brings co-design and co-participation in knowledge sharing and knowledge building facilitated by digital and social technologies	Reflexive and responsive teaching using expansive thinking, providing ongoing feedback for students' continual improvement. Need to balance both structure, openness and flexibility
Ulrich	The autonomy of informal learning spaces should be respected, leaving regulation to general social & political rules. Conceive non-formal learning as a bridge concept for transferring informal practices to educational settings, e.g., through project-based learning	Social media literacy and competency is a key condition for supporting productive participation and engagement in online communities. Education should foster motivation, confidence and self-efficacy for this kind of engagement and agency	Educators should foster mutual awareness and exchange between formal and informal learning spaces, trying to overcome social and mental barriers. Teacher professional development can take inspiration from informal practices
Ayoub	Formal and non-formal education system regulate through validation of learning outcomes while informal regulates through self-regulatory processes. In formal learning can also be validated and recognized by institutions	Through a combination of innovative thinking, human-computer collaboration, and self-regulation	A shift to the development of hybrid learning systems where the educator play the role of a motivators for self-regulated learning
Brendan	Blurring the boundaries of formal education and informal and non-formal learning experiences through blended learning environments, regulated through learner autonomy and self-regulated learning	Students engage in self-directed learning with constructive instructor feedback, peer support, and independent and guided practices	Act as brokers in an enriched digital learning ecosystem to minimize the gap between formal and informal learning spaces

**Table 1** (continued)

Authors	Q1. Who should regulate whose learning?	Q2. How do learners shape and navigate learning in a digital realm?	Q3. How must the roles of educators and knowledgeable others be redefined in digital learning ecosystems?
Shesha	Balancing between institutional, self, and community regulation. Self-regulation allows flexibility and supports individual goals; community regulation can provide support but also conform learners to certain expectations	Self-awareness, self-management, collaboration, critical thinking, and creativity	Teachers as critical facilitators, creators, developers, mentors, coaches, and knowledge and skill navigators
Ferial	Collaborative effort of many stakeholders: software company, government, schooling, teachers & students	Students personally direct their learning, with others, collaborating and developing literacy skills	Educators as guiding, personalizing and building students' skills as global citizens

Charoula, Shesha; Ferial); social responses that drive shared ownership- team work, collaboration, participatory contribution (represented by Michele, Ulrich) and cognitive responses that leverage critical complexities- problem-solving, critical thinking, constructive feedback, innovative thinking (represented by Eugenia, Charoula, Shesha, Brendan, Ayoub). Michele contextualised a student approach in saying that “in participatory learning ecosystems, learners choose what to learn and how they learn”. The dimensions of emotional, social and cognitive engagement types proliferate digital interaction literature (see for instance COI- Garrison et al., 2001), however, what was evident also was the interplay between the dimensions such that ‘passionate learning’ as emotional-social engagement driving (and sustaining) more complex cognitive engagement.

*Unravelling educators’ role:* To move into shared digital learning spaces, the authors agreed that there is a need to shift ‘instructional’ role towards moderator and thought-provoker; and the need to heighten communication and feedback practices, with Ayoub explaining that “above all the teacher/educator should play the role of a motivator for self-regulated learning”. To accomplish this, the authors identified characteristics of the educator- the facilitator, mentor, coach, broker (represented by Eugenia, Charoula, Shesha, Brendan, Ayoub, Ferial) but also the need for on-going responsive, reflexive communication exchanges (represented by Ulrich, Michele) that requires “teachers to balance both structure and openness, to offer flexible boundaries that support and guide learners as they undertake meaningful, challenging and complex collaborative inquiries” stated by Michele. Connecting to the student role, educators were also tasked with motivating and lifting students to engage with each other as knowledgeable contributors.

In bringing these three themes together in considering HCHI that underpin formal, non-formal and informal learning, consideration of different forms of regulation beyond the self are needed for passionate learning driving cognitive engagement through social-emotional interplay while the educator swivels from an instructor’s role to that of a broker of communication maintaining flexible boundaries.

## 9 Part 3: Discussion of Synergies: What this Means for an Evolving Learning Ecosystem

In responding to the major question that directed this article: *How should the connections between formal, non-formal, and informal learning be considered in a digitally mediated world?* an unravelling of theoretical understandings of regulation, student approaches and educators’ role follows as synergies that emerged amongst the authors’ perspectives. By doing this we came to a more informed position on the ‘connection’ which we evidenced as a bridge between formal and informal learning spaces in a computer mediated world.

*A bridge for the connections between formal, non-formal and informal learning spaces in a digitally mediated world:* Having unraveled the three elements here, as a group we came to new considerations that underpin the concept of a bridge as identified in Part 1 based on Johnson and Majewska (2022). Firstly, formal education institutions can establish strategic partnerships and collaborations with learning organisations outside the formal educational system such as citizen science projects, online platforms, non government organisations, museums, and libraries (Bates, 2019). These partnerships enable passionate learning arising from authentic co-design and knowledge building interactions (Aristeidou & Herodotou, 2020). These collaborations facilitate the infusion of expertise and resources from knowledgeable others into the curriculum providing valuable learning

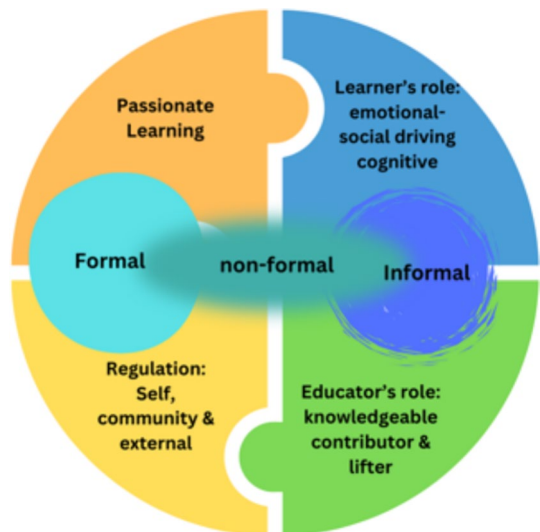
resources through non-formal and in-formal approaches. Formal education can adopt successful informal practices emerging from open social media spaces for project-based learning through forms of non-formal learning (Chounta et al., 2017).

Secondly, the creation of digital learning communities within formal and non-formal spaces is illustrative of ways of working in an unregulated more student-lead cohesive space where the educator is a co-participant. These communities serve as platforms for collaboration, knowledge sharing, and co-creation of content (Dabbagh & Kitsantas, 2012; Tan et al., 2021). They enable interactions among learners, educators, and knowledgeable others, fostering a sense of belonging and collective learning. The more formal ‘educator’ shifts to the ‘meddler in the middle’, a long ago call from Erica McWilliams (McWilliams, 2008) as unravelled by the authors. As a co-learner, the more knowledgeable-other takes on the role to tease out student’s/learner’s thinking and helps them to take mutual responsibility for contributions of content, ideas and direction.

Finally, the recognition of the *value* of informal learning experiences by formal education institutions is crucial, valuing the learning process rather than the product (Prestridge et al., 2021). Even though digital badges or micro-credentials can validate the skills and knowledge acquired outside the traditional structure (Siemens & Gasevic, 2012), motivating and building capabilities of learners to explore and excel through informal learning processes, as part of doing formal learning, is essential for the (digital) mediated world (Aristeidou & Herodotou, 2020; Khaddage & Flintoff, 2023). By neglecting to educate students on how to effectively navigate with technology and use it to learn informally, we are not only denying them access to valuable learning tools and resources, but also are failing to equip them for a future that has evolved beyond our expectations especially now in the ChatGPT and OpenAI era.

In responding to a bridge for connecting formal, non-formal and informal in a digitally mediated world, these authors consider removing notion of blending or unifying the learning spaces, but rather maintaining the boundaries and perplexities associated with each learning dimension and creating opportunities or a ‘bridge’ to authentically draw on processes of each through passionate learning. Informal learning will not authentically occur

**Fig. 1** Bridging the disconnections of formal-non-informal learning in a digitally mediated world



in formal learning activities. It is not effective to consider an engulfment approach where formal learning absorbs informal learning. We offer the position that non-formal learning, represented in Fig. 1, becomes the bridge, the place where passionate learning can mediate authentic formal and informal practices. Passionate learning was described by authors as project based activities requiring purposeful and complex team work engaged in valued sensemaking for civic action. Based on these findings a model is presented as a representation of an evolving learning ecosystem the incorporates what has been unraveled in our polylogue (see Fig. 1):

## 10 Conclusion

In unraveling the intricate interplay between formal education, non-formal, and informal learning within the realm of HCHI, our research endeavors have evolved into a complex and collaborative journey. Spanning over 19 months, commencing in May 2022, our EDU-SummIT Working Group embarked on this exploratory path by soliciting initial insights from participants on the theme of “Learning beyond formal schooling: human–computer–human interactions in a digital interconnected era.” This collective effort has culminated in a shared representation that we now present to the broader research community

These efforts have not only been an endeavor to represent emerging ideas but, for some, a reflection of their life’s work, knowledge, and passion. Throughout this polylogue, the focus has been on navigating the complexities inherent in understanding how learning extends beyond the traditional boundaries of formal education, influenced by the dynamic landscape of HCHI in our increasingly digital, interactive and interconnected world. Rather than adopting an approach that blurs boundaries, our research has been a concerted effort to build bridges. We recognize the intricate relationships that exist between formal, non-formal, and informal learning, acknowledging the transformative impact of HCHI on human discourse and the emergence of digital cultures. The modulation of HCHI across formal, non-formal, and informal contexts is evident in its influence on relationships, communication patterns, and the learning process itself.

Our exploration has substantiated the claim that social media, mobile technologies and virtual communities, as manifestations of HCHI, create new and rich opportunities for informal learning. We firmly oppose the ‘engulfment’ strategy that seeks to incorporate or subsume informal learning under organized education. Instead, we advocate for recognizing and respecting the autonomy and independence of these informal learning spaces. The potential for innovative forms of working, thinking, and learning lies in nurturing and preserving this independence.

The research question we identified explored into critical aspects of an evolving learning ecosystem, addressing issues of regulation in a digital age, the dynamics of learner engagement in digital realms, and the redefinition of roles for educators in digital learning ecosystems. Following Luhmann’s conception of “education as a social system” (Baraldi & Corsi, 2017; Luhmann, 2002), learning practices embedded in educational institutions and informal learning spaces should be conceived as autonomous subsystems. Autonomous social subsystems can interact and influence each other through communication. Communication, in this sense, can be based on personal interaction and exchange but also on exchange through public and social media channels. By exploring this potential, we aim to contribute to the ongoing discourse on negotiating the balance between formal education systems and the autonomy of informal learning experiences in the networked digital landscape.

In conclusion, our collaborative effort signifies a commitment to understanding, respecting, and bridging the diverse dimensions of learning facilitated by HCHI. It is our hope that the insights presented here will inspire further exploration and dialogue within the research community, fostering a more comprehensive understanding of learning beyond the confines of formal schooling in our digitally interconnected era.

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## Declarations

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