Leveraging Collective Intelligence from Crowdsourcing to Co-creation in Field Studies

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The paper explores the advantages and forms of harnessing collective intelligence (CI) that can support cognition, coordination, and collaboration in architectural education. These forms focus on various design tasks by enhancing groups' performance, bringing together diverse actors within a distributed network, and strengthening the process through informed and inclusive decisions. Specifically, we propose a co-creation strategy to comprehensively map place values and rapidly scan the field. By incorporating the technical requirements and contextual constraints of various fields, we conducted iterative workshops within the action research circle. The results show that the CI approach yields significantly positive impacts, justifying its application through a functional triple structure that replaces individually challenging and frustrating fieldwork. This structure involves: (1) definition of parameters and tasks for groups based on objectives, (2) the collection and extraction of values from the field, and (3) the creation of collective cartographies. Additionally, our research makes a valuable contribution by providing a theoretical framework for diverse forms of CI, highlighting the advantages of crowdsourcing-based platforms in both urban and rural contexts, and evaluating the usability of tested mobile apps. We conclude the paper by discussing the limitations, adaptabilities, and potentials for the broader use of CI in the field studies of students.

Keywords: *Collective Intelligence, Co-creation, Field Study.*

INTRODUCTION

What exactly is collective intelligence? There are many definitions of collective intelligence (CI). Rather than adopting a precise definition, the research literature has been scanned to tease out various aspects of CI. This draws attention to several characteristics that are frequently used to define CI, including wholeness, decentralization, distribution, diversity, mutual sensitivity, and collaboration. However, the key factor used to introduce CI is that the wholeness is greater than the sum of the parts in collaboration.

The ways of harnessing CI have evolved with technology. In the CI design playbook created by Nesta (the UK's innovation agency for social good), three factors are outlined to explain concisely how technology amplifies CI: (1) bring more brains together, (2) generate new sources of data such as satellite imagery or mobile data, and (3) enhance human intelligence with machine learning to make better predictions from lots of unstructured information (Peach et al., 2019).

There are diverse CI models for a wide range of domains. A recent systematic literature review presents 12 models that use CI platforms as a vital resource for learning, problem-solving, decision-making, and predictions in different configurations (Suran et al., 2020). According to the defined

components of CI (people, activities, and means), 24 unique attributes are identified, including independence, motivation, critical mass, self-organization, massive interaction, and robustness. This literature review (Suran et al., 2020) confirms the adaptive system of CI, which encompasses various models belonging to diverse disciplines, approaches, and goals.

The World Health Organization utilized CI to gather data, interpret, analyze, innovate, and quickly learn from action on the ground to fight smallpox in the 20th century (Mulgan, 2018). Similarly, the recent pandemic situation has reaffirmed the importance of CI potential based on information technology to tackle global challenges. In the case of COVID-19, CI is primarily used through the apps developed by governmental or private initiatives to identify, inform, take precautions, make better decisions, and monitor the spread of infection. These benefits are predominantly derived from crowdsourcing. However, crowdfunding is also utilized to cover the cost of virus research, support vulnerable groups due to lockdowns, and procure medical devices (Liceras, 2020). While Sennett criticizes power structures that exploit the pandemic crisis to legitimate control, he confirms the power of good ICT (information and communication technology) in producing social outcomes through diversity (Sennett, 2020).

Besides the recent pandemic period, CI has long been used to address the climate challenge and related crises by diagnosing environmental problems, raising awareness, learning, and taking collaborative action. Similar to the Haiti earthquake (2014), the earthquake in Turkey-Syria (2023) can be given as another current example of harnessing CI in crises as a strategy for disaster response. There are some critical crowdsourcing platforms used for emergency declarations, augmenting coordination, connecting people, providing aid and psychological support (like deprem.io, depremenkaz.xyz, afetharita, yakinimibul.net, and deprem.basarsoft), and also establishing baseline metrics to assist in disaster response (like hotosm.org). Effective use of such CI tools can be vital in the management of this regional crisis, where coordination is critical.

The eCAADe 2022 conference emphasizes spatial design as "an increasingly social, participatory, and inclusive practice" with social technologies and crowdsourcing applications. The current eCAADe theme also explores similar concepts, aiming for a more "participatory, collaborative, open, inclusive, and reconsidered digital architecture". In this research, our objective is to reassess the potential for using CI in architectural education. Considering the conference's focus on these shared concepts, this study can contribute to the ongoing discussion. What is the importance of CI in design? Hight and Perry define CI in design through its potential to restructure and transform separate design practices and disciplines into techno-social networks (Hight & Perry, 2006). Briscoe and Hadilou further explore CI as an analytical simulation tool for crowdsourced data and social interaction (Briscoe & Hadilou, 2013). From a pedagogical perspective, CI can support design education, particularly in facilitating collaborative learning, as demonstrated by Tenório et al. (2021).

There are models and platforms developed to support cognition, coordination, and collaboration in planning and design education, such as web-based massive online courses (i.e., Edx, AVOCAAD, and Coursera), geographic information system (GIS)-based platforms, virtual environments, and mixed reality in outdoor experiences. The rescaling and reshaping of the studio process, integrating diverse actors (universities, citizens, sectors, experts, administrative bodies, etc.), virtual environments (like cyberscapes), and interactive settings, has opened up new ways of harnessing CI.

In this scope, increasing applications have contributed to a better understanding the potentials and limitations of utilizing CI in design education: Sketchdrive used in a massive online studio at TU Delft Faculty of Architecture (Ouwerkerk, 2018); social-geographic web platform (GEO-VEM) used in the design studio at KU Leuven University (Pak & Verbeke, 2015); EquiCity, a generative and

participatory design tool developed by Genesis Lab (Azadi &, Nourian 2021); Hybrid Ideation Space (HIS) used in partnership with Berkeley University Architecture and Montréal University Industrial Design (HIS) (Dorta et al., 2011); Architasker, a large-scale crowdsourcing model used in Tel Aviv University (Dortheimer et al., 2020); CityWiki and Douyocity in University of Granada etc. Besides the experimental studies, there are also commercial crowdsourcing models like the Arcbazar competition platform for design projects.

Similar CI-based ideas have been proposed in architectural education. However, there is a lack of knowledge regarding the utilization of CI and crowdsourcing applications during field studies. We have introduced the implementation of easy-to-use strategies by adopting CI. Specifically, our study is structured around a co-creation approach aimed at enhancing collaboration and interaction among students during field studies. We seek to answer the following questions: How can we leverage CI, from crowdsourcing to co-creation, in an efficient and feasible manner? What are the distinctions between emerging crowdsourcing tools in terms of usability? What are the primary strengths and weaknesses associated with harnessing CI in field studies?

Hence, we focused on identifying technical and non-technical problems, students' and tutors' expectations, and, in particular, obstacles to achieving better collaboration in the field study. The proposed strategy is tested in online, hybrid, and face-to-face environments, considering actual demands and applicability related to constraints of the global pandemic period and the current regional earthquake crisis. The following parts describe the research methodology and report the findings related to the process and outcomes of an ongoing research project.

METHODOLOGY

The systematic inquiry follows a four-step process: plan, act, observe, and reflect, based on Kurt Lewin's action research (Adelman, 1993).

- Identify the level of interaction between groups during the pandemic period and address the challenges faced by students in field study, leading to develop an action plan.
- Integrate the proposed strategy into design courses with a particular emphasis on field studies in diverse contexts.
- Evaluate the effectiveness of the modified action plan through participant surveys, workshop outputs, and observations during the process, aiming to gather feedback.
- Modify or develop a new co-creation strategy to enhance utility, adaptability, and usability, based on the insights gained from the evaluation process.

In this regard, complementary workshops have been conducted in three universities: Istanbul Yıldız Technical University (YTÜ), Karabük University (KBÜ), and Granada University (UGR), with the participation of 600 students from 1st to the 3rd years of study (Figure 1).

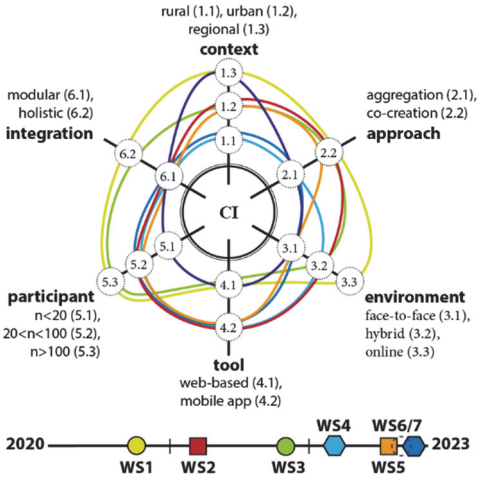

Figure 1
General setting and chronology of the workshops (number of participants and universities: WS1:220-YTÜ, WS2:34-YTÜ, WS3:180-YTÜ, WS4:40-KBÜ, WS5:35-YTÜ, WS6:12-UGR, WS7: 42-KBÜ) WS8: 37-UGR)

The workshop settings are illustrated around six attributes: contexts with various scales, two different CI approaches, changing teaching environments due to pandemic and earthquake crises, crowdsourcing tools, the number of participants, and forms of integration into the course. The WS shapes (square, circle, and polygon) on the chronology line represent the workshops to be compared in the context of the common (re)action circle. Comparative analysis is related to the utility of CI approaches, the usability of employed platforms, and their applicability in different contexts.

Co-creation

During the pandemic period, we conducted a preliminary diagnosis of issues in the online design studio. We utilized semi-structured surveys involving 1st and 2nd-year students (N:87). The surveys revealed a significant difference in the level of interaction between studio groups during online sessions. Students belonging to the same studio group (consisting of 10-15 students) reported higher interaction scores (mean: 4.54) compared to students from different groups (mean: 2.68) and different years of study (mean: 1.51) on a 5-point Likert scale. This indicates critical variations in interaction levels between studio groups. Additional barriers to active engagement were identified, including poor communication, and an unsuitable work atmosphere. Similar statistical scores for interaction levels (mean scores of 3.67, 2.37, and 2.14) were obtained in subsequent surveys conducted in face-to-face studios. Promoting group interaction is crucial in both scenarios. The second diagnosis pertains to field studies, where students' expectations emphasized the need for strategies that enhance dialogue, sharing, and interaction. These strategies aim to improve comprehension, socialization, inclusiveness, and time management during field studies. The findings underscore the clear necessity for reform, particularly in the context of the pandemic.

In this context, our objective is to develop a co-creation strategy for field studies. The model leverages CI from crowdsourcing to co-creation, promoting interaction between groups and enabling the collective handling of complexities and rapid scanning of the field. The co-creation strategy is structured around a functional triple model, aiming to replace individual fieldwork challenges. It involves (1) defining parameters and tasks for groups based on the objectives, (2) collecting and extracting values from the field, and (3) creating collective cartographies (refer to Figure 2). Each iterative workshop allows us to test and refine the strategy, addressing both technical and non-technical issues.

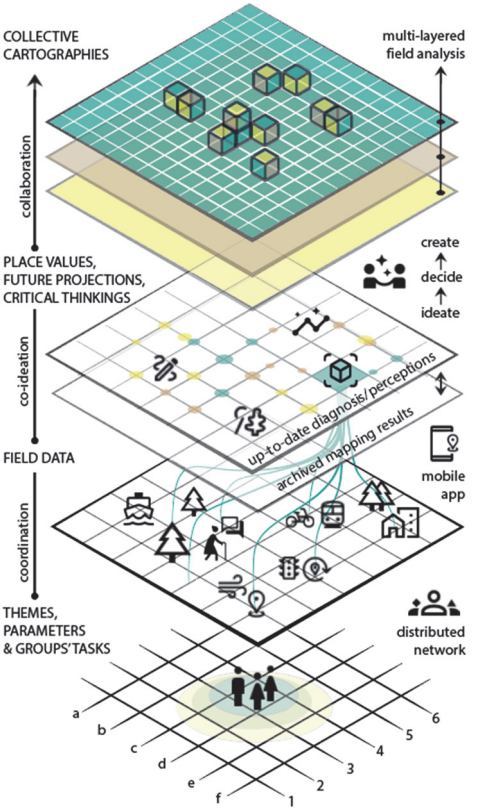

Figure 2
Structure of the co-creation model for field study

RESULTS

The chapter presents the results obtained from iterative workshops aimed at evaluating and improving the strategy based on the defined factors. As mentioned in the action circle, these experiences vary in each case but are comparable regarding modified settings. The findings are categorized into several themes, such as group interactions, the usability of crowdsourcing tools (Emapic, Ushahidi, Felt, Fulcrum, ArcGIS Field Maps, and Survey123), the distribution of field data, the co-creation of cartographies, and the harnessing collective intelligence in design.

Network and group interactions

For the first phase, parameters and tasks for groups were defined based on the objectives and constraints of each field study. The interaction patterns in group works encompassing a wide variety of actors, both human or non-human, were observed in the process.



Figure 3
Interaction forms in various phases of the field studies

To enhance interaction, we created distributed networks among students through collectively defined sub-themes based on field objectives. This led to diverse interaction patterns through small teams comprising students from different studio groups. Activities such as citizen interviews, asynchronous work, field data discussions, and cartography co-creation sessions (Figure 3) further enriched the interactions.

After WS2, the average score for the level of interaction between groups increased to 3.52 (+31%). Additionally, a significant improvement was observed after WS5 compared to the initial diagnosis. The enhanced group interaction, characterized by robust, inclusive, and versatile collaboration, led to better fulfillment of team tasks, as reported by students. This improvement encompassed aspects such as timing, motivation, learning, scaling, diversification, and reliability. However, some negative effects and conflicts between teams were also reported. One recurring concern was that group failures overshadowed individual efforts. The usability of platforms and virtual networks also impacted field interaction.

Utility and usability

The employed tools were evaluated through the PGUS (Participatory GIS Usability Scale) (Ballatore et al., 2019) to improve their actual utility and solve the detected problems in the action circle (Table 1). The tools have various promising features, such as empowering citizens to social change, automating inspection management, data analyzing, and creating maps. Considering the distinctive features, we used them to work together, collate, and map field data.

Table 1
Mean values for usability of apps (Fu:Fulcrum, Us:Ushahidi, Fe:Felt, and Ar:ArcGIS)

Factors	Fu	Us	Fe	Ar
User Interface	3,37	3,62	4,15	3,90
Spatial Interface	3,34	3,11	4,10	3,96
Learnability	3,45	3,79	4,11	3,86
Effectiveness	3,54	3,57	4,05	4,03
Communication	3,67	3,79	4,37	4,16
Total	**3,47**	**3,58**	**4,16**	**3,98**

The qualitative analysis, which involved the evaluation of 186 students, allowed for comparisons between factors and tools. Ushahidi [1], Fulcrum [2], Emapic [3] and Felt [4] are open-source community-based apps, while ArcGIS Dashboards are powered by Esri. The tools can be grouped into two categories: mobile apps (Fulcrum and Ushahidi) utilized in face-to-face courses (outside field study), and web-based apps (ArcGIS and Felt) utilized in online courses. The results indicate that learnability, effectiveness, and communication factors received slightly higher scores than the spatial interface in mobile apps, with Ushahidi scoring the highest (3.58-3.47) across all factors. In web-based apps, communication received the highest score, and Felt outperformed ArcGIS. Scores for virtual experiences were significantly higher than those for outside experiences with mobile apps. Interviews with studio group tutors supported these findings. Additionally, certain tools offer functional advantages, such as Ushahidi and Fulcrum providing minute-by-minute change graphs for monitoring and Fulcrum enabling flexible use and synchronization in rural areas without internet access.

The utility of the digital tools for design education, including Sketchdrive, GEO-VEM, EquiCity, HIS, CityWiki, and Douyocity, was evaluated through several factors. These factors differ according to contexts, including communication, representation, and motivation (Maher et al., 2011); evaluation, ideation, and self-organization (Paulini et al., 2011); interaction, collaboration, and social participation (Schnabel & Ham, 2012). Hence, we have reconsidered factors related to the objectives of CI strategies. We assessed the effects on ideation and evaluation variables for design proposals in addition to the level of interaction described above in the field study. The customizations of the Emapic interface in WS3, based on feedback obtained from WS1, confirm significant improvements on these three factors (Figure 4).

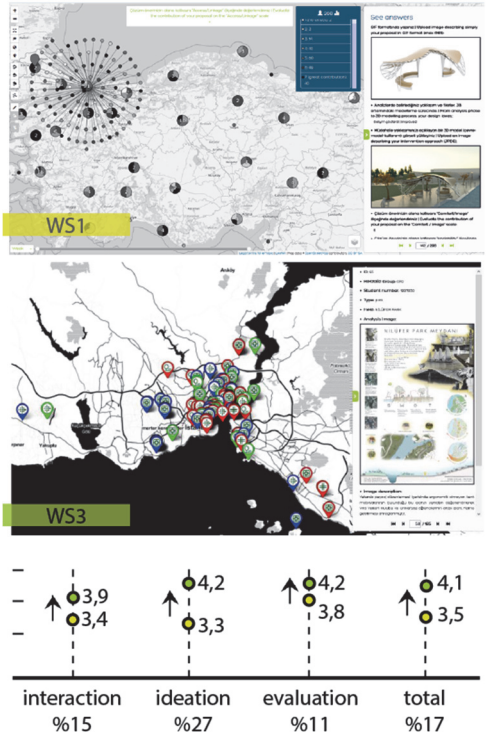

Figure 4
Customization of the Emapic web-based platform interface and its effects on interaction, ideation, and evaluation factors based on the evaluation in WS1 and WS3

Distribution

Field data reflects spatial perceptions and identifies points of interest associated with the microtasks assigned to the group. The primary finding is that distribution mainly relies on students' visual perception, while other senses like sound and smell actively shape our understanding of environmental psychology and contribute to the sense of place. This underscores the importance of providing preliminary instruction to foster comprehensive and diverse spatial perceptions, especially among first-year architectural students. Gender-related differences in spatial perception cannot be examined due to the platform's lack of personal information. Additionally, ArcGIS Field Maps provide location tracking along with captured data.

To understand perceptions in the field study, it's important to consider the physical and virtual (hybrid) worlds together. This includes media environments that are deeply ingrained in our daily lives, as well as crowdsourcing platforms used for data collection, monitoring, and communication, which contribute to this hybrid collective sphere. These platforms have a significant impact by fostering distributed, informative, and competitive networks among participants. Mapping the distribution of collected data in the field relates to the spatial perceptions of students and reveals variations between urban and rural contexts in terms of complexity (Figure 5). To decode this distribution, we utilized Kevin Lynch's five spatial elements of mental maps (Lynch, 1981), allowing us to identify what remained constant or changed across repeated field studies.

In the district of Istanbul (Kuzguncuk), WS2 and WS5 patterns align with key elements such as E1 (waterfront), P1 (main street), N1, N2, N3, and N4 (junctions and meeting points), L1 and L2 (historical monuments), and L3 (urban garden). However, there have been changes resulting from social activities (point X), and the transformation of public spaces due to the pandemic.

In the villages of Yazıköy (Ya) and Yörük (Y), which are located near Safranbolu, WS4 and WS7 exhibit similar patterns but with varying densities around key elements: YaN1 (center of the Muslim quarter with coffeehouse and fountain), YaN2 (center of the Christian quarter with chapel and hammam), YaN3 (secondary center with mosque), YaP1 (connection to the city of Safranbolu), YaP2 (main street and old edge between Christian and Muslim quarter), YP1 (main street and connection to the city), and YaN1 (center).

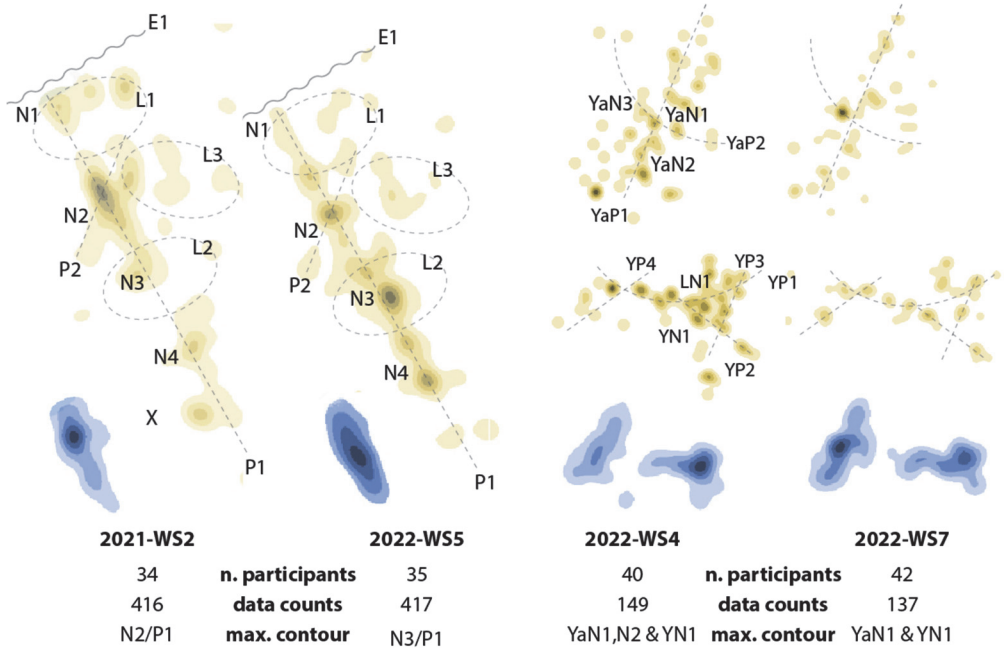

Figure 5
Data distributions (extracted from Ushahidi, Fulcrum, and Emapic) in iterative workshops and comparison between urban and rural contexts (P: path, N: node, L: landmark, E: edge)

Collective cartographies

In the final step of the proposed strategy, field data was processed using identified themes and attachments, such as sketches, pictograms, diagrams, and collages. These representations, whether manually crafted or digitally created, provide diverse and deeper insights into the field. Collective cartographies incorporate critical reflections, future projections, and perceived values from the field, fostering active participation in the co-creation process. Additionally, they allow for detailed addressing of specific issues in the subsequent design phase.

Students bring diverse perspectives to the field, encompassing social, cultural, natural, and morphological aspects. Through group discussions and decisions, individual contributions are integrated into collective cartographies. It becomes essential to address how field detections relate to the holistic understanding, establish connections between layers, select appropriate representational strategies, and prioritize components within the context. The resulting multilayered cartographies, serve as valuable support for students' progress towards designing a more refined project.

Also, the co-creation of cartographies includes several reported issues related to conflicts within or between groups in decision-making. In the context of collaborative learning, these conflicts are regarded as significant as consensus, as they contribute to the overall value of the activities. Consequently, these activities strengthen the strategy's effectiveness, encompassing field coordination and co-creation.

Harnessing CI in design

The distinction between the forms of harnessing CI needs to be clarified. While CI can catalyze a process through the cooperation of independent agents, it also encompasses more profound contributions that emerge from co-ideation to co-action. We intended to encourage both forms of CI with the proposed strategy for field studies.

Another complementary action circle has been established for further design phase. Design proposals that emphasize various public spaces were uploaded on the same platform during the pandemic period to facilitate sharing, learning, transparency, and increased interaction in massive courses. This strategy aims to create an alternative space for interaction, providing multiple solutions for similar project areas or challenges, and utilizing a parametric structure for data-driven proposals (Figure 6). Through this approach, the diversity of harnessing CI in design is evident, with each action circle developing solutions within its specific context. Furthermore, the integration of these action circles enables broader utilization and collaboration.

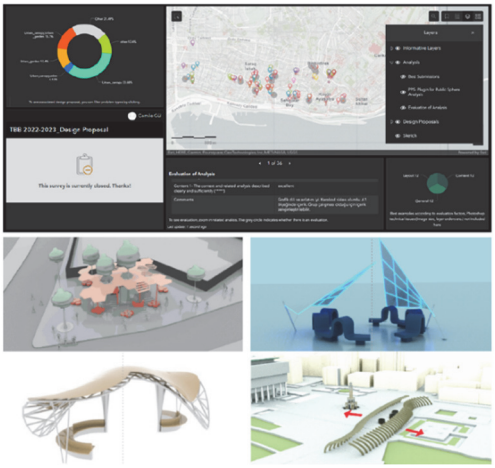

Figure 6
ArcGIS Dashboard illustration of harnessing CI in sharing and evaluating design proposals in WS5 (a total of 169 proposals have been developed in the online course by 2nd year architectural students for public space design)

Limitations

We believe that the research applications cover an acceptable variety to confirm the adaptability of the proposed strategy in different contexts. While CI can enhance certain aspects of field studies through co-creation, we have also encountered various technical and non-technical limitations.

The technical limitations primarily stem from the usability of the crowdsourcing tools. However, iterative actions have led to solutions and customizations (WS1-3) to overcome these

limitations. Improving usability, especially in terms of flexibility to accommodate diverse requirements, remains a necessity. As part of our plans, we intend to test other open-source tools, including KoboToolbox, Epicollect, and QField.

Due to the absence of a reliable measuring model for co-creation in design, our research has primarily concentrated on factors associated with identified issues in action circles. However, there is a pressing need to develop a precise measuring model that encompasses pedagogical aspects. Achten and Beetz conducted a comprehensive review of over 300 studies, on technology-driven and collaborative design. The major problem that was highlighted is the applicability of these studies or the ignoring of the demands from practice (Achten & Beetz, 2009). On the basis of this argument, we aimed to develop an easy-to-use and affordable strategy to solve the urgent demands during the pandemic.

The continued use and refinement of the strategy will enhance its feasibility and benefits. However, the progress or lack of progress of proposed co-creation strategies is a multi-way affair. This means that long-range improvements, namely the permanence of proposed strategies, are up to the actors' actual demands.

CONCLUSION AND FUTURE WORK

This research offers a CI-based strategy to overcome complexity and frustration during the field study process by sensing and diagnosing the physical world in a versatile, interactive, and effective manner. Solution-oriented action circles were created by integrating crowdsourcing tools into a learning environment and tested through iterative workshops to assess limitations and opportunities. The transition from traditional challenging field studies to an interactive, self-organized, and distributed learning process was promoted, particularly for hybrid and online design courses during the pandemic and 2023 earthquake conditions in Turkey. Various limitations of this transition were reported. The strategy contributed to the diversity and resilience of the learning process, culminating in the co-creation of multilayered cartographies. It was confirmed that groups' interactions in hybrid spaces and their collaborations have significant potential for leveraging CI from aggregation to co-creation in field studies.

The wider aim of this research is to discuss the adaptabilities, representativeness, interactivity, and potentials for the broader use of CI strategies in further design phases. Given the increased use of social technologies and crowdsourcing applications, it is important to reconsider CI in design education. Ongoing research therefore focuses on integration action circles to sustain collaboration from field analyses to design proposals. To achieve that, the outlined collaborative design process (see Harnessing CI in Design) should be improved. Another step will be augmenting CI including emotional experiences (i.e., mobile electroencephalogram), computer vision to better understand spatial perceptions, new sources of data (like comparison satellite images, social media reactions and comments, etc.) to the multilayers, predictive analytics to forecast scenarios based on archived datasets, and citizen involvement.

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