Fostering Creative Style "Contamination" and Self-Efficacy in STEAM Students through Multidisciplinary Co-Design

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***Abstract*—In the rapidly evolving landscape of STEAM disciplines, the demand for multidisciplinary communication, problem-solving skills, and creativity has become increasingly critical. Traditional educational curricula often fall short in preparing students with the competencies needed to navigate these complex, interdisciplinary challenges in their professional careers. This study explores the outcomes of a three-day co-design spring school involving 27 students from diverse STEAM fields. The focus is on how participation in community-driven, real-world design activities influenced their self-efficacy, growth mindset, and creative problem-solving abilities.**

To achieve this, we employed a mixed-methods approach, incorporating pre- and post-questionnaires, student diaries, design artifacts, and observational notes. The pre-questionnaire aimed to establish a baseline for creative problem-solving styles and mindset using a reduced version of the Basadur Creative Problem Solving Profile (CPSP), as well as self-efficacy using selected items from Limeri's mindset scale. The post-program assessments measured changes in these dimensions and further explored participants' perceptions of the experience.

The results indicate that students reported experimenting with a different creative approach than their usual one. Additionally, their involvement in a co-design activity targeting the local community and a real world problem significantly influenced the way they approached tasks. Creative style "contamination" was particularly observed in engineering students, who shifted from evaluative to ideative and thinking styles. While mindsets, due to their nature, exhibited limited and non-significant shifts, participants expressed a stronger belief in their ability to contribute to meaningful, real-world projects in terms of a growth mindset. Self-efficacy showed significant improvement, but only in terms of increased confidence in performing diverse tasks.

The findings emphasize the importance of co-design 'for people' and real-world design projects to promote creative adaptability, improve teamwork between disciplines, and encourage students to step outside their comfort zones. In the long term, this approach offers a promising model for STEAM education, preparing students for an increasingly complex and interdisciplinary professional world.

***Index Terms*—Creative Styles, Growth Mindset, Co-Design**

I. Introduction

The Co-Design STEAM Spring School arose from the pressing social needs of the Val di Fiemme community in Italy, particularly in Cavalese. The project aimed to address intergenerational disconnection and community isolation, exacerbated by the closure of the Youth Center after 15 years of activity due to inadequate facilities, limited space, and declining participation. This closure coincided with a decrease in participation in the Cavalese Senior Center, particularly in the post-pandemic period. In response, the municipality established a collaborative network involving public and private entities, as well as third-sector organizations, to develop innovative socially responsive solutions.

Students from the Universities of Trento and Bolzano were engaged in field research and envision technology-driven strategies to reimagine the Senior Center as an intergenerational, multifunctional space accessible to the entire community. Thus, the Spring School was conceived as an innovative educational initiative designed to foster collaboration, creativity, and problem-solving skills among students from various STEAM disciplines. Its primary objective was to equip participants with the tools needed to navigate complex and multidisciplinary challenges in contemporary professional settings. By combining diverse academic perspectives with real-world problem-solving, the program sought to address gaps in traditional educational approaches.

The program brought together 27 students: 18 from the University of Trento, primarily from Engineering and Cognitive Science programs, and 9 from the Free University of Bolzano, representing fields such as Design and Arts. They were guided by a team of nine educators with extensive interdisciplinary expertise and experience in both formal and informal educational settings. Gender balance within the teaching team further emphasized the program's commitment to inclusivity and diverse perspectives.

Hosted directly in the space in Cavalese, the camp offered an immersive experience in interdisciplinary collaboration. Students from the different academic faculties worked together to design innovative technological solutions addressing challenges identified in dialogue with the local community. Guided by Human-Centered Design principles, participants engaged directly with stakeholders to identify needs, frame problems, and propose actionable solutions. These open-ended, ill-

defined challenges demanded iterative analysis and interpretation, fostering critical thinking and adaptability. Collaborating in heterogeneous teams enabled students to appreciate and leverage each other's expertise, expanding their understanding of diverse approaches to problem-solving. For many, this experience marked a departure from their disciplinary comfort zones, highlighting the value of interdisciplinary collaboration.

II. Background

curricula [1]. Bridging this gap is essential for fostering innovation, as STEM and engineering programs stand to benefit significantly from activities and interventions specifically designed to nurture creativity. This need for adaptation is especially pressing given projections that 65% of children who began primary school in 2019 will eventually work in jobs that do not yet exist [2]. Preparing future generations for such a shift requires a comprehensive modernization of educational systems at all levels–from primary schools to higher education–to equip students with the skills necessary to thrive in the digital age.

STEAM education, as an evolution of the traditional STEM model, integrates the Arts alongside Science, Technology, Engineering, and Mathematics, offering a broader and more holistic framework for learning. By incorporating creative and artistic practices, STEAM seeks to cultivate innovation, critical thinking, and interdisciplinary collaboration, all of which are vital to tackling the complex challenges of contemporary society. This integration aligns with a growing emphasis on citizen empowerment, recognizing education as a transformative tool for societal advancement and sustainable growth. The transition from STEM to STEAM reflects a shift in focus from purely technical skill development to a more comprehensive educational approach that fosters creativity and adaptability. Such efforts align with the broader goal of preparing students to navigate and contribute to a rapidly evolving technological landscape. For this reason, the present study adopts STEAM as the guiding framework to explore the intersection of creativity and interdisciplinary collaboration in education.

Co-design and community engagement are gaining recognition as key processes for the successful research and development of innovative and human-centered solutions able to successfully tackle real-needs and bring a sustainable societal impact. These approaches highlight the value of a direct involvement of stakeholders behind the ideation of contextually sound solutions. Among effective community engagement frameworks, engaging young audiences beyond the design process can produce educational outcomes [1]. The concept of *creative style contamination* in the work context, refers to the phenomenon of blending and interference between the different creative styles of the individual involved within a collaborative environment [3]. This phenomenon is particularly relevant for its impact on the overall creative output of the group and secondly for the increasingly growing demand for successful multidisciplinary teams in technical domains.

Research shows the impact of creative styles in group performances for instance in the specific dynamics of divergent and convergent phases: groups with varying creative styles could both encounter difficulties and opportunities in getting aligned on idea fluency, elaboration and evaluation [4]. Differences in creative styles can be a resource but at the same time, a poor management and ability to deal and blend with different styles can lead to unpleasant situations of dilution of ideas or difficulties in convergent phases [5].

In fact, when individual creative styles conflict, groups may find it difficult to maintain a clear direction [4]. In order to fulfill the team's creative potential, it is pivotal to strive for balancing structure and flexibility while fostering awareness of individual differences on this matter and adaptability. Despite challenges, creative style contamination represents a powerful resource to foster innovation by substantially supporting the synthesis of diverse perspectives, leading to unique solutions that might not emerge in more homogeneous groups [6].

III. Study Objectives

This study aims at exploring how multidisciplinary co-design activities targeting local communities can support creative style "contamination" stimulating students' ability to engage in diverse problem solving activities. More concretely, this project investigates whether the participation in specifically co-design projects can enhance self-efficacy while promoting a growth mindset, focusing on students' confidence in tackling real-world challenges.

IV. Methods

This research addressed the effects of multidisciplinary collaboration in the context of a codesign activity on creative style contamination and whether the engagement in community-based design can positively impact students' confidence in their abilities while fostering a growth mindset.

A. Participants

The study involved a sample of 27 students, consisting of 13 males and 14 females, with an average age of 23.8 years (SD = 3.01). Participants came from diverse academic backgrounds, distributed as follows: 6 from Master's programs in Human-Computer Interaction, 10 from Engineering and Computer Science, 9 from Design, 1 from Education, and 1 from Sociology. The setting was international and multilingual, with English as the main language of the event. To recruit participants, the initiative was advertised in the two universities' campuses targeting the departments of Computer Science, Design, and Cognitive Science. Given the high demand and the limited number of available positions, a selection process was performed requiring students to apply by submitting a CV and a motivational letter. All applicants were carefully screened based on academic merit and relevant skills with the purpose of creating a diverse, representative and interdisciplinary setting. In order to maximize collaborative dynamics across different perspectives and encourage multidisciplinary collaboration, we formed groups according to criteria such as including at least one representative from each academic discipline, equal gender distribution and linguistic diversity.

B. Spring School Structure

Given the main goal to be addressed, the Spring School was structured to achieve four main objectives: (1) empower students with foundational knowledge in electronics and computing through hands-on exploration of smart materials and computational tools, (2) encourage participants to reflect from diverse perspectives on their activities, fostering collective sense-making, (3) challenge stereotypes related to culture in electronics and computing, and (4) promote dialogue among students while eliciting their perspectives on co-creation spaces, emphasizing collaboration both within their teams and with the broader community.

Participants, working collaboratively, were tasked with framing potential solutions to real-world problems identified through interviews and dialogues with the local population. By emphasizing Human-Centered Design and collaboration within heterogeneous groups, the program underscored key aspects of problem-solving. These included tackling ill-defined problems, which often lack clear definitions, engaging in iterative analysis and interpretation, and recognizing the value of diverse teamwork in framing both problems and solutions. Collaborating with peers from different backgrounds enabled students to observe each other's skills and knowledge in action, broadening their perspectives on challenges and potential solutions. To support these processes, materials and activities were tailored to accommodate varying levels and types of expertise, guiding students through the stages of Human-Centered Design.

Spanning three days, the Spring School consisted of sessions addressing different topics and activities each day, all aimed at engaging students with real-world stakeholders and collaborative problem-solving frameworks.

On the *first* day, participants were introduced to the initiative's goals and objectives through a session led by professors specialized in collaborative design techniques. This included an overview of interview methods and proto-persona development. Participants also engaged with the hosting town's municipality, gaining an understanding of the local area through a guided tour and an introduction to its recent history. Initial interviews with local stakeholders enabled students to draft proto-personas, laying the foundation for understanding the community's needs. The *second* day focused on deepening local engagement and continuing data collection through interactions with citizens and policymakers. These activities refined the participants' insights and informed the brainstorming of potential solutions. Technical workshops on themes such as electronics, sustainability, and computing, along with scenario-writing exercises, provided students with tools to support the ideation process. On the *final* day, participants refined their proposals by interacting with domain experts and presented actionable design scenarios to the group. This final session included feedback from both experts and stakeholders, ensuring that the proposed solutions were grounded in the needs and context of the local community. Through this carefully structured progression, the Spring School fostered meaningful interdisciplinary collaboration, critical thinking, and creative problem-solving skills in a real-world setting.

C. Data Collection

To capture the dynamic environment of the Spring School and to address the main research goal, a mixed-methods approach was employed. This included pre- and post-activity questionnaires, participant diaries, observational notes, and the analysis of design artifacts produced during the program.

The pre-activity questionnaire served as a baseline assessment, incorporating a reduced version of the Creative Problem Solving Style (CPSS) scale [7], the Growth Mindset subscale [8], and self-efficacy items. Open-ended prompts invited participants to describe co-design in three words and share their personal motivations for attending.

The post-activity questionnaire reassessed participants using the CPSS, Growth Mindset subscale, and self-efficacy items to evaluate changes influenced by their participation. Additional prompts explored their reflections on creative approaches used, the impact of the "co-design for people" setting, and included the Intrinsic Motivation Inventory scale [9] to assess the activity's effects and participants' perceptions of their experience.

Throughout the program, participants documented their thoughts and reflections in digital learning diaries, using a Google Form to upload written entries along with media files, providing a rich, personal account of their journey.

Finally, design artifacts produced as the output of the Spring School, including final presentations, were analyzed to contextualize the creative processes and collaborative dynamics underlying the students' work. This comprehensive data collection approach ensured a robust understanding of both individual and group-level outcomes.

D. Data Analysis

The analysis combined qualitative and quantitative methods to meet the research objectives. Quantitative data from Likert-scale items in pre- and post-activity questionnaires were analyzed using t-tests for parametric data and Wilcoxon rank tests for non-parametric data to assess changes in participants' responses. Qualitative data, including open-ended responses and diary entries, underwent thematic analysis [10] to identify recurring themes. Due to the small sample size and nuanced topic, adjectives from participants were grouped into meaningful categories instead of using sentiment analysis, offering a deeper insight into their perceptions. This dual approach provided a comprehensive view of participants' experiences and the program's impact.

V. Results

A. Questionnaires

The qualitative and quantitative analysis of the data collected through the questionnaires revealed key insights, presented in the following sections.

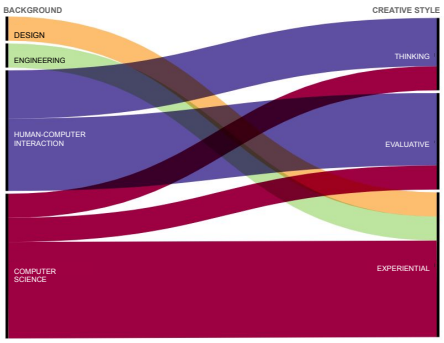

Fig. 1. The alluvial diagram illustrates the distribution of students across four creative approaches–Ideative, Experiencing, Thinking, and Evaluative—based on their academic backgrounds prior to the activity.

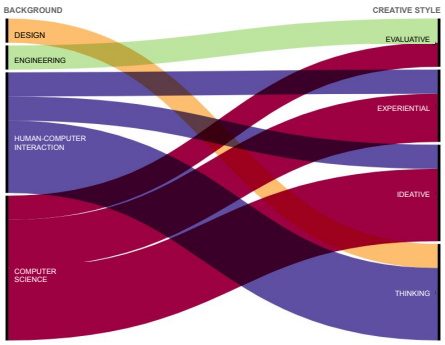

Fig. 2. The alluvial diagram shows the distribution of students across four creative approaches based on their academic backgrounds reported after the activity.

Creative Styles: Participants reported engaging with a different creative style during the Spring School experience ($p < .03$) and highlighted that participating in a community-oriented co-design activity significantly influenced this creative style shift ($p < .01$). When comparing responses from the Creative Problem Solving Style (CPSS) scale in the pre-activity questionnaire (baseline) with those in the post-activity questionnaire, 84% of participants indicated a change in their creative style specifically for the Spring School experience. The initial distribution of creative styles (Figure 1) was dominated by Experiencing (46.15%), followed by Evaluative and Thinking (both 23.08%). After reflecting on the Spring School experience, a significant shift emerged (Figure 2), with notable growth in the Ideative style: Experiencing (23.08%), Thinking (30.77%), and Ideative (15.38%). This redistribution highlights the Spring School's role in fostering ideative creativity and broadening participants' creative capacities. Despite not being a well known data visualization method, alluvial diagram was chosen as particularly suited to visually represent proportions and transitions of students from different backgrounds within the creative styles approach.

Growth Mindset and Self Efficacy: Given the relatively stable nature of growth mindset and self-efficacy constructs, the data revealed limited or non-significant shifts in these areas. However, participants reported an overall stronger belief in their ability to contribute to meaningful, real-world projects, reflecting an enhanced growth mindset. For self-efficacy, the analysis indicated a significant improvement, specifically in participants' confidence to perform diverse tasks ($p < .05$). Regarding growth mindset, statistically significant results emerged only for reversed items. Participants demonstrated improved responses to statements such as "It would be very difficult for me to improve how well I can apply knowledge" and "Becoming competent in doing the Spring School activities requires natural talent that just can't be taught" ($p < .05$). These findings suggest a subtle yet meaningful shift in participants' attitudes towards their capacity to learn and apply skills through effort and practice.

B. Adjectives

The adjectives chosen by participants to describe their creative approach prior to the activity predominantly reflected an internal, individualistic perspective on problem-solving. Terms like "independent," "reflective," "iterative," and "analytic" suggested a preference for solitary exploration and iterative refinement, often revealing a perfectionist tendency. Other descriptors, such as "imaginative," "inventive," "logical," and "systematic," emphasized internal processes, particularly idea generation and problem-solving strategies. Mixed sentiments also emerged, revealing some uncertainty about creativity and openness to collaboration, as reflected in the juxtaposition of words like "inclusive" and "iterative" with "chaotic," "anxious," and "unprofessional."

The adjectives collected post-activity revealed a marked shift, emphasizing collaboration, goal orientation, and practicality. Terms like "collaborative," "shared," and "inclusive" highlighted teamwork and inclusivity, while descriptors such as "hands-on," "pragmatic," and "functional" reflected a focus on action and adaptability. Compared to the initial individualistic perspective, the post-activity descriptions suggest a blended view of intuition and analytical thinking, evidenced by terms like "inspired," "intuitive," "reasoned," and "structured," reflecting shifts in creative styles and diverse approaches fostered during the Spring School.

C. Diaries

Thematic analysis of the diaries [10] revealed a multifaceted experience, blending collaborative learning, practical skill application, and cross-cultural challenges. While participants largely reported positive experiences, issues like language barriers and unmet expectations highlighted areas for improvement. The key themes identified are:

Collaboration and Multidisciplinarity: Participants valued the opportunity to work in diverse teams that extended beyond their academic specializations. The collaborative, non-competitive environment encouraged participants to engage with other groups, sharing initial research findings and fostering a sense of mutual support and exploration.

Peer Learning and Expertise Sharing: The interdisciplinary nature of the program prompted continuous sharing of expertise and techniques among participants, leading to mutual learning. For example, participants noted the benefit of consulting with more experienced peers for practical tips, which enriched their understanding and broadened their perspectives.

Real-World Relevance: The connection between the project and the local context underscored the real-world applicability of the methodologies taught during the workshop sessions. Participants appreciated the tangible impact of their work and its potential to address local community needs.

Enrichment and Personal Development: The hands-on nature of the experience was widely regarded as a valuable opportunity for skill enhancement in data collection and analysis. Participants reported that activities such as conducting interviews, developing proto-personas, and reasoning through scenarios improved their adaptability to unfamiliar tasks. These experiences also fostered self-awareness, particularly in managing diverse group dynamics.

Overall, the diaries highlighted the strengths of the program in fostering interdisciplinary collaboration and real-world problem-solving while pointing to areas such as clearer goal-setting and enhanced support for navigating cultural contexts to further refine future iterations.

VI. Discussion and Conclusions

The findings from the Spring School reveal the program's potential to foster creativity, collaboration, and practical problem-solving skills while highlighting key areas for refinement. Below, the results are discussed in light of the objectives and challenges of the initiative.

Shifts in creative styles: The observed shift in creative styles demonstrates the program's capacity to encourage participants to move beyond their default approaches to problem-solving. The increase in the ideative style reflects the influence of the co-design methodology and the collaborative, community-oriented framework. This shift aligns with the program's goal of exposing participants to diverse perspectives and enabling them to explore innovative solutions. However, the fact that 16% of participants reported no change suggests that individual predispositions and prior experiences may still play a role in shaping creative approaches, warranting further investigation into tailored interventions.

Growth mindset and self-efficacy: The limited shifts in growth mindset and self-efficacy reflect the relatively stable nature of these constructs, particularly over short-term interventions. Given that participants self-selected for the program, it is likely they already possessed a growth mindset, making significant changes less pronounced. Nonetheless, the program achieved notable improvements in self-efficacy, particularly in participants' confidence to perform diverse tasks, and subtle but meaningful changes in responses to reversed growth mindset items. These findings suggest that the program successfully reinforced participants' beliefs about their capacity to acquire and apply new skills. This underscores the value of hands-on, real-world activities in enhancing self-efficacy and supporting growth-oriented behaviors, while highlighting the need for longer-term or more targeted interventions to foster more substantial shifts in mindset among individuals already inclined toward growth-oriented thinking.

Reflections on creative approaches: The shift in adjectives describing participants' creative approaches suggests a positive transformation. Pre-activity terms reflected individualistic tendencies, while post-activity descriptors emphasized collaboration, practicality, and adaptability. This evolution highlights the program's success in fostering a more dynamic, inclusive view of creativity. The blending of intuition and analytical thinking further underscores the program's role in broadening participants' problem-solving approaches.

Multifaceted experiences and challenges: Thematic analysis of diaries highlighted the program's strengths in fostering collaboration, peer learning, and real-world relevance. Participants valued the interdisciplinary setting, which broadened their academic focus and promoted mutual learning. The emphasis on human-centered design and stakeholder engagement underscored the practical impact of their work. Challenges included language barriers, cultural differences, and unclear project expectations. While some found the open-ended nature enriching, others struggled, leading to mixed views on specific tools and methods.

Implications for future programs: Overall, the results underscore the potential of interdisciplinary, community-driven educational initiatives to foster creativity, collaboration, and practical problem-solving skills in STEAM students. Future programs could benefit from integrating longer-term interventions to reinforce shifts in growth mindset and self-efficacy, as well as offering more structured support to help participants navigate ambiguity and cultural contexts. These refinements could enhance the impact of similar initiatives, further bridging the gap between academic learning and real-world challenges.

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