Understanding How Creativity Support Tools Can Foster Happiness

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Abstract

Engaging in creative activities makes people happy. Creativity support tools (CSTs) are technologies that facilitate creative activities in the digital domain; however, little is known about how the use of CSTs affects happiness stemming from creative endeavours. To address this gap, we conducted a two-phase study. First, we carried out an exploratory interview study (N=15) to examine participants' perceptions of how their chosen CSTs impacted their feelings of happiness. Our analysis shows that the CSTs our participants used introduced barriers to benefits typically associated with creativity—such as feeling joy, experiencing satisfaction, and alleviating negative feelings—and therefore did not make them happy. To explore how CSTs might be designed to facilitate happiness, we conducted a brainstorming study with experts (N=9). Participants generated six ideas for happiness-promoting CSTs. Drawing from both phases, we present a set of implications for design to help re-imagine CSTs as supports for cultivating happiness through creativity.

CCS Concepts

• **Human-centered computing** → **Empirical studies in HCI**; **Interaction paradigms**.

Keywords

Happiness, creativity support tools, design

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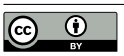

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1 Introduction

Creativity is a process of producing novel and useful products [66], wherein the novelty and usefulness can be defined by an individual, a small community, or by a broader audience [53]. Engaging in creative activities has been shown to make people happy because it leads to positive experiences such as building a sense of purpose, promoting feelings of accomplishment, and creating opportunities to socialize with others (e.g., [13, 15, 17, 29, 86, 87]). Here, happiness is commonly defined as an increase in positive affect (e.g., joy), decrease in negative affect (e.g., stress), and an increase in overall life satisfaction (e.g., feeling a sense of accomplishment) [27, 28]. With the introduction of digitalization, tools like drawing apps, design software, and fabrication machines are used for engaging in creative activities [38]. In human-computer interaction (HCI), such tools, which include applications and hybrid tools (e.g., tangibles, hardware devices), are called creativity support tools (CSTs), and are broadly defined as digital platforms that have one or more features in support of creative activities [37, 71]. *Although we know that creative activities make people happy, we do not know if engaging in creative activities using CSTs makes people happy.* We explore this gap in our research, and ask two overarching research questions (RQ): **RQ1**—if and how does creativity facilitated through CSTs make people happy? and **RQ2**—which types of CST software features could be helpful for fostering happiness when engaged in creative activities?

HCI researchers have posited that CSTs can become pathways to promote affective experiences like joy [40, 70], and reframe negative experiences like failures [54]. However, in practice, CSTs have often not been designed (or evaluated) for the more experiential qualities of creativity. For example, a recent survey by Cox et al. [71] found that CST evaluations have focused predominantly on general usability measures, and there are very few studies that have looked at user-centric measures such as happiness [57, 78, 94].

On the other hand, HCI researchers have also argued that technologies (broadly) can and should facilitate experiences like happiness to address the real *whys* that motivate people when engaging with technologies (e.g., to feel a sense of accomplishment, to do meaningful work) [11, 25, 39, 47], yet we do not have enough guidance on how to do so for CSTs. This research is often framed in

two distinct ways: 1) outcome-oriented, wherein technologies help people accomplish a goal, and the resulting success generates happiness (e.g., completing a task may foster feelings of accomplishment), and 2) process-oriented, wherein technologies facilitate practices that help with building happiness, regardless of outcome generation (e.g., mindfulness facilitated through colouring may promote satisfaction). Although these theories and frameworks elaborate on how to achieve these two pathways [11, 25, 39, 47], very few implementation examples have explicitly used these theories in design (e.g., [83]), and where examples exist (e.g., [24]) they are mostly about improving mental health (e.g., [5, 52]) and are not in the domain of CSTs.

Thus, research is required to bring the concepts of CSTs and happiness together. Our research takes a step towards better understanding how CSTs can help contribute to people's experiences of happiness when engaged in creative activities. We conducted an exploratory interview study with 15 participants to learn about their views on if and how they think creative activities and the CSTs they use regularly in their personal or work life impact their feelings of happiness (RQ1). Our findings show that although engaging in creative activities like drawing, fiber crafts, and music making made our participants happy, the companion CSTs they used (like Adobe products, Pinterest, Procreate) did not always replicate such experiences of happiness. Through our qualitative analysis, we find that this could be because the CSTs our participants used introduced barriers to experiencing joy and satisfaction when engaging in creative activities. Informed by our interview study findings, we wanted to explore how CSTs *could* be designed to facilitate experiences like happiness. Thus, we conducted a brainstorming study with nine HCI researchers who are experts in happiness and CSTs (RQ2). Participants brainstormed and envisioned six ideas for CSTs that demonstrate ways in which CSTs can explicitly foster happiness. Based on our findings from both studies, we discuss a set of implications for design and design resources for how CST designs can be extended to not only help people achieve creative tasks, but also foster happiness when engaged in creative experiences.

We make three main contributions. First, we offer a rich understanding of people's experiences with creative activities and CSTs, and how these experiences impact their happiness. Second, we discuss several design ideas for CSTs that illustrate examples of how CSTs can foster happiness. Third, we discuss a set of implications for design and design resources that can guide the design of future happiness fostering CSTs.

2 Background and Related Work

We draw from research in HCI, design, and psychology to understand the relationship between creativity and happiness. Within HCI and design, we specifically look to research that theorizes and demonstrates explicit ways technologies can be designed to foster and improve happiness.

For this paper, and for this section in particular, it is important to note that we broadly look to examples in areas like overall well-being, psychological well-being, and experiences like flow and mindfulness, because they are related to happiness. However, for our studies and proposed implications for design, we focused on the construct of happiness [27], which is ontologically and empirically distinct from constructs like overall well-being, flow, and psychological well-being [58, 90]. Happiness focuses on an *individual's overall assessment* of satisfaction and the balance between positive (e.g., having fun, feeling joy) and negative affective experiences (e.g., reduced frustration, less overwhelm) [27, 90]. To operationalize and understand happiness as experienced within a specific domain (e.g., workplace happiness), the dimensions of affect and satisfaction are assessed relative to the domain [20]. Concepts like experiencing flow, gratitude, or mindfulness are related to happiness because these have been suggested as processes that help people build overall or domain-specific happiness [48, 56, 90].

2.1 Happiness and Creativity

A meta-analysis study found that creative people tend to have higher well-being, and those with higher well-being tend to be more creative [1]. Because engaging in creative activities can create many positive experiences, such as positive mood (e.g., [1, 13, 73]), help people build a sense of purpose [31], create flow experiences that promote nurturing of talent and developing skills [79], and feel a sustained sense of positive affect and flourishing [16], they tend to improve overall well-being. They also found that when creativity is operationalized as an activity (instead of capacity) that incorporates more behavioural, goal-oriented, and motivational factors, then it is likely that there is a stronger relationship between creativity and well-being [1]. Engagement in creative activities has been used as a strategy to improve happiness. For example, a scoping review covering over 3000 studies in art found that engagement in art activities such as singing, group drumming, and daily photography can improve happiness [30]. Similarly, a study conducted with 465 college students looked at engagement in maker and DIY activities (such as cooking, baking, and gardening), and found that such activities are a potential pathway to building happiness, and that factors such as the motivation for engagement in activity, and characteristics of the person (e.g., maker identity, trait rumination) had an association with happiness [15]. Lastly, Nevay et al., [61] conducted a series of workshops that involved designing artifacts using e-textile and traditional textile crafting techniques to identify factors associated with well-being, and to measure the impact on mental well-being. They found that factors such as the potential to learn new skills and socialize with others contributed to an improvement of well-being. Our study extends the literature in this area by offering insights into if and how people's use of commercial CSTs for engaging in creative activities makes people happy.

2.2 Designing Technologies for Happiness

Within HCI, researchers have proposed that technologies can aim to foster experiential metrics (like well-being and happiness), and help people flourish [11, 24, 25]. In this section, we briefly discuss two main areas of research development—1) frameworks that inform technology design, and 2) tools and systems that have been designed with the intent of fostering happiness.

2.2.1 Happiness Design Frameworks. Several frameworks have been proposed within HCI for designing technologies that can facilitate experiences that aim to make people happy.

Positive Computing is focused on "the design and development of technology to support psychological well-being and human potential" [11]. This framework [10] identifies a set of factors that determine well-being (e.g., positive emotions, engagement, and mindfulness) and links them to psychological models that describe the importance of that factor, strategies that have proven to improve that particular factor, and evaluation methods. Based on this framework, they propose that positive computing technologies can be integrated to improve well-being in 3 main ways: 1) preventative design—wherein designs address problems or obstacles to well-being (e.g., cyberbulling), 2) active design—wherein new features or interaction designs can be added to existing technologies (e.g., Instagram) in order to improve factors of well-being, and 3) dedicated designs—wherein new technologies that explicitly focus on fostering well-being are developed.

Positive Design takes strategies from positive psychology to foster a fulfilling life [67]. This framework identifies three main factors as important for deliberatively improving happiness—pleasure, virtue, and personal significance [25]. The framework suggests that designing for each individual factor can predict happiness, but only when all three are supported by design do people flourish [75].

Possibility-driven Design takes an optimistic approach to design, in contrast to popular problem-driven design which aims to fix problems [24]. The goal is to design products that look at the possibility of more and create new, happiness-inducing experiences. For example, self-service kiosks (e.g., coffee machines) can be designed to create positive social experiences instead of focusing solely on the functional problems [9, 42].

The above design frameworks are based on happiness theories such as the Positive Emotions, Engagement, Relationships, Meaning, and Achievement (PERMA) model [81]. Theories like the PERMA model outline *what* makes people happy and *how* people can build happiness. We refer to the PERMA model when discussing study results and implications for design. A gap across these different design frameworks is that there is relatively little guidance on how such frameworks can be applied (e.g., see discussion by [64, 83]). For example, the creators of the positive design framework note that although they have described the foundations, future work is required to identify design approaches to implement this framework that can apply more generally, or to specific domains [25]. Our research refers to these design approaches in the discussion section of this paper, and suggests how they might apply when designing CSTs that serve the dual purpose of not only being useful for the task at hand, but also explicitly focusing on fostering happiness.

2.2.2 Happiness Tools and Implementations. Despite the many design approaches suggested by the frameworks, there are relatively few examples of technologies that focus on happiness. One example is the HappinessCounter, an interactive mirror that encourages the act of smiling [92] and is based on the happiness fostering strategy that simply acting happy and looking on the bright side can lift mood [34]. Another area of focus is fostering reflection and gratitude to build happiness, which includes mobile applications to document and reflect upon everyday experiences [12, 51], and apps to take positive action towards others [76]. Lastly, technologies have also focused on building happiness through mindfulness, and examples include mobile apps that provide guided sessions for mindfulness training and meditation [3]. Our research draws from these examples to think about how CSTs can be designed to not only support productivity but also promote happiness.

2.3 Fostering Happiness through CSTs

There are many examples of evaluating CSTs using happiness-related metrics such as enjoyment using scales such as the CSI [14]. However, they primarily assess enjoyment as a metric of tool usability, and not as an experience [71]. Specific to promoting happiness, a common area of focus is fostering happiness through mindfulness activities such as colouring (e.g., [4, 50, 57, 84, 94]). For example, Mantzios et al. [57] compared the effectiveness of a pen-and-paper based colouring setup to an app-based setup, and found that anxiety decreased pre- and post-test for both the conditions, and mindfulness significantly improved from pre- to post-test in the app condition. A more recent example is Mindful Scroll, a mobile coloring app for mindfulness wherein the app continuously generates a sets of shapes with distinct color palettes and fill styles that are revealed as the user colors [94]. Evaluation of Mindful Scroll shows that it can promote mindfulness and improve mood and happiness. In music, Schlagowski et al. [78] explored the impact of augmented reality (AR) on music making tasks, and found that their tool well supported aspects of the CSI (e.g., enjoyment and exploration), and user experience (e.g., efficiency), which increased the likelihood of experiencing flow by their participants. Our study builds on these studies and provides insights into how CSTs could be designed to foster happiness when users are engaged in creative activities.

3 Evaluation

To address our research questions (RQ1, RQ2), we conducted a two-phase study: an interview and a brainstorming study. In both these studies we chose to study CSTs broadly rather than restrict our analysis to particular tool types or creative activities. We did this because CSTs are fluidly used across diverse creative activities (e.g., Illustrator can be used in graphic design, sewing pattern creation, or digital fabrication such as laser cutting) and we thought that a broader lens would allow us to capture generalizable patterns of tool use and experiences of happiness that extend beyond any single type of creative activity.

For CSTs, we include both software and hybrid interfaces (e.g., mechanical devices, tangibles) similar to Frich et al. [37]. Within such a range, although some activities (e.g., 3D modelling) and tools (e.g., 3D printers) can be tightly coupled, an analytical distinction can still be made between tool-activity. Although CSTs mediate creative work [38], many activities can persist (e.g., modelling and sculpting by hand) or adapt (e.g., hybrid prototyping [26]) even when tools change or are absent [32, 38]. The ability of people to analytically distinguish between an activity and tool is also assumed by HCI methods (e.g., [41]) where designers are asked to learn about activities from end-users regardless of technological mediation. Such a distinction has been assumed in creativity and well-being research as well (e.g., [15, 59]). We too adopt this assumption and clarified the distinction further in our studies through separate question blocks and discussion.

4 Phase 1: Interview Study

We conducted an interview study with 15 participants to gather insights around three main topics: (1) how people think creative activities contribute to their experiences of happiness, (2) how they perceive CSTs impact their happiness, and (3) how our participants envisioned future technologies could be designed to foster and sustain happiness in the context of creative activities.

4.1 Study Procedure

All participants were asked to complete a questionnaire consisting of 14 questions prior to meeting for the interview. The first four questions focused on demographic information such as age and professional background. Questions 5 and 6 asked participants to list the creative activities they engaged in and the technologies they used for engaging in those creative activities respectively. The remainder of our questionnaire was split into two main blocks related to the impact of activities (Q7–Q10) and tools (Q11–Q14) on positive affect, negative affect, overall life satisfaction, and domain satisfaction respectively. For questions 7–14, participants responded using a 5-item Likert scale that ranged from strongly agree to strongly disagree, and the questions were developed based on the definition of happiness [27] we adopted in this study mapped to the domain of creativity. Such mapping of the definition has been done in other contexts such as the workplace [20].

The primary reason for gathering the questionnaire data was to gain some understanding of the participants prior to engaging in the interview, and to give participants an opportunity to reflect on their views on happiness prior to the interview study. As such, the questionnaire response was not used as a sole signal for understanding impacts on happiness, and participants were free to change their questionnaire responses (some did; see Appendix B) during the interview upon further discussion and reflection.

The interviews were conducted remotely, and we used a semi-structured interview format. At the start of the interview, the researcher briefly described the definition of happiness that we adopted for this study. Our interview consisted of two blocks of questions (creative activities and tools; see Appendix C), which built upon the questionnaire responses. The primary goal for the interview was to better understand the reasoning behind participants' Likert scale scores, and to gather examples of how creative activities and technologies had an impact on people's happiness. Each interview was conducted 1-on-1 between the participant and the researcher. Participants received a $30 gift card remuneration. Our study procedure was approved by our university ethics board.

4.2 Recruitment and Participant Demographics

We shared our study recruitment call via social media, university mailing lists, and through personal contacts. We recruited participants who were at least 18 years of age, lived in North America (NA), and engaged in creative activities (such as sewing, painting, programming, and music making) at least once a month in their professional or personal life. The choice of restricting our study to NA was primarily pragmatic for reasons such as relative flexibility for scheduling interviews. Interested participants contacted the researcher and received the consent form for participating in the study. We recruited everyone who met our recruitment criteria, completed the consent form, and was available to participate in the interview during the study period.

We recruited 16 participants, but one participant (P5) could not participate due to time constraints, and so we had a total of 15 participants in our study. Eleven participants self-identified as women and five as men; the age range was 18-34 years. At the time of the interview, one participant worked as a research scientist (P13), another owned their own technology company (P9), and others were students (P1–P8, P10–P12, and P14–P16). All participants engaged in creative activities semi-regularly (at least once a month), and used a breadth of technologies to engage in these activities. Some such activities and technologies included: *Procreate* for digital drawing and art (P2, P3, P10), the *Adobe* Suite for visual and graphic design (P12–P14), and CAD software such as *Fusion 360* and *AutoCAD* for 3D modelling (P3, P4, P9, P12, P16). Participants' information is summarized in Table 2 in Appendix A.

4.3 Data Analyses

Quantitative Analyses: We compared participant responses in the survey questions to the neutral value on the scale (i.e., 3) using one-sample Wilcoxon signed-rank tests to determine if participants significantly agreed with each statement. To compare their feelings about their creative activity to the CST used to support that activity, we conducted paired Wilcoxon signed-rank tests between their answers to the questions asking about the same outcome, i.e., *Does engaging in your listed creative activities help with increasing positive affect?* and *Does using CSTs help with increasing positive affect?*. To account for eight multiple tests, we set $alpha = .00625$.

Qualitative Analyses: Fourteen interviews were video recorded after receiving consent from the participants. One participant preferred not to be audio or video recorded, and so the interviewer took notes, summarizing their responses for each question. The summaries were verified orally by asking the participant to confirm if the notes captured their answers correctly. The interviews lasted between 34 minutes to 1.25 hours. Each recorded interview was transcribed and then qualitatively analyzed.

The 15 interview transcripts were coded iteratively using the open-coding method [2, 60]. At the start of our coding process, two researchers (R1 and R2) independently coded one participant's transcript that was fairly rich in content. At the end of this round, we had a total of 63 codes and of these we had seven disagreements. Disagreements included situations such as one coder identifying that a specific interpretation was likely incorrect (1 of 7), or needing to edit the code to more clearly explain its meaning (6 of 7). The disagreements were identified and resolved via discussions between the two coders. After this round, each coder coded seven transcripts each, and at the end of each coding session, the two coders met, discussed their codes, resolved any disagreements that arose, and merged the individual codebooks. Our final codebook had 328 codes and included codes such as "creative activities are an outlet for expression and so contribute to feeling happiness" and "although tools may increase efficiency and people seek this, it may take away from tasks that bring happiness".

The codes were grouped into three themes using the thematic analysis method [2]. We iteratively formed the themes—in the first round, all authors (R1–R5) met and discussed the codebook to

develop an initial set of groupings, and then, over four rounds, two authors (R1 and R5) met and refined the groupings, which led to having three overarching themes: (1) building blocks or drivers of happiness that come from creative activities and CSTs, (2) strategies for building happiness, and (3) tool ideas for facilitating happiness through CSTs. These themes are further discussed in the results section of this paper. The questionnaire responses are summarized in Table 4.

5 Interview Study Results

5.1 Summary of Happiness Questionnaire Responses

Participants in our interview study generally viewed creative activities as positively impacting their happiness (Table 1) . Compared to the neutral value on the scale (i.e., 3), participants significantly agreed that engaging in creative activities such as digital art, fiber crafts, music making, fabrication, and broadly UI/UX design strongly contributed to increasing their positive affect and overall life satisfaction (median=5), to decreasing their negative affect (median=4), and to increasing feelings of domain satisfaction (median=4).

In contrast, participants significantly agreed that the use of CST tools to support their creative activity, including the use of software (e.g., Krita, Procreate, Figma, Python, SolidWorks) and hardware (e.g., 3D printer and sewing machines) tools, positively contributed to increasing their positive affect (median=4), but were neutral about their CST's role in decreasing negative affect, and increasing feelings of overall life satisfaction and domain satisfaction (median=3).

We also compared participants' agreements with statements about the creative activity to ones about the CST used to support that activity for each outcome. Participants felt that engaging in the creative activity significantly increased their positive affect and life satisfaction more than the use of the tool, and significantly decreased their negative affect more than using the tool did. The difference for domain satisfaction failed to reach significance after *alpha* correction for multiple tests (see Table 1).

5.2 Determinant Factors of Happiness From Creative Activities

Multiple factors (referred to as *determinant factors*) such as being able to generate an outcome, socializing, and learning new skills can predict people's happiness [56]. Positive psychology researchers have discussed this idea through theories such as the PERMA model for flourishing [80], and in describing the components of subjective well-being [27]. Past studies at the intersection of creativity and happiness also confirm this finding [1, 13, 16, 31, 73, 79]. Similarly, we found in our study that multiple factors had an impact on our participants' affective and cognitive states in the context of creative activities, which in turn made them (un)happy. In addition, through data analysis we found that all participants viewed the creative process as consisting of two high-level components—the creative activity itself (e.g., drawing), and the tools that participants used to accomplish their creative activities (e.g., a digital drawing software). Engaging with these two components gave rise to a number of factors that determined if our participant felt joy, satisfaction, frustration, or other similar states that impacted their happiness. In some cases participants attributed these determinant factors as coming from the *creative activities only*. For example, P12 was neutral about CST use increasing their positive affect because they felt that *"it wasn't necessarily technology driven that would affect [...] that would have a positive affect or a positive effect on my mood. It was, it would be the activity itself"*. In some other cases, the participants attributed the determinant factors as being related to *tools only*. For example, P1 spoke about usability of tools and said, *"positive affect from Infinite Painter because it's just much more usable than the other softwares I had tried like the UI was more minimal and just easier for me to use and I liked the specific brushes they had and so that just increased my positive affect"*. And lastly, participants also sometimes attributed the factors as coming from *both the creative activity and the companion tools* and this was because they considered tools as mediators of the creative activities. For example, P4 said *"like with the sewing machine, just association between that device and like the fun activity [...] being able to add more to it, add more functionality and do more diverse things and challenge myself with the sewing machine, I think it like adds to the positive feeling"*.

In this section, we briefly discuss the determinant factors for happiness, and focus more on the novel and HCI-relevant results related to if and how CST use supports such determinant factors.

5.2.1 Creative Outcome. Accomplishment is one of the five factors of happiness per the PERMA model [80]. Creating an outcome was mentioned as a determinant factor for feeling happy during a creative activity by 14 of 15 (with the exception of P14) participants. When participants created an outcome, they felt a sense of accomplishment and pride and this made them happy. For example, P12 said, *"I mentioned woodworking, there was one time where my apartment needed a shoe rack and I was able to make one out of scrap wood. And I think what made me happy about it was sort of the sense of accomplishment"* [P12]. Participants highlighted that outcome creation through CSTs however did not always re-create such experiences of happiness. Barriers to creation led to participants not feeling happy. For example, P2 spoke about Procreate—they found that even though the tool provides the required materials (many different types of brushes and colours) for digital drawing, the learning curve was steep, and it was difficult for them to know if they were making any progress, and therefore could not feel a sense of accomplishment. They added that although they used resources like YouTube to learn to use Procreate, such exercises often led to following a tutorial, and did not result in the creator feeling a sense of ownership over what they had created. Together for these reasons, they felt that *"[...] I'm not happy with it [Procreate]. [...] Procreate is just I feel like it is a supply machine"* [P2]. Similarly, P6 spoke about using Procreate and its implications on their feelings of satisfaction. They shared how auto-creation features can contribute a little to feeling satisfied with the task because it can help them *"achieve something"* and it *"lowers the difficulty to complete"* what they wanted, such as drawing a circle. However, they also felt that such automation features missed the opportunity to engage the user in a task in ways that can create a deeper sense of satisfaction with the task—*"currently I feel a lot of features, they either cannot*

Table 1: Summarized data from the demographics questionnaire of interview participants. Question format was the same for each: e.g. *Does engaging in your listed creative activities help with increasing positive affect? Does using CSTs help with increasing positive affect?* All questions were rated on a 5-point Likert scale with 1= "Strongly Disagree" and 5="Strongly Agree". One-sample Wilcoxon signed-rank tests compared participant responses to the neutral value on the scale (i.e., 3). Paired Wilcoxon signed-rank tests compared answers for the creative activity to the CST. To account for multiple tests, α=.00625.

Outcome	Domain	Median	One-sample	Paired
Positive Affect	Creative Activity	5	$z = 3.542, p < .001$	$z = -2.879, p = .004$
	CST	4	$z = 2.887, p = .004$	
Negative Affect	Creative Activity	4	$z = 3.017, p = .003$	$z = -3.127, p = .002$
	CST	3	$z = 1.134, p = 257$	
Life Satisfaction	Creative Activity	5	$z = 3.286, p < .001$	$z = -2.879, p = .004$
	CST	3	$z = 2.121, p = .034$	
Domain Satisfaction	Creative Activity	4	$z = 3.153, p = .002$	$z = -2.373, p = .018$
	CST	3	$z = 1.732, p = .083$	

do anything for you or they do it really well for you, but like the interaction in between is really limited [...] if I'm targeting on some achievement or sense of satisfaction, I would like this kind of thing to have some interaction with me [...] I hope there are some kind of discussion [...] some kind of like bounce back and forth kind of conversation" [P6].

5.2.2 Inspiration. Prior work has shown that inspiration is a predictor of happiness for creative activities [89]. Some participants (P3, P7, P8, P10) found social media platforms and their related features to be helpful for finding inspiration, and the resulting outcome of idea-finding made them happy. For example, P10 said, *"I had Pinterest in mind [...] because like the algorithm is tailored for myself, it often helps me with getting more ideas [...] just coming up with an idea makes me feel happy"*. In contrast, P8 felt that while tools like Pinterest help *"boost [their] creativity"*, they do not reduce their negative affect—*"when I'm looking for inspiration [on tools like Pinterest] that it ends up feeling like I have wasted my time"*. P3 added that such inspiration-providing social media platforms, like Pinterest and magazine sites, can feel addictive, and so they prefer to avoid them (*"the social media sites or the like magazine sites I mentioned, like those do give me a sense of almost happiness. But it's sort of almost like cheap dopamine hits rather than genuine satisfaction at myself, so I'd almost prefer to like have the experience be as unwelcoming as it can be, so I won't waste time on it"*).

5.2.3 Managing Negative Emotions. Another determinant factor that was mentioned by 12 participants (P1, P2–P4, P6, P7, P11–P16) was managing negative emotions. Participants mentioned that if they wanted to distract (P2, P7, P10, P15) themselves from the negative emotions they were feeling or wanted to release their negative emotions (P2–P4, P6, P7, P11–P13), then engaging in creative activities was helpful. This in turn promoted positive emotions and satisfaction (e.g., participant P12 spoke about cathartic experiences felt when making music). However, engaging with CSTs did not consistently re-create such experiences. P1, P6, and P16 said that they did not see an intention in tool design to alter their emotional states—*"like I'm using Krita to create a digital drawing [...] so maybe there are good parts of it which increase positive affect, but I think decreasing negative affect is somewhat more intentional and there I don't see this intention behind the programs"* [P1]. P2 found that creative activities helped them reduce their negative feelings, but when they relied on technology to engage in the creative activity it often negatively impacted their creative self-efficacy—*"I tried to do sketching when I was sad [...] I was just copying it [from YouTube or other online resources] and doing it so [...] it is helping me with like wasting my time [...] but creative part I don't know"*. P14 found that domain-agnostic CSTs, such as Photoshop which they used for their work and hobby, resulted in lowering positive affect (*" I don't know why now that I think of it. Maybe it's because like I had to use a platform that I used for work as well. So it's like the line between like work and play is a little bit blurred when I use Photoshop"*).

5.2.4 Social Validation. Many (12 of 15) participants highlighted that external validation, such as seeing other people engage with their outcomes, made them happy and it also sustained their happiness over time. For example, doing something for others (P1, P2, P7, P8), such as making gifts or producing work for them, brought satisfaction and feelings of joy. Sometimes receiving external validation (P2, P7, P8, P11, P12) also created a sustained sense of happiness. P2, P8, and P11 mentioned that social media comments and likes can help one get such external validation, but over time, such validations are seen as a negative dependency. For example, P2 engaged in the creative activity of making art such as digital sketching and mandala art. They mentioned that previously they felt happy from social media engagement, *"it is about the appreciation I get [...] like taking a picture and posting it in the Instagram and getting all the likes"* but over time they have moved away from such external validation, and chose to explicitly build happiness through self validation (*"I would say of late I'm feeling it is just for me like in the past eight months whatever I did I didn't take a picture and post it on Instagram"*). In contrast to general purpose tools like Instagram that get re-appropriated as CSTs for sharing creative outcomes, when CSTs are more purpose-built, it might be possible to re-create positive validation experiences. For example, P7 uploaded their cosplay 3D models to Thingiverse and found such sharing fulfilling—*"I feel like socially very fulfilled when I feel like my work can help other people too [...] I like, go on my Thingiverse account sometimes and*

you can see how many people download your files and like, it makes me happy".

5.3 Strategies for Building Happiness During Creative Activities

Determinant factors describe *what* makes people happy, whereas strategies are about *how* people become happy [33, 34, 56]. Researchers in psychology have identified and empirically evaluated the efficacy of strategies such as mindfulness and flow for building happiness [33, 34]. These strategies typically include behaviour and cognitive practices for improving or building happiness. Here we describe the strategies our participants used consciously or subconsciously for feeling happy during creative engagement, and their thoughts on whether CSTs support such strategies, or how they could in the future.

From our data analysis, we found that the strategies our participants highlighted are similar to happiness-building strategies proposed by Lyubomirsky [56]— **1)** increasing flow experiences, **2)** committing to your goals, and **3)** being more sociable. Eight participants (P1–P4, P6, P9–P11) explicitly mentioned having actively sought one or more of these strategies for feeling happy during creative activities, while the remaining 7 of 15 found them to be primarily unconscious choices, and identified them as potential strategies for building happiness upon reflection during the interviews. Participants typically also mentioned the use of multiple strategies, and found different strategies to be useful at certain points in time. For example, P11 mentioned four strategies as potentially useful for improving their happiness—scheduling time for creative activities, drawing inspiration from others, learning new things, and being social. Similar to section 4.2, **we will briefly describe the strategies from psychology first, and then focus on the novel insights related to CST design**.

5.3.1 Increasing Flow Experiences. *Flow* is about experiencing a state of complete immersion in an activity, and has been found to be one of the strongest predictors for feeling happy within a creativity context [19, 48]. There are multiple ways to be in flow, such as learning something new, and working on challenging problems [18, 56]. In our study, doing a creative activity and learning something new were mentioned as ways to build happiness (P1, P3, P4, P7, P8, P10, P11, P14–P16). For example, P1 said, *" I think I have an increase in positive affect because the activities in themselves I find enjoyable [...] you kind of get in the flow of it".* However, in order to experience flow, it is important that there is a balance between the challenges one experiences and one's skills [35]. With CSTs, participants found this balance was difficult to achieve, and as a result, they felt more negative affect, or less satisfaction. For example, P15 mentioned that steep learning curves in complex software like 3D modelling tools can make them feel less happy and satisfied. Similarly, P4 and P16 described scenarios where they wanted to make an object for digital fabrication, but found it difficult using their software of choice, which increased negative affect (*"[...] specifically when I'm using Fusion 360 because I'm newer to it and don't know the best ways to use it, sometimes it can be really frustrating [...] So like that specifically didn't add to my happiness"* [P4]). P16 suggested that if the tool could help teach while a person was engaged in a creative process then it would be *"immensely positive and be like happiness and dancing inducing"* [P16].

5.3.2 Committing to Your Goals. Committing to pursuing goals is another way to build happiness [56]. The pursuit of goals helps build happiness because it can give people a sense of purpose, boost self-esteem, and the accomplishment of goals can lead to emotional boosts [56, 82]. There are many ways one can build happiness through the pursuit of goals, such as choosing goals (e.g., ones that are intrinsically motivating), experiencing autonomy in pursuing the goals (e.g., flexibility in selecting goals to match current mood), and choosing how one executes a goal (e.g., breaking down a goal into sub-goals) [56, 68]. In our study, participants spoke about many such approaches. Participants (P4, P8, P9) found that time management was their conscious or unconscious strategy that led to feeling happy. For example, P4 mentioned that being able to start and finish a creative project within a time frame (rather than continuing it another time) gave them *"immediate satisfaction [...] endorphin boost immediately when it's done"*, which contributed to their happiness. Participants also spoke about how they pursued their goals and the impact this had on their feelings of happiness. For example, some participants (P1, P4, P9) mentioned that consciously selecting to work on familiar projects that they could accomplish with certainty was a way to feel happiness. For example, P9 said, *"[...] a very, very achievable thing. I'll probably do that in 45 minutes. I know that it's going to workout because I have that confidence. So then that I will do".* Such choices were often made by the participants themselves, and participants did not mention CSTs as contributing to such ways of committing to pursuing goals. However, when asked about how CSTs could be designed to support creators' happiness, they highlighted new ideas for CSTs that could assist with such approaches to goal-following. For example, P9 spoke about how part of pursuing a goal requires being able to clearly define that goal, and suggested that if CSTs could provide inspiration for defining their goals, that would generally increase their positive disposition throughout the creative process (*"either clearly defining the goal or creating anticipation for the goal or something along those lines, should generally increase my positive disposition throughout the process, and so some tools [...] that are able to give inspiration for the goal"* [P9]). At a higher level, a commonly mentioned idea (by P1, P3, P4, P8, P9, P11, P13) was related to keeping track of the creative process. For example, P11 said, *"I think, I know one of the aspects of happiness is being able to see like [...] see progression in your work or being able to see the impact of that [...] So maybe if there's some way that could be like integrated into the drawing program or another program, that could be useful to fuel more satisfaction in your work".*

5.3.3 Being More Sociable. Engaging in social interactions can boost happiness [74]. In creative contexts, this can happen because social interactions lead to feelings of belonging (e.g., [88]), and enable creating support groups that help one accomplish their creative goals [77]. This was also echoed by our participants who found that joining or creating self-organized social groups (P4, P8, P10, P13, P14) created a sense of community, made creative engagement a fun experience, and overall promoted feelings of happiness (e.g., *" I started a discord server for different cosplayers and cosplay photographers [...] I've been told by others in the discord group, has also helped them accomplish the same things, so I feel very,*

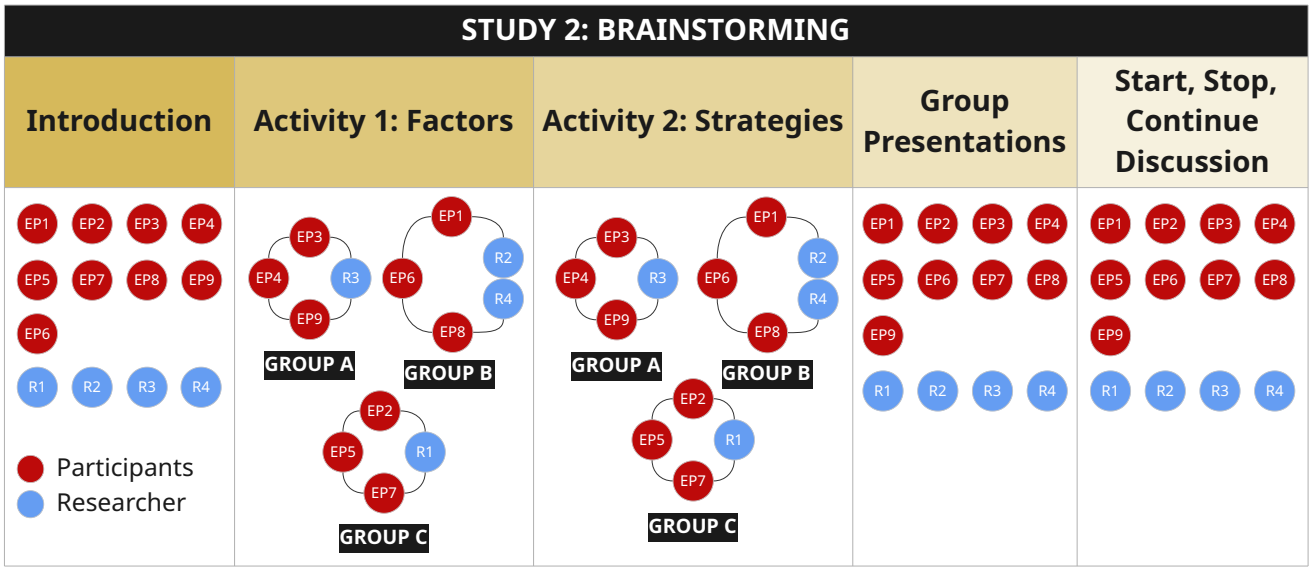


Figure 1: An overview of the brainstorming study procedure.

very engaged and satisfied and happy and also proud of the social domain aspect of it" [P4]). Regarding CSTs, participants' responses highlighted that CSTs did not necessarily address their specific needs for social interactions that could in turn foster happiness. For example, P3, P4, and P15 spoke about how CSTs would benefit from having features that enabled easier sharing and discussion with others. For example, P4 said, *"I mentioned I use Procreate, I use Fusion 360. Those definitely feel like again, a solo activity of like, be sitting at my computer and, you know, struggling with Fusion 360 to make my 3D models or on Procreate just like kind of sitting there and drawing out designs that I want to make. Yeah, having like that, turn into more of a social activity could be fun"*. Some participants (P1, P9, P13) spoke about how CSTs could create an encouraging environment to promote some of the benefits received from social interactions. For example, P9 spoke about how individuals may not be able to build happiness by themselves, but social interactions can encourage such feelings through receiving feedback and encouragement (*"the ability also to provide encouragement. [...] For instance you savor the thing by showing people [...] so if you're talking to experts, and they're saying you know this is the stage that you're at, this is the thing you're producing, and here's the encouragement for it"*). They suggested that CSTs could create such an environment by enabling conversations with human experts or an AI agent (*"I envisioned a little like AI agent or entity and they could maybe like analyze what you've done and give you suggestions and how to improve or fix things and also on the flip side I could say, maybe you could say wow, that looks really good for example* [P1]).

6 Phase 2: Brainstorming Study

We conducted a brainstorming session with nine participants (EP) to gather insights on how future CSTs could be designed to explicitly foster happiness (RQ2). Akin to participatory design methods [69], our aim was to bring together participants who are end-users and stakeholders (our participants are end-users of CSTs, and have expertise in CST and happiness research) to reflect on and explore designing happiness fostering CSTs.

6.1 Study Procedure

The brainstorming session was conducted remotely and lasted about 2.5 hours. The session had five main sections (Figure 1). We started with an introductory session wherein we shared the goals of the study, and provided existing definitions for happiness and CSTs from psychology [27] and HCI [37] respectively. Next, participants completed two design activities that focused on brainstorming CST ideas using determinant factors and strategies for building happiness, informed by our insights from the interview study (Figure 2). We shared a non-exhaustive list of determinant factors and strategies with the participants based on existing studies in the areas of creativity and happiness [18, 33, 56], and our interview study results. Participants were free to select from this list or determine their own based on personal or research experience. These activities were completed in breakout groups of three participants along with one or two research team facilitators (Figure 1). For the design activities, we followed a typical brainstorming format [63], wherein participants first identified a problem/scenario for design, then developed several ideas individually, and finally converged on a single idea as a group based on discussion. We provided an interaction scenario for each activity based on examples from our interview study but participants were also free to develop their own. Lastly, a group discussion was conducted wherein participants first briefly presented the ideas they had generated within their groups, and then we used the Start, Stop, Continue framework [23, 44] to identify and discuss potential design priorities for research in this area. Participants documented their individual and group ideas

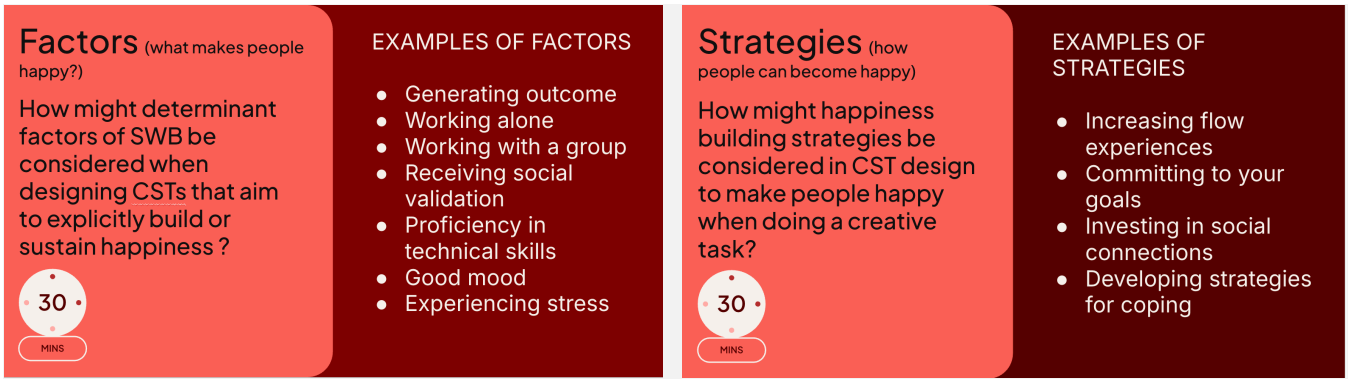


Figure 2: Slides shown to introduce participants to the brainstorming design activities related to factors and strategies.

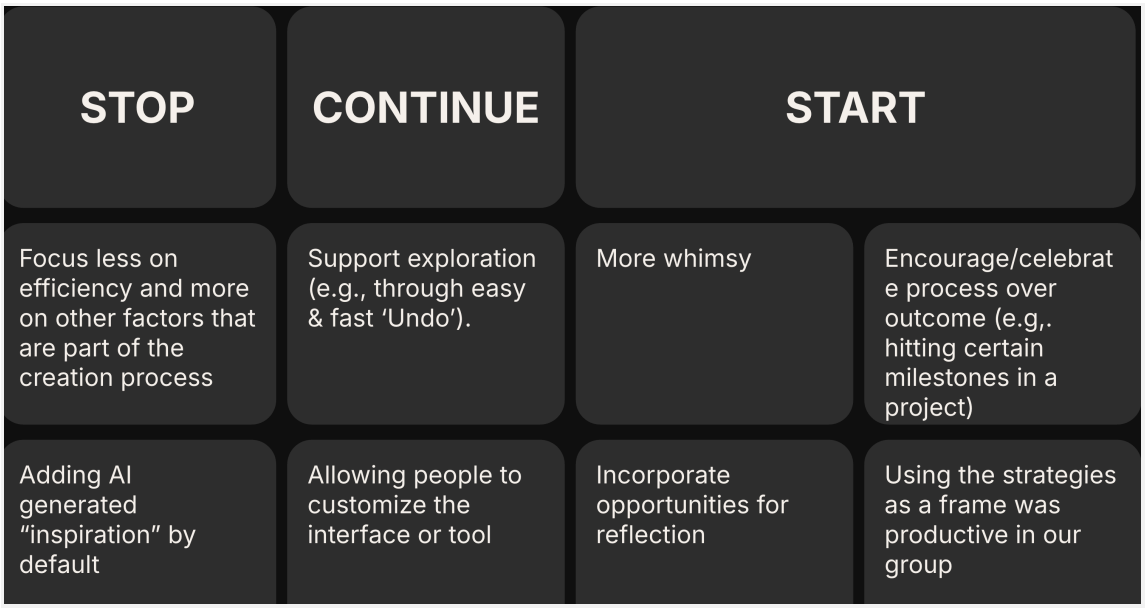


Figure 3: Examples of participant responses to the Stop, Continue, and Start activity.

during the two design activities using a slide deck template we had created for the study. Similarly, participants entered their thoughts for the Start, Stop, and Continue activity using slides in the deck we had created (a collated slide with some participant responses is shown in Figure 3). The design activities lasted about 30 minutes each (1 hour total), and the presentation and discussion activities lasted about 40 minutes. Participants received a $10 e-gift card remuneration. Our study was approved by our university ethics board.

6.2 Recruitment and Participant Demographic

Similar to the interview study procedure, we shared our recruitment call via social media and through personal contacts, and recruited participants from NA. For participants' expertise, we set a minimum limit of three years of research experience and publication of two full-length papers in topics related to CSTs and happiness. These requirements were based on typical expectations in NA universities for PhD students to demonstrate research expertise, and therefore we considered them broadly applicable for identifying expertise. All participants were asked to complete an 8-question pre-study questionnaire that gathered data about participants' research background and demographics, and a happiness questionnaire. The happiness questionnaire was the same as the interview study with the exception that in this phase, we gathered data about participants' perceptions about CSTs only.

A total of nine participants took part in our study. Participants ages ranged from 25 to 44 years old, and four self-identified as women and three as men. At the time of data gathering, four participants were senior PhD students (P1–P4), one was working as a research scientist in industry (P5), one was a freelance researcher and technical writer (P6), and three were HCI professors (P7–P9). Seven participants had experience conducting research in the area

of CSTs, and five had experience conducting research related to happiness. Participants used a variety of CSTs such as Arduino, Adobe products, image editing tools, Gen AI tools, and mind mapping tools. Participants' information is summarized in Table 3 in Appendix A.

6.3 Data Analyses

From the brainstorming session we gathered two main data sources: a video recording of the full session, and the slide deck, wherein participants documented their individual and group ideas. The video recording was transcribed for qualitative analysis. Two researchers (R1 and R3) independently coded the breakout session transcript for Group B and the corresponding slides that included the brainstormed ideas. We met to discuss our codes and resolved questions and disagreements. R1 then coded the remaining data. The final codebook has 153 codes grouped into categories such as "factors and strategies used in the converged group ideas", the "envisioned software and hardware-based features in the individual and group ideas", and "idea critique".

7 Brainstorming Study Results

7.1 Summary of Brainstormed Ideas

The nine participants (EPs) in our brainstorming study produced 77 ideas in total. For each activity, the groups created one final idea based on their individual ideas (total 6 ideas; illustrated in Figures 4, 5). These ideas were based on either the scenarios we provided (scenarios 1 and 3), or those created by the participants (scenarios 2, 4, and 5), and each scenario included imagined end-users (e.g., Tim, a high school student or Anna, a costume designer). Next we briefly describe the final ideas (Figures 4, 5).

Idea 1: This CST focused on helping Tim engage in a graphic design activity. To help alleviate Tim's stress about peers liking his design, participants proposed that Tim could share his project with his peers gradually through a GitHub-like system and get feedback. To address the frustration he felt with finding inspiring yet skill-appropriate materials, participants proposed a YouTube-like system where Tim could annotate difficult parts of a tutorial, triggering them to be broken into smaller, achievable steps. The idea aimed to address three determinants of happiness—*working with others*, *social validation*, and *competence*. Participants envisioned that sharing progress could help Tim see personal growth, receiving feedback could sustain his motivation, and breaking down complex ideas could build competence.

Idea 2: This CST focused on helping a hobbyist sewist share projects with others. Participants proposed a live streaming platform with recording devices built into the sewing machine, allowing viewers to give feedback and encouragement. A companion haptic vest would let the sewist *feel* positive feedback. The idea addressed two determinants of happiness—*working with others* and *social validation*. Participants proposed that collaboration with the community could ease the loneliness felt when doing solo activities like sewing, while both tactile and text-based feedback received from the audience watching the live stream could increase joy and task satisfaction.

Idea 3: This CST, similar to Idea 1, focused on helping Tim generate outcomes and reduce stress through reassurance. The CST was

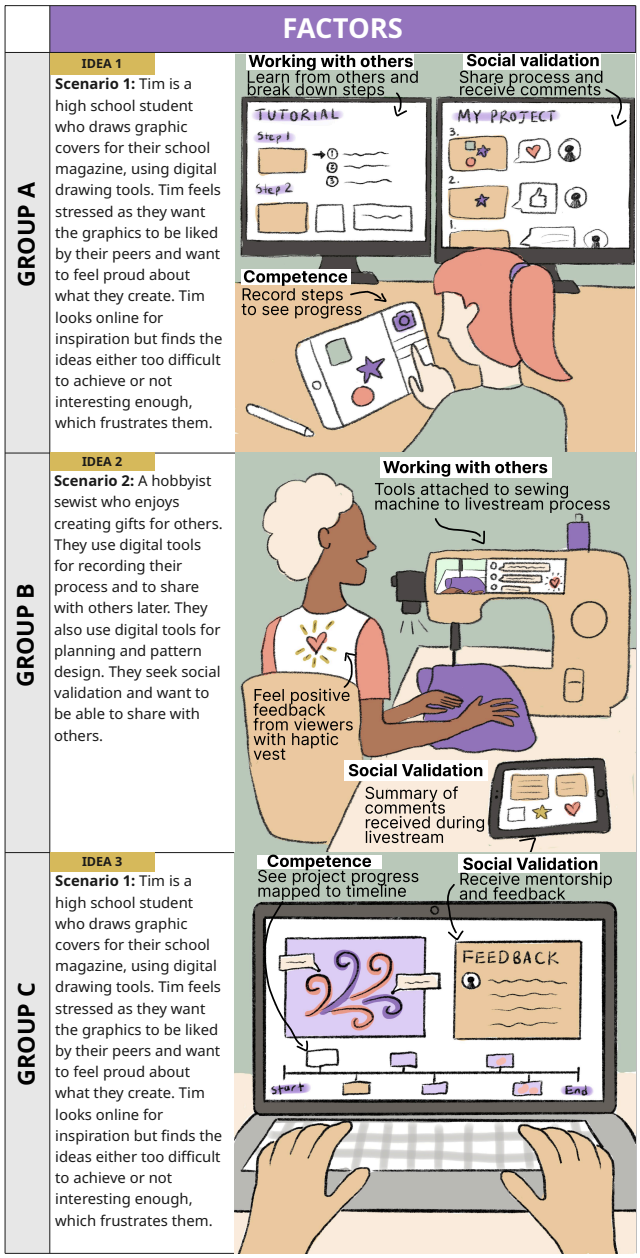


Figure 4: Illustrations of the final ideas brainstormed by the participants using *determinant factors* of happiness as a starting point for design.

framed as a mentorship and learning tool, where Tim could share work with experts for technical feedback. The tool also included a showcase area wherein Tim could gather feedback from the broader community. Lastly, to help Tim reflect on his progress participants envisioned adding a feature that would show project progress over time. Through these features, participants proposed that two main determinant factors—*competence* and *social validation*—could be supported. Participants posited that receiving feedback from others

could reassure Tim that his work is appreciated, and practice and skill-building could strengthen his sense of competence.

Idea 4: This CST emphasized the strategy of *investing in social connections* by recognizing others' contributions. Envisioned as a gallery, the CST would display projects with linked credits to collaborators, reminding creators to reflect on and appreciate shared contributions. Beyond links, participants also proposed that the CST could include personalized thank-you gestures such as notes or help with making personalized gifts. Participants suggested that such tools could foster reflection and gratitude within creative collaboration, in turn improving positive affect and satisfaction with the activity.

Idea 5: This CST focused on the strategy of *developing coping mechanisms* through a virtual rubber duck assistant integrated into a programming IDE. The rubber duck assistant could monitor frustration via webcam or microphone, reference past work, and provide both technical guidance (e.g., debugging support, circuit suggestions) and emotional encouragement (through reassuring or encouraging the end-user). Participants proposed that such a CST could help creators manage stress and remain in flow.

Idea 6: This CST combined two strategies—*developing coping strategies* and *increasing flow* for fostering happiness. The CST was meant to provide support during moments when Tim felt stuck in design work. The CST would either provide task-relevant information (e.g., mood boards, tutorials) or suggest activities that could help Tim recover by taking a break (e.g., playing games, or doing puzzles). To detect when Tim is stalled, the system would use interaction logs or manual input. The participants also suggested that there must be a limit to how many times the end-user can indicate needing such help, to avoid procrastination. To ensure novelty of such experiences, participants suggested new activities would be generated daily by the CST. It was proposed that such a CST could help reduce frustration and promote flow.

Overall, through the final ideas (ideas 1–6) and the individual ideas participants brainstormed, we observed that participants brought up many software and hardware feature ideas which could be summarized as belonging to four main categories—*social and community features* (e.g, sharing features, commenting feature, and attribution supports), *emotion and motivation supporting features* (e.g., a virtual assistant that provides encouragement, cognitive reset activities generator, and reflection reminder), *cognitive and problem-solving supports* (e.g., features that help break down a problem into smaller parts, inspiration galleries, automatic solution providers), and *process awareness features* (e.g., process history visualizer, and process recorder). Some of these ideas generated by the experts were similar to those mentioned by our interview participants—such as features that help with finding inspirational materials, community engagement supports, and capturing and visualizing the creative process, as well as those demonstrated in research related to community engagement, and visualizing the creative process (e.g., [8, 70, 91]). However, during the brainstorming study, because we explicitly focused on factors and strategies, additional ideas that were more holistic or augmenting existing ideas in their consideration of happiness, were suggested—such as the cognitive reset features (idea 6), features that promote whimsy (idea 5), features

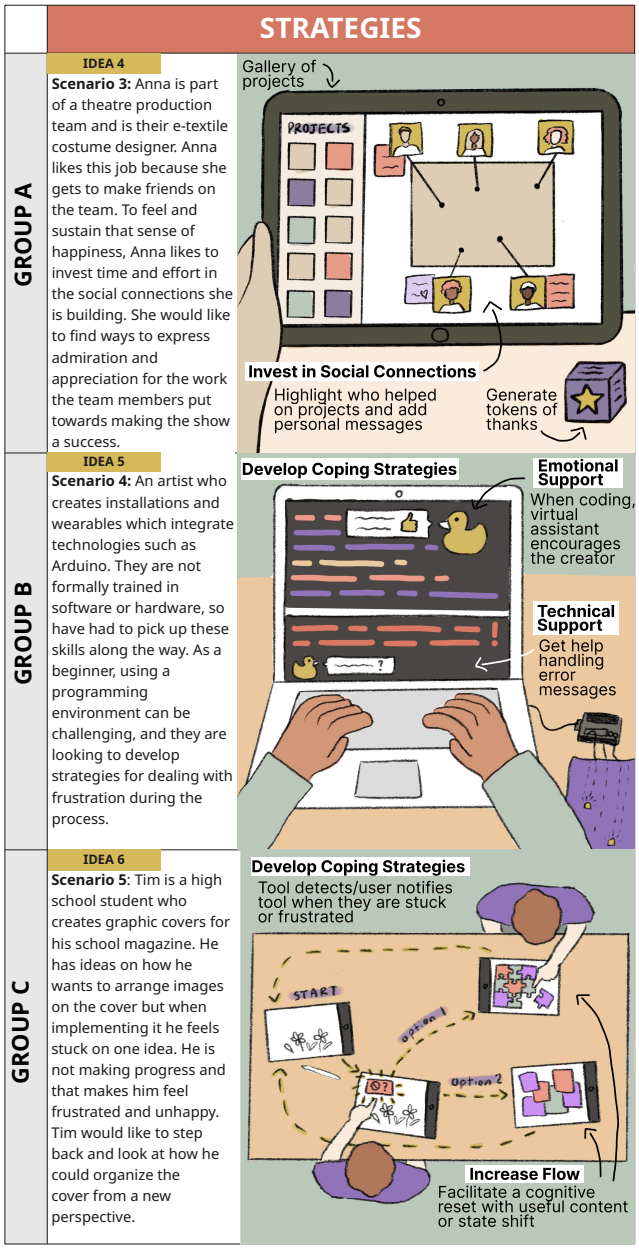


Figure 5: Illustrations of the final ideas brainstormed by the participants using *happiness fostering strategies* as a starting point for design.

that help break down a complex project into more achievable outcomes (idea 1), attribution features (idea 4), and celebrate progress making (all ideas).

7.2 Strengths and Challenges

Participants discussed the strengths and limitations of their ideas within breakout groups as well as with the full group during the Start, Stop, and Continue activity.

7.2.1 Strengths: In general, the rationale for why the software and hardware features in the proposed CST ideas (Figures 4, 5) could contribute to making someone happy touched on aspects of affect and satisfaction. Participants highlighted that their ideas had the potential to cultivate joy, promote mindfulness, help creators celebrate their achievements, and enable reflection individually and with others, and this in turn could create more positive and satisfying experiences that make someone feel happy. This rationale resonates with existing theories like the PERMA model, wherein things that facilitate the five components are said to contribute to building happiness [80].

In addition, one participant who uses self-determination theory (SDT) [21] in their research, expressed that these ideas also covered aspects related to basic psychological needs—competence, autonomy, and relatedness—and as such had the potential to foster happiness [22]: *"Like the relatedness belonging to a community, the competence where you where you make it own or like the competence where you where you feel like you're actually good at what you're doing here, and autonomy, where you can make it your own, you'd make the choices and you have choices in in making that. So yeah, I guess we're covering basically everything that's needed for feeling good from that theory perspective, at least."* [EP3].

7.2.2 Challenges: Participants highlighted challenges with designing CSTs for cultivating happiness. First was regarding the difficulty of resolving the tension between supporting the primary task of creating an outcome and the broader goal of supporting happiness. For example, EP5 said, *"The primary goal of these [existing commercial] tools is to create a tangible outcome and all of these other factors to generate happiness are sort of secondary. And so I could see them [proposed CST ideas] getting pushed in priority down lower if they interfere with that primary task of creating a result"*. Such tension could also arise from the creative context for which end-users use CSTs. For example, EP6 said *"I don't know if companies would want to put them [proposed virtual rubber duck CST] in their IDEs. I mean they should. But like if you think that what IDEs look like, they don't look fun, they are very like serious and and so implementing something that is kind of fun or whimsical could have like the Clippy effect [...]. So there's like a stigma against anything that's not super serious, productive, efficient"*.

In critiquing the designs, participants also spoke about needing to find the balance between promoting happiness and unhappiness. This was specifically mentioned in regards to social interaction features. For example, participants highlighted that some features (e.g., becoming overreliant on positive feedback) may have negative impacts, but if carefully designed, such risks could be mitigated; EP5 said that *"[...] having that reflective practice in there could be something"* that could reduce or mitigate such risks.

Another challenge mentioned by the participants was that happiness is a subjective construct, and as such could lead to technical challenges such as scope creep and difficulties creating solutions that work for many (*"Something that I've been thinking about a lot is just like flexibility is helpful in these subjective scenarios. Like if you have the option to toggle certain things on or off depending on what you you know feel in that moment and how it's going to affect your happiness"* [EP7]).

Lastly, a challenge related to evaluating these CSTs was also brought up by some. For example, related to idea 6, EP5 said, *"Yeah, I feel like one drawback might be that because these [strategies] are closer to the solution [helping Tim overcome his creative block] but farther away from the actual end goal [e.g., creating graphics] is that it's not clear that these are going to solve the problem. So like that, you know, we're still not making sure that Tim completes his thing, but this is at least closer to the strategy that might help him get there"*.

8 Discussion and Future Work

We first summarize key insights from both studies and then present a set of *implications for design*. The *implications* include conceptual considerations for designing happiness fostering CSTs (sections 8.2, 8.2.3, and 8.2.5) and practical design resources to guide future work (section 8.2.4).

8.1 Key Insights

The key insights we gathered are summarized in Figure 6. We asked two research questions:

RQ1: If and how does creativity facilitated through CSTs make people happy? — From the survey data, we found that for our interview participants, the creative activities, compared to the companion CSTs they used, were perceived as the main drivers of their happiness. One possible explanation for this result could be because the CSTs our interview participants used introduced barriers to experiencing joy, reducing frustration, or feeling satisfaction from the task. In both results sections 5.2 and 5.3, several similar barriers to feeling happiness emerged, such as complex software that hindered the enjoyment of outcome generation and experiencing flow, or inspirational materials such as tutorials which tended to negatively impact creative self-efficacy or hamper feelings of satisfaction. Additionally, while certain features were noted to facilitate feelings of accomplishment, satisfaction with the task at hand, and occasionally surprise (e.g., tools affording unexpected outcomes, algorithms providing personalized solutions, and usable tools), most participants characterized such experiences as incidental rather than the design being in service of fostering happiness. These insights are aligned with results on *what* determines happiness and *how* people build happiness in other contexts, like life (e.g., [56, 82]) and work (e.g., [93]), and for specific end-user groups like students (e.g., [85]).

RQ2: Which types of CST software features could be helpful for fostering happiness when engaged in creative activities? — From our brainstorming study, we found that although participants considered that current CSTs have helpful features, like documentation support, interface customization options, and enabling easy explorations, what they are missing more broadly is a *"level of care"* [EP1] for the end-users, that their proposed ideas more often tended to highlight. Such a lack of "care" has been highlighted across many different types of technologies in concepts like positive computing [11], positive design [25], positive technology [72], and slow technology [43, 62].

8.2 Implications for Design

8.2.1 Leveraging PERMA for Designing CSTs. In our interview results (section 5), three aspects of PERMA were mentioned more

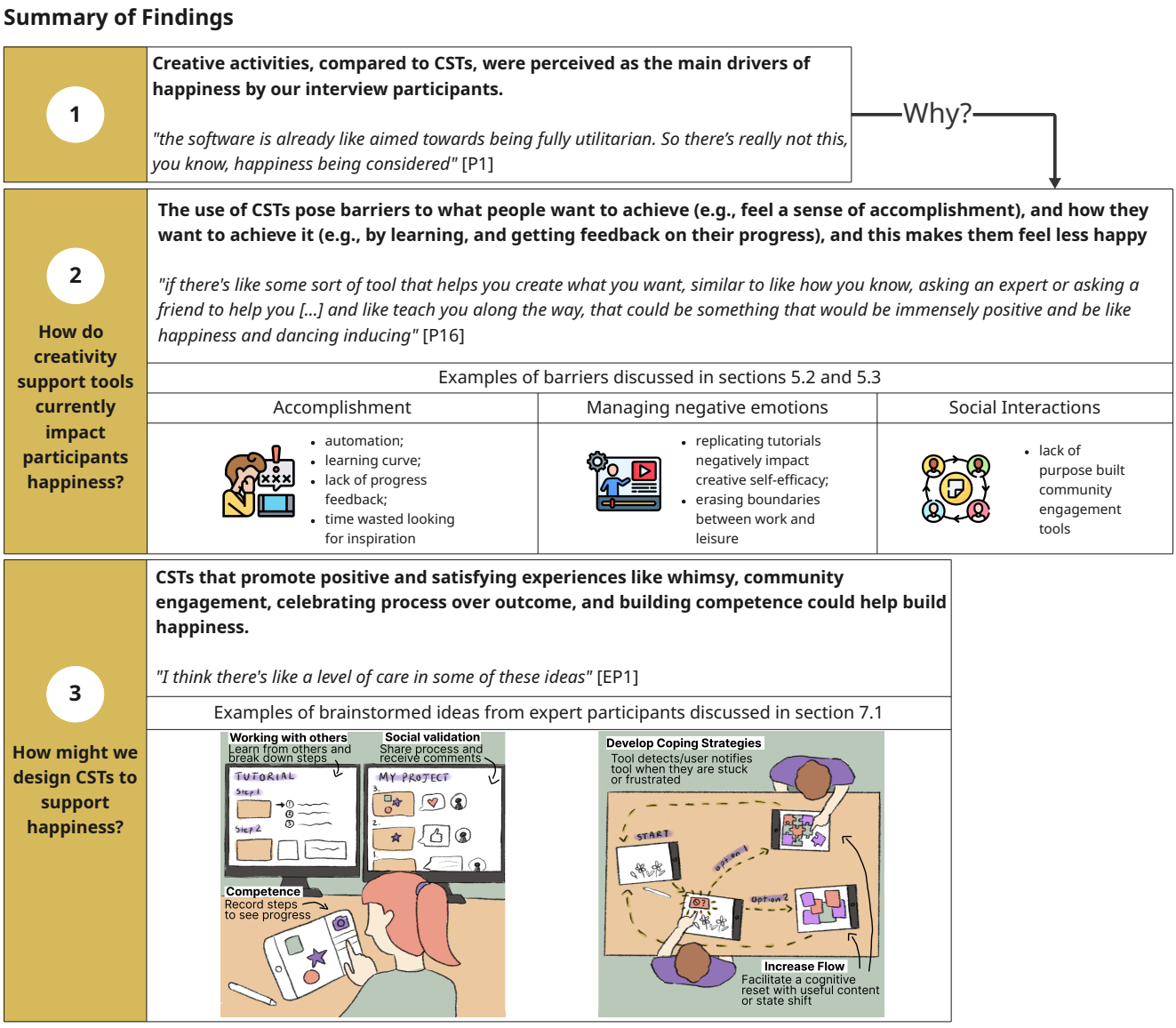
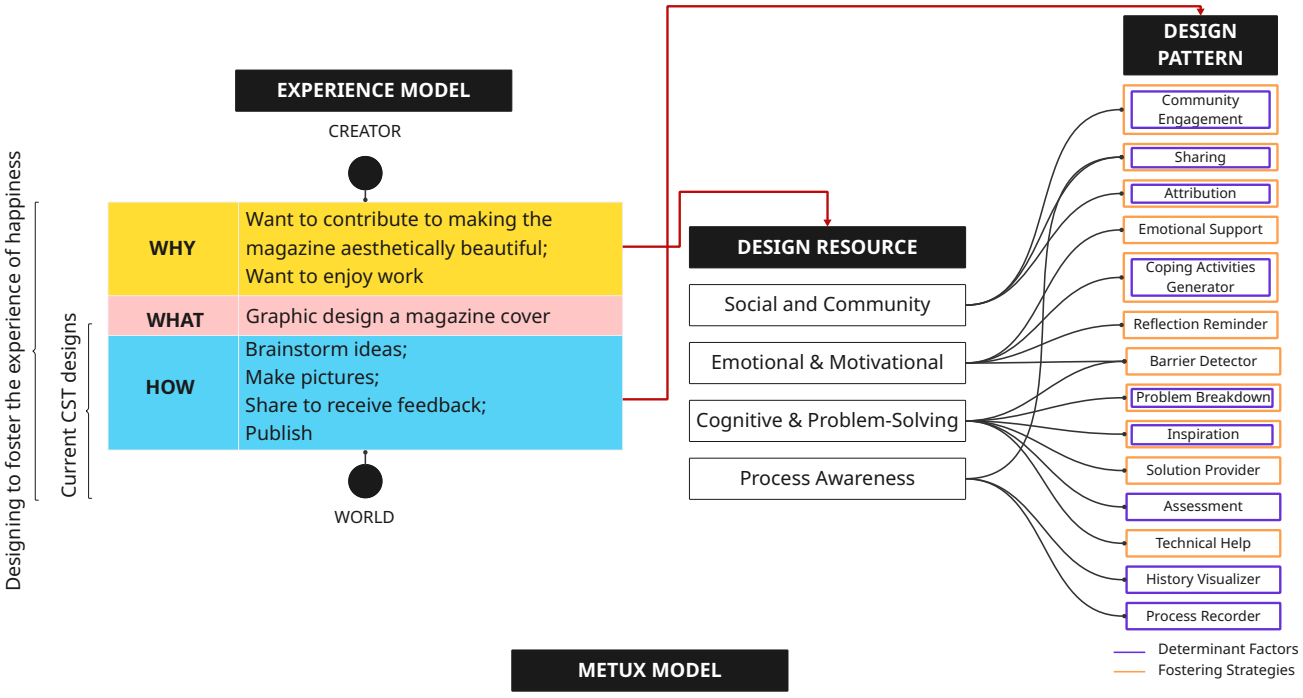


Figure 6: A summary of our key findings from both the interview and brainstorming study.

explicitly: Engagement (E), Positive Relationships (R), and Accomplishment (A). The remaining two, Positive Emotions (P) and Meaning (M), were mentioned across the results but indirectly. It is possible that we heard more explicit mentions of E, R, and A because current CST features support these to promote creativity. Because there is a bidirectional relationship between happiness and creativity [1], this could have led participants to reflect on the supports for E, R, and A more often when considering happiness. For example, CSTs that assist with outcome realization are one of the most prevalent categories [37, 49], and because one of the determinant factors for participants' happiness was outcome generation, participants perhaps saw features that support outcomes as sites for improving creative experiences and happiness.

The indirect mentions of P and M also shed light on how PERMA applies to technology-mediated designs. Traditional PERMA fostering strategies for P and M (e.g., how one can use their passions to help others) are largely non-technical [82]. Therefore, translating them to designs for improving creativity and happiness can be difficult. To bridge this gap, researchers can look to our study findings and related research (e.g., [8, 91, 94]) as a starting point. For example, in our brainstormed ideas, participants described meaning-making as an embodied outcome that could be supported through mentorship features, attribution features, and tracking skill growth. In research, ideas like Tseng's [91] process-oriented documentation has been posited as enabling reflection on self growth. Likewise, online creative communities have been proposed as sites for showing



Sphere of Experience	Example: Creator Experience for Graphic Design	Possible Outcomes
Adoption	Willingly downloads a graphic design software.	Uses the app.
Interface	Has the necessary controls, navigation, information display, and aesthetics.	Finds the software usable and enjoyable.
Tasks	Wants to commit dedicated time for doing the work, brainstorming ideas, making pictures, sharing with the team for feedback, publishing.	Derives satisfaction and joy from performing and completing the tasks.
Behaviour	Wants to commit to their goals.	Is engaged and satisfied in the activity of graphic design. Enjoys partaking in the activity.
Life	Wants to experience happiness.	The use of CST in one domain (e.g., work), helped with skill development that could be applied in other life domains such as hobby leading to increased life satisfaction.

Figure 7: Considerations for designing CSTs that aim to foster happiness—1) consider the experience model levels to think through the interactions the creator will have with a CST, 2) think about the design resources that can help with designing interactive CSTs that support happiness of the creator when engaged in a creative activity, and 3) for evaluation consider the different levels upon which a technology can have an impact.

care for others [8]. Future investigations of such designs as interventions for supporting PERMA can help expand our knowledge on how to translate happiness theories to technology design.

Takeaway: Designers of CSTs can use features that support each part of PERMA as levers to foster happiness in technology-mediated experiences.

8.2.2 Facilitating Care through CSTs. The brainstormed ideas in our study (section 7) build on previously demonstrated CST designs, but as a set they are novel in their focus on happiness. For example, even though ideas of social validation have been demonstrated in CSTs (e.g., Tseng's [91] shareable process visualizations), and in platforms like Thingiverse (through "like" buttons and comment features), the ideas participants proposed go beyond such concepts. For example, sharing the creative process was part of some ideas (ideas 1 and 3), but this was not only to reflect on documentation, but to celebrate making progress as its own goal. Thus, the ideas have subtle differences from existing solutions: like gradually revealing the process to show progress over time (idea 1), and sharing the process to receive mentorship (versus only comments) (idea 3). Similarly, receiving feedback and likes from community members was not only for validation but to *feel* the positive feedback as a way to reduce loneliness and increase joy (idea 2). Ideas related

to embedding strategies (ideas 4–6) although include known techniques in software like rubber ducking, and real-world practices like showing support through attribution, also highlight how digital designs can put an emphasis on celebrating effort, promoting whimsy, and building relatedness.

This notion of focusing on happiness as an end in itself versus as a means to an end, emerged from our data analysis, and is what we refer to as "care" in CST designs (a term we borrow from our participant quotes). This notion aligns with arguments made by existing frameworks (e.g., [11, 25, 46, 72, 83]). Specific to CSTs, it aligns with Li et al.'s argument [55] who discuss that traditional CST designs tend to create normative grounds that can restrict the types of experiences creators can have with a tool. Therefore, finding ways for tools to become more responsive to the needs of a creator can help advance the CST research agenda [55].

Takeaway: Designers of CSTs can position *care* not as ancillary but as a central design value to broaden what CSTs offer creators.

8.2.3 Addressing Tensions between Supporting Creator's Productivity versus Happiness. Supporting production has long been a primary goal of CSTs [37], and indeed, many of our participants emphasized using CSTs to accomplish creative tasks. However, if the goal is to foster happiness, designers must navigate the tension between helping creators produce desired outcomes and supporting the intrinsic experiences people gain from creative activities (e.g., joy, satisfaction, or fulfillment) (section 7.1). Facilitating happiness does not conflict with productivity; it simply shifts the design emphasis [24, 65]. In this framing, production becomes an integral part of the process but not the sole objective. To address this design tension, we can draw from topics like technology-mediated experience design [45], and positive computing [11]. Hassenzahl defines an experience as something holistic that comprises perception, action, motivation, and cognition [36, 45]. The technology-mediated experience model suggests beginning with the *why* (things that motivate people, such as wanting to contribute, express oneself creatively, or enjoy work), then considering the *what* (the activities users want to accomplish, e.g., graphic design), and finally the *how* (specific tasks, such as brainstorming ideas, sharing outcomes, or publishing) when designing technologies. Studies like ours can help researchers populate such experience models as shown via our example in Figure 7. Future studies can develop additional models based on studies of happiness such as within specific activities (like design tasks) and for specific end-users (e.g., specific cultural groups), to help HCI researchers to more fully comprehend the construct of happiness within technology-mediated creative activities.

Takeaway: To design for happiness, we suggest first eliciting users' intrinsic motivations (why versus how), and then translating these motivations into experience goals. Such experience goals can then be used to guide feature decisions for implementing CSTs.

8.2.4 Designing Interactions to Create the Experience of Happiness. Once we have an experience model, the next step is translating it into practical design and implementation ideas. Our interview participants expressed difficulty envisioning CSTs that explicitly support happiness (e.g., *"I think I've just never seen it before [...] I would be interested and curious in seeing software that had these, you know, features to support happiness as well as their just the basic utility of doing the creative work"* [P1]). Similarly, the literature highlights that current HCI models and frameworks related to fostering happiness lack practical design guidance [64, 83]. While frameworks such as positive design [25] and positive computing [11] outline conceptual levels of consideration, they stop short of offering actionable design resources.

Drawing on our brainstorming study, we propose an initial set of design resources and design patterns that may support happiness (Figure 7). Following Bentvelzen et al. [6], we define a design resource as a high-level concept which, if implemented, could lead to fostering happiness. Design patterns are more concrete ideas for implementing the design resources in a system. We propose four main design resources (Figure 7): social and community support, emotional and motivational support, cognitive and problem-solving supports, and process awareness supports (discussed in section 7.1). These resources map onto the *why* level of experience (motivations) and the corresponding patterns map onto the *how* level of the experience (tasks) model. For example, if users want to feel capable of contributing meaningful designs and enjoy their work, design resources such as community engagement and process awareness could be supported by concrete patterns like sharing progress, receiving expert feedback, or interacting with an "emotional support" virtual assistant. While not exhaustive, these patterns align well with the types of tasks CSTs commonly support [37]. Future work can extend this initial set of design resources and design patterns, and test applicability across contexts, including identifying which design resources are appropriate for whom while also carefully identifying potential for negative implication (such as those caused by social media style interactions [7]).

Takeaway: When making feature decisions for implementing CSTs that aim to cultivate happiness, designers can first identify which design resources are relevant for their context, and then identify design patterns.

8.2.5 Evaluating CSTs for Assessing Impact on Happiness. Another consideration is knowing whether the CSTs designed using the experience model, and our proposed design resources, can indeed foster happiness. The METUX (Motivation, Engagement, and Thriving in User Experience) model [65] could be used as a starting point to address this challenge. The METUX model assesses the extent to which technologies satisfy basic psychological needs—autonomy, competence, and relatedness—across multiple spheres of experience: adoption, interface, tasks, behavior, life, and society. Both the METUX model and the construct of happiness are rooted in SDT [58, 74], and SDT is a domain-supportive theory that can be applied to contexts such as CSTs. Based on this, we propose that adapting the METUX model for evaluating happiness-fostering CSTs could be useful. Specifically, we suggest assessing happiness-related outcomes across five spheres of experience: adoption, interface, tasks, behavior, and life. The sixth METUX sphere, societal impacts, is excluded here as it is less commonly considered in current CSTs [37]. Figure 7 illustrates an example of this adaptation, wherein at each sphere level the motivations of the end-user are identified, and possible ways in which a technology-enabled task can impact the spheres are listed in the "possible outcome" column.

Additionally, being explicit about whether a CST design targets determinant factors or strategies can clarify evaluation metrics.

For example, fostering a sense of accomplishment can involve supporting the determinant factor of output generation or supporting strategies such as developing coping mechanisms. Although the goal is the same, designs focused on determinant factors may primarily assess whether outcomes are produced and how that affect users' sense of happiness. In contrast, strategy-focused designs may not help users develop outcomes directly or even aim to but could still improve users' sense of accomplishment by increasing reflection. We encourage future research to explore, extend, and validate these evaluation considerations.

Takeaway: Researchers and designers could effectively evaluate whether CSTs foster happiness by operationalizing happiness into smaller, observable, and measurable outcomes.

9 Limitations

As a first study to explore the role of CSTs in making people happy when engaged in creative activities, there are several areas for future explorations. First, in our interviews and brainstorming sessions, participants discussed commercial CSTs such as Adobe products, Pinterest, and Programming IDEs they use in their everyday life. Therefore, we do not know if CSTs proposed in research will lead to similar insights, and thus studying research-based CST designs from a happiness perspective is an avenue for future exploration, as also proposed by Cox et al. [71]. Second, in our study, participants generally took the view that happiness was an important or useful construct to consider in design. Thus, they were open to the idea of designing technologies that explicitly prioritized focusing on happiness in addition to general usability. However, we acknowledge that based on demographics, cultural learnings, and other context-specific factors, happiness may not be as important for some people, and traditional metrics of design—such as improving productivity—may continue to dominate design requirements. Broadening future studies to include members from different cultural backgrounds and contexts could help us learn more about ways to emphasize and de-emphasize the focus on happiness in technology design. Third, participants in our Brainstorming study had expertise in research topics related to CSTs or happiness, which made them stakeholders, and because they used varied CSTs in their day-to-day life, they were also end-users of CSTs. This dual role may have led to specific design ideas that participants without such dual roles may not have proposed. Future studies can confirm and expand upon our findings by broadening their participants demographics.

10 Conclusion

In this paper, we explored how creativity facilitated through CSTs can foster happiness. Through our studies, we found that while creative activities themselves strongly contribute to happiness, CSTs introduce barriers that can diminish the feeling of happiness. To address this challenges, we discuss using an experience-centered design approach, propose a set of design resources and patterns for design and implementation of CSTs, and suggest an adaptation of the METUX model for evaluating the impact of CSTs on creators' happiness. Together, these insights provide a foundation for designing CSTs that not only helps creators achieve their goals but also contributes to their joy, satisfaction, and sense of fulfillment. We encourage future research to expand on our work, and to continue bridging technology-facilitated creativity and experiences that such activities can bring, like happiness, in meaningful ways.

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A Participant Demographics

P#	Gender	Age Range	Background	Creative Activities	Tools Utilized
P1	Female	18 to 24	MSc Student	Drawing/Digital Art	Tablets, Krita, Infinite Painter
P2	Female	18 to 24	Student	Digital Sketching, Mandala Art, Knitting	Procreate
P3	Female	18 to 24	Undergraduate Student	Woodwork, Laser Cutting, 3D printing, Collaging, Printmaking, Painting	3D printer, CNC, Fusion360, AutoCAD, Pinterest, YouTube, Online Magazines
P4	Female	25 to 34	PhD Student	Crocheting, Sewing, Wig styling, Photography, 3D printing, Painting, Costume Design Sketching	Sewing Machine, iPad, Procreate, 3D Printer, Fusion 360
P6	Female	25 to 34	PhD Student	Sewing, DIY Bullet Journaling, Prototyping	Procreate, Goodnotes, Figma, Python
P7	Female	18 to 24	Undergraduate Student	Knitting, Crocheting, Sewing	Creative Websites, Online Forums, Tally, YouTube
P8	Female	25 to 34	PhD Student	Sewing, Nail Art, Cookie Decorating	Social Media
P9	Male	25 to 34	Business Owner	Playing Trumpet in a Band, Playing Cello Solo, Making Audio/Music, Drawing Maps, Designing Consumer Electronics	CakeWalk, Krita, Pen and paper, SolidWorks
P10	Female	18 to 24	Undergraduate Student	Digital Drawing, Multimodality Art	Procreate, Pinterest, Coolors.co
P11	Female	18 to 24	MSc Student	Digital Drawing, UX/UI Design, Drawing, Playing Guitar	iPad, Procreate, Apple Pencil, Clip Studio Paint, Pure Ref, Pinterest, Twitter, Figma, Google
P12	Male	35 to 44	PhD Student	Visual Design, Music Performance, Design and Fabrication	Adobe Illustrator. Rhino3D, Ableton Live
P13	Male	25 to 34	Research Scientist	Flamenco Guitarist, Drawing, Graphic Design, AI Animation, Standup Comedy, Poetry	Guitar, Phone, Paper, Markers, Tablet, ComfyUI, Adobe Premiere Pro, Adobe Illustrator, Adobe Indesign, Midjourney, Runway ML, Luma Labs, Phone, Notes App on Phone, Audio Recorder, Unplugged Microphone, Audition, Slack, WhatsApp, Microsoft Powerpoint, Microsoft Word
P14	Male	25 to 34	MS Student	Doodling, Graphic Design	Adobe Illustrator, Adobe Photoshop, Pen and Paper
P15	Female	18 to 24	Undergraduate Student	Music, Drawing, Origami	Laptop, iPad
P16	Male	18 to 24	Undergraduate Student	Makerspace Fabrication, Sewing, Cooking, Playing Alto Saxophone	Fusion 360, 3D Printer, Laser Cutter, Code Editors, Metronome, Sewing Machine

Table 2: An overview of our interview study participants.

P#	Gender	Age Range	Research Background	Years Conducting Research in the Area of CSTs	Years Conducting Research Related to Happiness	CSTs Utilized
EP1	Female	35 to 44	PhD student	5-9 years	5-9 years	Arduino, AI tools, Adobe Creative Suite, Drawing software
EP2	Female	25 to 34	PhD Candidate, Co-Founder of a wearables company	5-9 years	-	Adobe Photoshop, Adobe Illustrator, Bekonix, Pinterest, Sketching tools, Sewing tools, Google docs
EP3	Female	25 to 34	PhD student	-	5-9 years	Procreate, Nomad Sculpt, Blender, Adobe Photosho
EP4	Male	25 to 34	PhD Candidate	-	5-9 years	Adobe Photoshop, iMovie, Garageband,
EP5	Male	35 to 44	Research Scientist, Manager at technology company	5-9 years	-	Adobe Illustrator, Midjourney, AI tools
EP6	Female	35 to 44	Freelance researcher, Technical writer	Less than 5 years	-	Adobe Photoshop, Adobe Illustrator, Silhouette Studio, Retina Engrave
EP7	Female	25 to 34	Assistant Professor	Less than 5 years	5-9 years	GenAI tools, Miro
EP8	Female	35 to 44	Assistant Professor	Less than 5 years	5-9 years	Miro, Adobe Photoshop, Instagram, AI tools, Open Brush
EP9	Male	35 to 44	Assistant Professor	15-19 years	-	Obsidian, Visual Studio Code, Codium, Ardour, Zrythm, Ossia, Gimp, Inkscape

Table 3: An overview of our brainstorming study participants.

B Interview Study Pre-Study Questionnaire Responses

Participant Number	P1	P2	P3	P4	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16
Does engaging in your listed creative activities help with increasing positive affect?	5	5	5	5	4	4	5	5	5	4	5	5	4	4	5
Does engaging in your listed creative activities help with decreasing negative affect?	5	5	4	5	4	4	3	3	5	3	4	5	4	4	3
Does engaging in your listed creative activities help with increasing overall life satisfaction?	5	5	5	5	4	4	5	4	4	5	5	5	3	3	4
Does engaging in your listed creative activities help with increasing feelings of domain satisfaction?	5	5	4	5	3	4	4	3	3	4	3 to **5	5	4	3 to **4	4
Does using the your listed technologies help with increasing positive affect?	4	3	3	4	4	4	4	3	4	3	3	5	4	4	3
Does using the your listed technologies help with decreasing negative affect?	3	3	3	4	3	3	2	3	4	3	3	5	3	3	3
Does using the your listed technologies help with increasing overall life satisfaction?	3	3	3	4	3	3	3	4	4	3 to **4	3	5	3	3	3
Does using the your listed technologies help with increasing feelings of domain satisfaction?	3	3	4	4	3	3	3 to **4	2	4	4	4 to **3	5	3 to **4	3	2

Table 4: Participant responses to the questionnaire. In this table, numerical ratings from 1 to 5 correspond to Likert scale ratings as follows: 1 - Strongly Disagree, 2 - Disagree, 3 - Neither agree nor disagree, 4 - Agree, 5 - Strongly Agree. Responses marked with ** indicate participants who changed their questionnaire score during the interview. Both the original score and the changed score values are listed in the table above.

C Interview Guide

We conducted semi-structured interviews in both our interview (phase 1) and brainstorming (phase 2) studies. The basic set of questions we covered in all 1-1 interview sessions, and during the brainstorming study are listed below .

C.1 Interview Study Guide

Questions about affect and satisfaction were asked in relation to participant's pre-study questionnaire responses.

CREATIVE ACTIVITIES

- Do you find engaging in creative activities contributes to increasing positive affect? Why? Please provide an example or two when you did some creative activity and you felt like it improved your mood, emotion, or it sparked some positive experience like you felt joy, contentment, or love.
- Do you find engaging in creative activities contributes to decreasing negative affect? Why? Please provide an example or two when you did some creative activity and you felt like it reduce stress, worry, frustration etc.
- Do you find engaging in creative activities contributes to increasing life satisfaction? Why? Please provide an example or two when you did some creative activity and you felt satisfied with life broadly for example, you felt you had done something meaningful, felt fulfilled, felt successful or felt satisfied with what you had accomplished.
- Do you find engaging in creative activities contributes to increasing life satisfaction? Why? Please provide an example or two when you did some creative activity and you felt satisfied with life broadly for example, you felt you had done something meaningful, felt fulfilled, felt successful or felt satisfied with what you had accomplished.
- Do you find that engaging in a creative activity makes you feel more satisfied about some specific domains in your life e.g., professional life, leisure, health, social relationships, or the specific creative domain you engage in. Please provide one or two examples of when you felt such type of satisfaction, and why.
- Do you feel you turn to creative activities as a way to feel happy?
- Are there any strategies or mechanisms you use to feel happy when engaging in creative activities? For e.g., do you pick some kind of creative activities over others? Select when and how frequently you engage in the activity? Engage in creative activity in specific contexts?
- Do any of the strategies give you more of a boost of happiness compared to others? Why?
- Can you think of an experience where you continued to feel happy for some time after having done something creative? What do you think contributed to that sense of sustained happiness?

CREATIVITY SUPPORT TOOLS

- Do you think creativity support tools should offer some kinds of support that would enable explicitly fostering happiness?
- How do CSTs impact your positive affect? Why? Please provide an example or two.
- How do CSTs impact your negative affect? Why? Please provide an example or two.
- How do CSTs impact your sense of overall life satisfaction? Why? Please provide an example or two.
- How do CSTs impact your sense of domain satisfaction? Why? Please provide an example or two.
- How do you think creative technologies could make you feel happy? For example, are there some features that make you feel happy? Something about the user interface? Or the user experience the tool offers?

C.2 Brainstorming Interview Guide

FACTORS

- What motivated you to select the factor(s) you chose?
- Why is the final idea your team proposed a good idea for fostering happiness?
- What are some limitations of your proposed idea?
- What are some potential challenges with using factors in CST design?
- Strengths of using factors in CST design?

STRATEGIES

- Why did you select the specific strategy?
- Why is the final idea your team proposed a good idea for fostering happiness?
- What are some limitations of your proposed idea?
- Challenges with using strategies in CST design?
- Strengths of using strategies in CST design?

DISCUSSION

- In terms of CST implementation what should we STOP doing so the designs are actually in service of happiness?
- In terms of CST design what should we CONTINUE doing to foster happiness?
- In terms of CST design what should we START doing to foster happiness?