Speculative and Critical Approach to Designing Technological Futures through HCI Education

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Abstract. We believe that challenging times demand HCI education to pay attention to current real-life, complex, systemic problems. Therefore, we suggest an integrated framework for teaching HCI that involves combining the transition design framework, which suggests long-term, future-oriented design on a large scale toward more sustainable lifestyles, and speculative and critical design. The integration of the two creates spaces for dialogues and debates enabling students to take a more critical perspective concerning possible futures and technology design. We suggest studio-based pedagogy and explicate various aspects of the course, including its theoretical and practical underpinnings, pedagogical approach, and provide examples of projects to illustrate how the framework was used and ways in which speculative and critical design and thinking were crucial for learning. Finally, we highlight six learning facets that might contribute to orienting students' upcoming professional work towards desirable futures.

Keywords: critical thinking; education; speculative design; research through design; transition design; studio pedagogy; experiential learning

1 Introduction

At present, unprecedented global changes are bringing deep uncertainty about possible futures for humanity and the planet. Every day, we learn about new threats, from extreme weather leading to floods, fires, and heat waves to viruses potentially deadlier than COVID 19 or increasing pollution of air and water. Warning signs have been visible for quite a while. Various groups have sought ways to raise awareness around such issues, among them the UN – producing climate reports, and suggesting the sustainability goals and ways of working with them [1, 2]. Diverse multi-disciplinary research teams have been considering pathways to frame and address issues, e.g., the researchers at The Stockholm Resilience Center proposed the concept of Planetary Boundaries, seeking to establish safe operating limits of our planet [3, 4]. However, several planetary boundaries have already been exceeded. At the same time, efforts to include the economic and social parameters were intensified, suggesting a doughnut model of socio-planetary boundaries to ensure that humanity's needs are met within the means of the planet [5, 6]. Furthermore, we are all increasingly aware that not acting on these global challenges is not a viable option for humanity.

Most visions of our futures, whatever they might be – utopian or dystopian, include

technologies that are seen as instrumental in shaping them. Even though technology indeed might play an essential role in the shaping of the future, the myth of modernity [7] and its weapons, reason and technology, also needs to be re-considered – we now have more than enough evidence to stop believing in the possibility of continued, perpetual progress supported by science and technology alone. As Tony Fry put it, *"We are finite beings living on a finite planet with finite resources that we squander at the speed of light, in geological terms"* [8].

Moreover, we often forget that technologies always make an impact – it just takes time to recognize their effects on socio-cultural development. Therefore, their design requires more holistic thinking and deeper entanglement with critical and social perspectives. In addition, it is imperative to assess, to the largest degree possible, how new designs might affect humanity and the planet, and not just specific user groups or even just humans. Interaction design and human-computer interaction (HCI) education also need a stronger focus on students' engagement with matters of global concern, e.g., climate change, biodiversity, consumption, privacy, surveillance, and increasing divides when learning to design new technologies. Despite the fact that these global, wicked problems [9] are not issues that course projects could resolve, students might learn how to think more critically about design and interrogate matters by designing. Quoting Fry [10] again, *"the future with a future for 'us' can only be reached by design."* If properly implemented, such education might sensitize students to thinking more broadly, sustainably, constructively, and from a longer-term perspective.

Recently, there has been a movement towards Responsible Innovation in HCI, e.g., [11–13], also in education. However, the pursuit of technological innovation brings about specific challenges [14], such as the negative environmental impacts from increasing greenhouse gas emissions or electronic waste, to name just the most obvious ones. Aiming to define innovation, Stilgoe and co-authors [15] suggest that *"Responsible innovation means taking care of the future through collective stewardship of science and innovation in the present"*, while von Schomberg [16] suggests that responsible innovation is *"[a] design strategy, which drives innovation and gives some ''steer'' towards achieving societal desirable goals."* Both definitions might be perceived as a means to add value in the process of technological design and development. Although adding value is not enough, it might help mitigate the technological determinism prevalent among HCI students who still believe in the myth of modernity and subscribe to the idea that innovation is about pursuing newness because it is always possible to push the boundaries of technology. However, it is prudent to teach HCI students to reflect on the socially desirable goals and the socio-cultural consequences of technological invention and innovation as part of the design process. The question that remains unanswered or, at best only partially answered, is: how to accomplish this?

Research through design (RtD) lends itself well to discussions around adding values by design, inquiry into the use of designed artefacts in real life, and tackling possible futures using various methods, tools, and techniques, including critical and speculative approaches. Zimmerman and Forlizzi [17] suggest that RtD researchers commonly engage in design practice to create artefacts or systems that are then used to experiment with (the Lab approach), research the use and situated use contexts (the Field approach), or, as in our case, criticize and speculate about the current situation and enable better-informed visions and experiences of the future (the Showroom approach). Thus, the

Showroom approach allows for exploration of possible futures through prototypes or installations designed for the purpose, much along the lines of the Audio Tooth Implant [18] or the Faraday chair [19]. Rather than referring to this particular line of RtD as the Showroom, we use Speculative and Critical Design (SCD) as it better describes the work presented in this paper.

RtD has been much discussed in HCI lately, especially in the context of understanding the relationship between research and design, e.g., [17, 20–26], and the relationship between particular designs and more abstract knowledge that they might generate. Some proposals regarding the latter discussed various forms of intermediate knowledge, e.g., annotated portfolios, strong concepts, design programs, manifestos, concept-driven design, and bridging concepts [26–32], to name a few. In terms of cognitive activity, design has a special place: *"The act of designing, of making, requires the designer to face several confrontations: between competing or conflicting background knowledge, between theory and technology, and between dream and reality"* [33].

In this paper, we discuss the opportunities that speculative and critical design offer to HCI education. We suggest an integrated framework consisting of SCD approach and Transition Design (TD) [34, 35]. The latter has recently gained traction as a design-led, multi-disciplinary approach that addresses pathways bridging the present and possible futures. Its central premise is the need for large-scale, society-level transitions towards sustained living. It aligns with systemic design [36–38], which is currently primarily embedded in design communities. At the same time, there is a pressing need to engage HCI educators in considering longer-term technology design and its implications [39, 40], including more critical reflections on social consequences and a need to start processes of transitioning toward more sustainable lifestyles. Therefore, we suggest that TD presents a good way to link its framework (explained in the next section) to HCI. While this may not have been possible to do at the time when sustainable HCI came to focus [41, 42], increasing complexity and scope of global problems call for the HCI community to explore different positions and perspectives on technology design and integrate a richer set of theories and methodological tools than those used traditionally in the field.

With this paper, we aim to contribute to a range of options for teaching SCD, in this case, by linking SCD and TD framework for teaching a graduate-level course in RtD within our study program Design, Use, and Interaction. The course is open for enrollment to both master and Ph.D. students. It is run as a studio-based intensive module, which implies full-time engagement for both students and instructors. The paper explicates various aspects of the course, including its theoretical and practical underpinnings, pedagogical approach, and examples of projects that illustrate how the framework was used and ways in which speculative and critical design and thinking were crucial for learning. We consider this to be the appropriate education for future interactive technology designers.

The paper is structured as follows. The background section discusses design for change, how it has been taken up in teaching HCI, and the studio pedagogy that we have adopted. Next, in Section 3, we describe our course and teaching strategies. Section 4 provides three examples of student projects, followed by a discussion in Section 5, providing six specific aspects that we believe make our approach successful.

2   Background

This section is divided into three themes: 1) making change through design, 2) teaching RtD in HCI, in particular, speculative and critical design, and 3) intensive studio approach courses and the learning pedagogies. Together, these set the stage for this work.

2.1   Making Change through Design

As a professional practice, design has been successfully creating ever more desirable products, helping to perpetuate consumerism at the same time. Consumerism is responsible for a significant part of the global challenges we face today, simple examples being the fashion industry's environmental impact or the electronic waste. At the same time, designers have a particular sensibility and way of thinking and seeing, including thinking constructively, synthetically, and holistically, which gives design and designers an opportunity, even the responsibility, to also be a part of finding solutions to current global challenges.

However, one must carefully consider the potential of design-led approaches to deal with such complex problems appropriately. For example, design thinking has been suggested as a way towards change [43], not only through innovating products but by applying design broader to tackle complex social problems, issues of organizational management, and strategic innovation. It has been successful only partially [44].

Among many books and published research articles addressing design, sustainment, and looking into the possible futures, we mention only a few. In [45], various contributors discuss the role of design and social responsibility regarding changes made by design activities, using case studies to showcase the power of design to address different Sustainable Development Goals (SDGs) and very complex problems of poverty, health and wellbeing, developing more sustainable cities and communities, and encouraging more responsible consumption, among other issues. On consumption, Crocker [46] suggests examining our material world and re-conceptualizing our relationship to it, advocating looking deeper into issues than just at the surface of consumerism and easy fixes. On a different note, Scott, Bakker, and Quist [47] advocate practice-oriented design. The practice-oriented design considers existing practices as a unit of design. Changing the constellation of elements that constitute a practice might create a new practice and change people's behaviors at scale, building on the social practice theory as a theory of change [48–51]. Finally, we mention the work in sustainable HCI. In their paper [52], Hansson, Pargman, and Pargman described a systematic literature review on how HCI researchers worked with sustainable development goals. They summarized main research trends in the field, identified the opportunities in areas that were not researched, discussed opportunities for pursuing sustainable HCI by the larger HCI community, and identified quality education (SDG 4) as one of the important areas to which the field could contribute significantly. The significance of this article is in its positioning of the sustainable HCI as a field that can, and should be, engaged in resolving global challenges.

A more recent, systemic, and radical suggestion, which is still largely a theoretical proposition, is transition design [34, 53, 54]. As mentioned in the introduction,

transition design aims to support systems-level change and societal transitions toward more sustainable and desirable long-term futures. To that end, the manifesto presenting the approach [35] suggests a four-component framework that contains some novel elements that are also interesting for educational purposes, as discussed later in this paper. First, the approach invites designers to examine their *posture and mindset* concerning their work context. It then suggests thinking more theoretically and philosophically and considering diverse (primarily social but also economic and other theories; social practice theory, nudging, and pressure points are examples) *theories of change* that might be utilized to initiate the change at scale. The third component of the approach requires finding *visions for transition*, where the design team uses various means to generate alternative visions of the future and use them to discuss challenges, opportunities, and possible consequences. Lockton and Candy [55] describe the initial vocabulary and approaches such as futuring, backcasting, imaginaries, and foresight practices that might be used for the purpose of creating visions. Finally, *new ways of designing* are called for. They imply perhaps entirely new approaches to design or integration of existing ways of designing, making them more powerful tools to address the complexity of issues. Finally, TD is envisioned to be multi-disciplinary and cross-sectorial to achieve an impact at the desired scale.

Interestingly, one of the essential development areas of transition design is academic. From the School of Design at Carnegie Mellon where TD[1] was conceived and where there is a running Ph.D. program in it, the approach has spread across the globe, perhaps still not as a whole education program at other universities and schools of design, but many places (like ours) offer courses in the approach. There is an overlap between TD and responsible research and innovation, sustainable design, responsible HCI, and other directions that advocate a serious look at the present challenges and radical changes to create opportunities to still have some desirable futures. However, we choose TD because of the applicability of its framework to the teaching setting. In particular, the visions for transition component lends itself exceptionally well to the design of speculative and critical prototypes. Such prototypes can make specific parts of the vision more tangible, real, and experiential. In turn, the engagement in debates and dialogues around the vision increases.

2.2 Teaching RtD in HCI: Speculative and Critical Design

Staley explains that his book [56] is inspired by Dunne and Raby's work and serves as an example of using speculative and critical design to take an alternative look at higher education and the opportunities for its re-imagination. Staley aimed to facilitate speculation and alternative visioning concerning higher education through debate, discussion, and collective definition of the preferable future of education, arriving at ten distinct alternatives described in the book. Similarly, we aim to take an alternative look at HCI education and design of technologies in more responsible and 'further into the future' looking ways. Like Staley, we claim that such re-conceptualization of teaching HCI would prepare students better for future challenges.

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[1] https://design.cmu.edu/content/phd

The main challenge for the instructor teaching design in HCI that tackles current challenges is selecting relevant topics, epistemological perspectives, theoretical anchoring, methodologies, concepts, and practices to engage students in active learning processes successfully. Although there have been attempts to discuss the potential of SCD and design fiction in HCI [57] for at least three decades, Jordan and Silva still consider the opportunity for HCI to be untapped. However, there are recent efforts to remedy this situation with a new textbook [58], which is a part of a larger project exploring speculative education[2]. The book offers a broad overview of speculative design practices and methods. In their workshop call to examine the role of SCD in education, Helgason and co-authors [59] state, *"SCD approaches offer the freedom to creatively explore and extrapolate from signals observed in the present, in order to ask questions about how the technologically augmented future - or indeed the present - could be, rather than merely how it should be. The proposal behind this workshop is that the inherently discursive and reflective nature of the Speculative or Critical Design approach makes it particularly useful for teaching both practice and theory."*

Having a few years of experience teaching RtD and using SCD to support finding and critically examining visions for transition, we hope that our experiences can contribute to establishing a set of practical understandings and exemplars of how to teach SCD in interaction design. The work of Bardzell, Bardzell, and Stolterman [60] has inspired us to think about how we read speculative and critical designs processes in the classroom: how we assess the value of SCD for learning through the project at hand, how to help students frame the problem space and use SCD in ways that enable critical and speculative thinking, creating debates around projects that enable learning. In the classroom setting, the pragmatic utility of SCD takes precedence. The authors' matrix comprised of six design dimensions (topic, purpose, functionality, interactivity, form, and materiality) across four aspects of criticality (changing perspectives, proposals for change, reflectiveness, and enhancing appreciation) has helped find ways to make headway concerning supporting and engaging in critical assessments of designs.

We next describe how we engaged graduate students who took our course in learning critical and speculative design and thinking in a studio setting.

2.3 Intensive Studio Approach Courses and the Learning

For about two decades, there have been discussions within the HCI community about studio-based approaches and the need to adapt them for teaching design in HCI [61–66], to name just a few papers and a workshop call on the studio approach. We highlight some of the arguments in cited papers that discuss the benefits of the studio approach. The essential argument is that designing digital artefacts is also design, although with the added digital materials. Thus, it would benefit from studio pedagogy, which has proven its effectiveness in design and architecture education for over a century.

The studio approach is commonly understood as a coherent system consisting of surface structures and materials, pedagogy, and epistemology that jointly create a unique, highly interactive learning environment. Surface structures refer to components of the learning environment such as the space, furniture, objects, assignments, and

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[2] https://speculativeedu.eu/

others. The pedagogical approach is commonly based on experiential learning [67, 68]. The epistemological understanding describes the beliefs and the nature of design knowledge and how it is constructed. In the studio setting, epistemology is often constructivist. Students learn by doing, gaining knowledge through activities, individually and socially (through formal and informal interactions with peers, teamwork, and communication with instructors), and construct meaning as they learn. Learning unfolds by shifting between concrete experiences, abstract thinking, reflective observations, and active experimentation [69]. A form of interaction among faculty and students characteristic of the studio approach is a regular design critique, or design crit, that elicits feedback from peers and instructors on the work in progress and also serves as an academic assessment tool [70].

Like the studio approach, intensive course formats have also been around for a long time [71]. As the name suggests, intensive courses are shorter than regular courses and offer a condensed, accelerated, or compressed curriculum [72]. A considerable body of research shows that intensive courses produce equivalent or better academic results than traditional ones [71–76]. Academic results are often understood as learning outcomes, e.g., [75–77], and various attributes are discussed to explain this success.

Studio courses do not necessarily need to be intensive courses. However, they have been quite successful when they adopt the format of intensive course modules, giving students an option to engage with courses sequentially rather than in parallel [77].

3 The course

This section first describes the formal course setup, followed by a description of how we integrated research into SCD with TD framework in practice.

3.1 The course setup

The RtD course that we teach is a graduate course, open to both master and doctoral students. Doctoral students are typically fewer, usually one or two per semester. The second author of this paper was one such student in the Fall of 2020 course, working as part of the team exploring the future of the high school education, see Section 4.1.

The course is a studio-based, intensive course over five weeks. The number of students in the course is limited to twelve. They need to be present full time and, thus, cannot take other courses simultaneously but might choose another intensive module before or after the RtD course or use the rest of the semester to pursue their thesis projects. The teaching team consists of two/three faculty members whose voices are most important in design crits. They provided some instruction, but only to directly support learning and the design practice in the context of the course. Guest lectures are invited when deemed essential for students' understanding of a particular topic.

The course takes place in a design lab, Fig. 1, where students can engage in design practice and prototyping with a variety of things at hand, such as a sewing machine, soldering kits, 3D printers, laser cutters, diverse digital components, scissors, glue, fabric, paper, tools for woodwork, and other materials to support making.

Fig. 1. The figure shows our design lab where studio-based learning takes place. Students use both horizontal and vertical surfaces, paper and electronic components to prototype.

The learning outcomes include: learning to differentiate between simple and complex design contexts (learning about wicked problems), setting contextual boundaries for the work, understanding of *design practice*, *design studies*, and *design exploration* and ability to fluidly combine them in design work (based on Fallman's design research triangle [78]), determining concepts that ground and support design, reflecting and articulating (reflecting in action and on action and communicating what is learned from these reflections), synthesizing ideas, or aspects of different prototypes, and make improved design suggestions that do not introduce new problems within the chosen context or at least cause fewer problems. The learning outcomes are somewhat generic, aligned with RtD because it is desirable to avoid repeated administrative approvals of changes in the outcomes and requirements for the course.

Every year, new themes are selected for the course. They usually require learning something different from what previous years students learned. For example, one year, the theme was related to artificial intelligence, and students prototyped AI-driven, mood-sensing art, self-writing books for children, or conversational companion robots. Another year, the theme was sustainability, focusing specifically on plastic waste or the sustainment of humanity as we know it.

The course ends with a presentation of designs and other work, serving as a final exam. Crits provide ongoing assessments during the course. The grade is pass/fail.

The course is organized so that in the first week, students get introduced to design practice. Simple projects are used for that purpose, such as making their own workbooks to collect design ideas or crafting facial masks, usable in the rest of the course. After that, there are four weeks to work on larger projects that tackles some real-life, complex problems. The course is structured to enable students to work with theory, design practice, and critical reflection (through discourse with peers, instructors, crits, reflection-on-action and in-action, or self-reflection). Furthermore, they engage in conceptual thinking, explorations, and broader critical reflections supported by TD. The schedule is shown in Fig. 2.

The challenge for instructors is to sequence the activities in ways that shift between developing design research skills and design practice and making skills, while fostering critical thinking along the way.

To illustrate what happens during the first week, we provide examples of the two briefs used in the initial week of the course during the Fall of 2020, as shown in Fig. 2. The first brief (B1) was to create a usable face mask. Each student worked individually. Through this exercise, students learned about form, function, and material choices, see Fig. 3.

The second brief (B2) was a team exercise, adding digital materiality to explorations. The students were asked first to put a NatureWatch camera together, using the principles from [79]. They were then tasked with exploring the use of the device and repurposing to arrive at novel and engaging uses for it. For example, the student team whose work is shown in Fig. 4, decided to explore privacy playfully, exchanging a 'surprise found in a box' for a photo of those wishing to look into the box.

Week 1 COURSE	Week 2 DISCOVERY	Week 3 CONCEPT	Week 4 PROTOTYPE	Week 5 (Finish) DOCUMENT/EXHIBIT
COURSE INTRODUCTION PROJECT BRIEF B1 - INDIVIDUAL READINGS (3 PAPERS)	TRANSITION DESIGN (GUEST LECTURE ON TD) PROJECT DOMAINS TEAMWORK NEW READING MATERIALS	WORKSHOP LO-FI PROTOTYPING	HI-FI PROTOTYPING	HI-FI PROTOTYPING DOCUMENTATION
PROJECT WORK ON B1 PRESENTATION OF THE PAPERS DISCUSSION (Q&A)	DOMAIN DISCOVERY EXAMPLARS DISCUSS PAPERS PROJECT WORK	WORKSHOP LO-FI PROTOTYPING	HI-FI PROTOTYPING	HI-FI PROTOTYPING DOCUMENTATION
STUDENT PRESENTATIONS CRITS PROJECT BRIEF B2 - TEAMWORK	IDEATION, STORYLINES, STUDENT PRESENTATION CRITS	LO-FI PROTOTYPING CRITS REQUIREMENTS	HI-FI PROTOTYPING CRITS DISCUSSIONS	HI-FI PROTOTYPING DOCUMENTATION
B2 DOMAIN DISCOVERY, CONCEPTS, SKETCHES, MOODBOARDS, STORYBOARDING, CRIT	IDEATION MOODBOARDING	LO-FI PROTOTYPING REQUIREMENTS	HI-FI PROTOTYPING SCALING STRATEGY	HI-FI PROTOTYPING DOCUMENTATION CRIT DISCUSSION
COLLAGES, PROTOTYPING, PAPERS DISCUSSION (SECOND) STUDENT PRESENTATIONS CRIT	CONCEPT PROPOSAL PEER REVIEW REFLECTIONS, DISCUSSION	LO-FI PROTOTYPING REFINMENTS PEER REVIEW READINGS DISCUSSION	HI-FI PROTOTYPING METHODS PEER REVIEW DISCUSSION	STRATEGY EXHIBIT PRESENTATIONS CLEAN UP

Fig. 2. Time organization that allows for exploration, theory, design practice, and reflection.
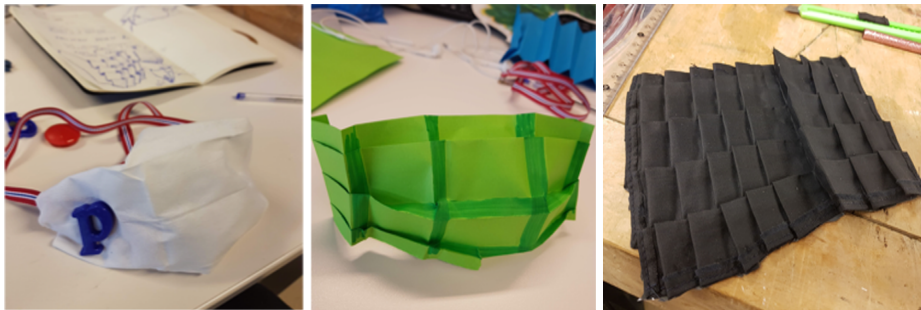
Fig. 3. The images show one student's progress on the mask assignment B1, exploring the folding forms of the mask and moving from paper prototyping to prototyping in textile.

THE SPECIFICS

What should the sign say?

What should be inside the box?

What should the box look like?

Fig. 4. A slide from a crit-related presentation shows how one of the teams tackled brief B2 and repurposed the NatureWatch camera [79] to explore what wins: curiosity or privacy.

3.2   The teaching strategies

Our basic teaching strategies rest on a combination of 1) a 'spiral' model (explained below) for communicating the initial knowledge about methodological approaches, 2) students working in teams, 3) facilitating knowledge construction through the entanglement of concrete design experience and abstract thinking by combining SCD and TD, and 4) shifting the perspectives and scales of change, using ambiguity and uncertainty, scrutiny through discussions and debates.

Since RtD and TD are novel for our students, they need an initial understanding of these approaches and how they differ from what they already know. The course students have a solid background in HCI. To make the new approaches accessible fast, we use the lecture format. We use three papers [17, 78, 80] as the core readings: on RtD, what kind of new knowledge to expect from it, and how to communicate RtD processes. However, the lectures are not delivered entirely traditionally – we follow a 'spiral' model that we arrived at by experimentation on how to impart the new knowledge effectively – the same core material is visited several times. Typically, the first time at lightning speed, communicating just the core notions, then a more solid presentation later, and finally, a plenary discussion after gaining practical experience through multiple design projects. For the discussion, the students also need to read the core material. In general, the amount of reading is intentionally kept low, as the course needs to engage students in various activities, where the design practice is primary.

The second encounter with the core material is rather conventional. It is a lecture, followed by questions and answers, explaining the three approaches to research through design (the Lab, the Field, and the Showroom) [17], focusing principally on the Showroom (SCD) since most projects use it. We spend some time showing examples of such projects and work by others, e.g., [18, 19]. Next, the design research triangle [78] is explained in detail and used from that point on as a tool for both communication

and reflection on course processes. Finally, the distinction between scientific knowledge and the kind of knowledge one might expect from RtD is explained [80]. The students then get to work on the first brief individually to gain practical experience.

The third time, after experiencing design practice, design exploration, and design studies by working on the briefs and having the students read the suggested papers on their own, the material is discussed in plenum. The students are encouraged to describe their processes using the new terminology. This helps them integrate their design research experience with a more abstract understanding of RtD gained from the lecture and reading assigned papers.

Similarly, the spiral model is used to introduce TD. The reading consists of two papers, introducing the TD and suggesting the basic vocabulary for visions [35, 55]. Additional readings for this part of the course depend on the topic(s) chosen for a particular course run. Typically, only a couple of core articles are suggested to student teams, which relate to their work directly. They can choose to read and discuss more papers or books independently, but this is not required.

Except for the first two days of the course, learning unfolds in teams comprised of 3-4 students. Although, in general, there is a complex and multi-layered relationship between team effectiveness, student learning, motivation, the teaching and assessment of teamwork [81], many potential downfalls are countered using the studio approach that provides the environment for an ongoing dialogue between students and instructors, providing immediate assessments of the teamwork and guidance. At the same time, instructors have the opportunity to follow each student's work. Based on our experiences with TD and SCD, integrating the two for teaching and learning provides additional motivation for students and supports more constructive involvement in teamwork. Students are also encouraged to refine their briefs guided by their own interests, which often enhances motivation.

In conjunction with more conceptual and theoretical work, active exploration and prototyping help to bridge the abstract - concrete gap. The environment itself, see Fig. 1, supports an easy shift between conceptual thinking, reflection, and practical work.

Understanding criticality is also important for this course, as students need to assess the consequences of their design choices and decisions. Experiencing ambiguity, uncertainty, and unfamiliarity is integral to the design and fundamental to its learning. It is crucial to allow students to hold the tension between different ideas and allow for their critical examination before settling on a solution. The seriousness of the problems typically discussed in the class often requires thinking about different scales and from different perspectives, which might also increase uncertainty. Almost by definition, both wicked problems and speculative approaches involve ambiguity and uncertainty. However, they are essential when learning to think critically. The studio setting helps students to work with these tensions not only cognitively but also hands-on. Engaging with materials in the lab, using bricolage and assemblages of things, skills, and knowledge, engaging the whole body in learning, they learn to appreciate the ambiguity, uncertainty, and functioning outside the comfort zone while thinking outside the box.

How suitable SCD is for creating visions for transition is best illustrated by examples of projects from the course.

4   Examples of Course Projects: Integrating SCD and TD

The projects used in this paper are selected among those produced in the last two years of teaching. Despite pandemic, the course has run successfully, and we use two projects from the course in the Fall of 2020: The High School–Futuring Education and Echo Chambers. The third project, The Bees, is from the previous run of the course.

4.1   Futuring Education – the high school in 2034

This project explored ways in which various technologies such as AI, machine learning, computer vision, surveillance and personalized data collection might play out in society in the next decades or so. Various contexts were considered for the project, for example, elderly care homes. The course team working on this project, two master and one Ph.D. student, selected the high school setting since it provided for a broader range of aspects that could be related to the wider society. The scenario featuring the influential high school placed in 2034 was then presented as a website along with other associated digital forums, such as teachers' 'WhatsApp'-like groups, students' 'Reddit' channels, and parents' Forum.

Fig. 5. The image shows how drones monitor students' movement during sport events.

The Futuring Education team was able to examine ways in which technologies might be implemented at this school for various purposes like health and education. For example, Fig. 5 shows how drones record sports performances and training sessions to identify possible points of improvement for each participating student, but also hints at issues such of privacy (there might be only a few private spaces away from drones). Furthermore, the school has robots that serve as social workers and nurses, technological solutions to promote sustainability, corporate sponsorship and color-washing, all mirroring the implementation of such technologies in society at large.

The main school website publicly promoted viewpoints of the school administration. Nevertheless, various groups voiced their concerns on the linked but private channels, such as the teachers' concern regarding the copyright ownership of video-taped course lectures, the students' subversive methods to evade cameras and other monitoring systems, or the media portrayal of the school referring to how the school attained high academic grades while being overly authoritarian and reliant on technology to achieve that attainment. The team actively used Auger's work [18] and two articles on annotated portfolios to communicate their research, convey the concept and explore the context by design [30, 82]. They also ran a variant of an annotated portfolio on the various categories within the website in order to consolidate and focus their points, presenting a very rich and provocative vision of the school. Humor, often dark, irony, and paradox were used to convey concerns about technology acceleration and adoption.
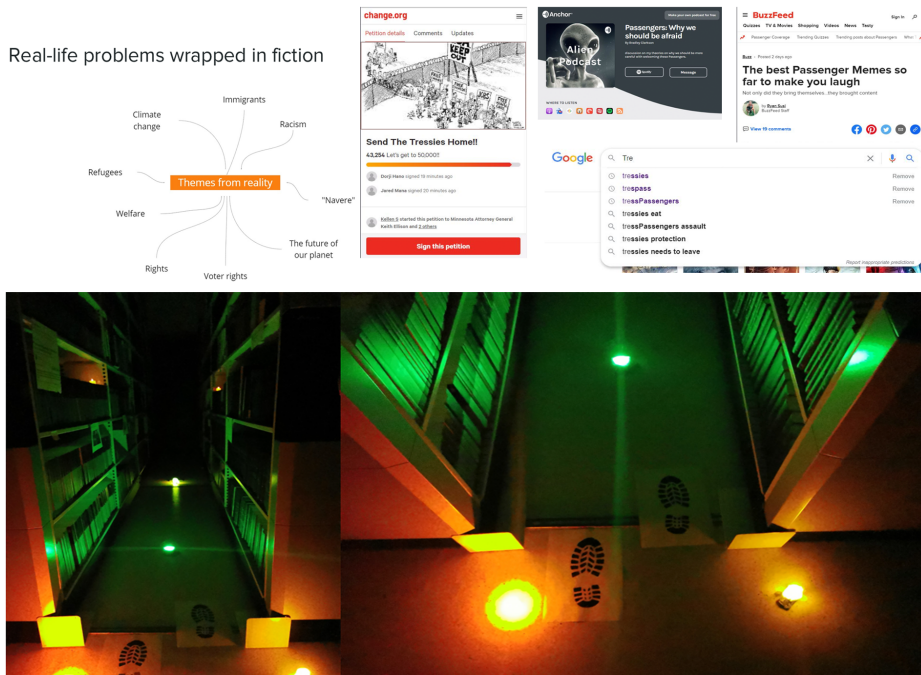
4.2 SoMe – echo chambers

The design context for this project was chosen so that the students could consider public, cultural institutions and what their role might be concerning creating more sustainable lifestyles. We chose to make the brief more concrete by choosing the academic library as such a public institution that might wish to support citizens in being better informed and, thus, making better choices in life.

The students drew inspiration from Auger and Blythe's work [19, 82] and various fiction movies. Soon, they arrived at the concept of misinformation as their focus. Perceiving the academic library as the institution whose aim is to ensure that its patrons receive quality information, they positioned it as the institution that might be central in fighting misinformation in the future.

When working, the student team followed the idea that each element that played a role in their narrative had to be carefully considered and made plausible and consistent with the rest of the narrative. They started working with fiction by creating social media posts concerning a made-up debate. As echo chambers and misinformation on social media have become increasingly present and troublesome, they decided to focus on replicate them. Rather than using familiar, real-life polarizing issues, the students opted to create Tressies, extraterrestrials that moved to Earth and, by doing so, polarized the human world – some wished them welcome, others wanted them gone.

The students chose to design an echo chambers installation, SoMe, in the library, to stimulate debate around misinformation and polarization. The installation shown in Fig. 6, featured echo chambers with different content around Tressies. The exposure to several echo chambers and the feelings they invoke was intended to stimulate a dialogue and mitigate polarization.

Fig. 6. The top row in the figure shows slides from SoMe team's crits and the bottom row shows the pilot run of the installation, arranged in the library's archive and featuring echo chambers.

4.3 The Bees

The inspiration to propose the topic of the relationship between nature, humans, and technology came from the work of Fritsch [83] and Verbeek [84], where Fritsch suggests that the end of the human relates to recent advances in technological implants and the rise of automation and robots replacing human skilled labor and Verbeek develops a post-phenomenological perspective through the lens of technological mediation in relationships between technology, humans, and nature. Thus, these two articles were prepared to follow the brief.

The students' response to the topic was positive, and they set out to explore a relatively distant future. Starting from the idea that new technologies need to be developed to prevent bees from dying, students used the theme to discuss the interconnectedness of the survival of humans and bees and question the primacy of humans on the planet. Using the three horizons and backcasting for generating visions of that distant future, students created a coherent narrative that starts at the department of computer science, at present, by the simple act of acquisition of two beehives that they wanted to make smart – this is the content of the 2018 column in Fig. 7. As their main value, the team proposed 'man is nature' and 'dependence' metaphors were used to explore their theme. The team suggested, as the vision of the future in 2100, that both humans and bees became cyborg inhabitants at that time, see Fig. 8.

Fig. 7. The three horizons technique and backcasting were used to examine nature/human relationship. The vision for 2100 features humans as cyborgs.
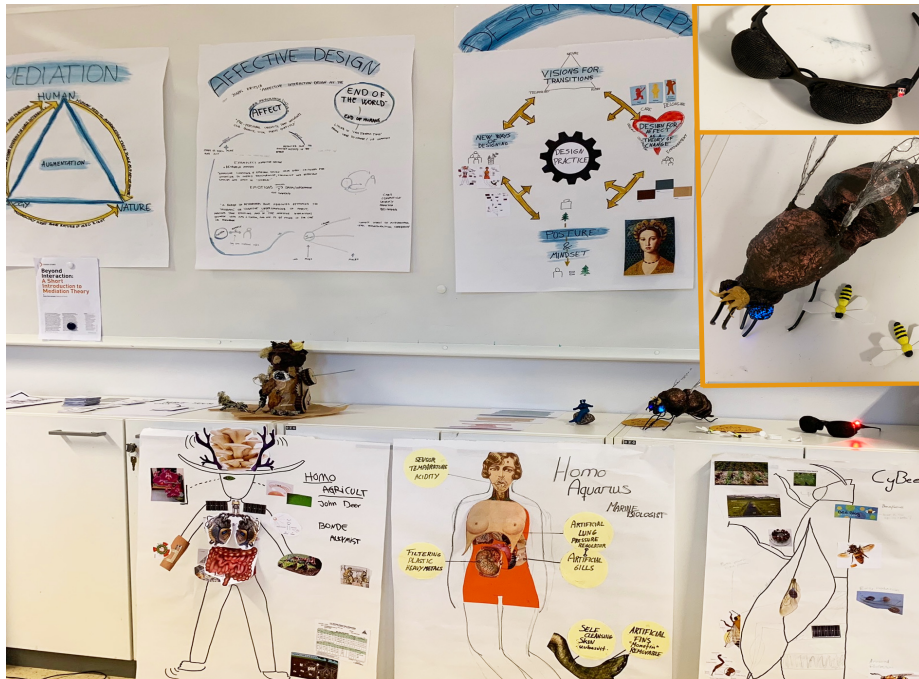

Fig. 8. The figure shows how students worked with mediation theory, affective design and TD, examining nature/human dependence. The vision for the year 2100 features cyborg inhabitants.

5 Discussion

Our approach to teaching rests on the integration of TD and RtD's speculative and critical approach and is guided by the idea that TD allows for more abstract, strategic, and critical thinking while RtD provides opportunities for engagement in speculative and critical design practice. Jointly, they support constructivist and experiential learning well.

After the first week, with increasing ease, the students could alternate between reading, thinking, assimilating, discussing theories such as technology mediation (The Bees), subversive social practices (Futuring Education), or politics and polarization issues with communication technologies (SoMe), and engaging in making prototypes using materials at hand in the lab like paper, clay, textiles, or electronics.

Using the TD framework, engaging with complex problems, and learning to think about them critically by creating visions of future technologies and lifestyles and considering how to initiate the change at a large scale, has worked well. The students learned to construct fictional narratives that suggest a range of possible future technologies (Futuring Education) and worlds (The Bees). They recognized the potential and usefulness of speculative and critical examination of those technologies as part of the technology design processes that might enable insight into their impacts and consequences [39]. For example, browsing through the high school's website engaged in reflection over the use of drones, robots, automatic grading, and other technologies that we see signals for today but become ubiquitous in 2034. In addition, students felt motivated and empowered by the opportunity to think about their own engagements with global challenges through the course.

The complexity of real-life problems, the fact that TD does not look for easy fixes but systemic solutions [35, 53], and the idea that solutions found should be time-proven contribute to the perception of TD as a theoretical rather than practical problem-solving tool. Whatever the praise or criticism of the approach, it has a great value in educational settings. The lack of practical applicability of TD within a short period that the course runs is well compensated by SCD practices.

When implementing the teaching strategies outlined in Section 3.2, we identified six important facets that supported successful integration of approaches and facilitated learning: 1) Familiarity (the integrated approach allows the students to experience new methodologies while utilizing known skills and frameworks); 2) Relatability (the speculative and critical approach requires the students to develop a consistent narrative and structure for the project that supports it, which greatly helps in their ability to understand the relationship between diverse components of the constructed narrative and methods, frameworks, and methodologies); 3) Communicability (the format of the speculative project makes use of their existing design skills to package all their working in a manner that is easy to disseminate; 4) Temporal Assessability (the format provides reasonable alternatives to assess projects that otherwise require much longer timeframes); 5) Empathy (the development and exploration of future concepts, multiple viewpoint and their methods of implementation tends to result in an understanding of others' viewpoints 6) Consequentiality (depending on the type of speculative project undertaken, the preparation of accompanying props can lead students to reflect more thoroughly on alternate viewpoints). We examine these facets in turn.

Familiarity. The introduction of Transition Design to a class of interaction design students requires many new methods such as backcasting, future scenarios, facilitating multiple viewpoints, multi-level perspectives, and extended timeframes to be outlined, understood, and practiced. Illustrating and practicing these methods individually requires considerable time. Often, the relevance might be difficult to understand as the examples used lack relatable context. However, in constructing a speculative project, the students will often arrive at a number of these methods or opportunities to implement these methods as they naturally progress through their project. These aspects can then be easily referred to and discussed as examples of these new methods. The students arrived at these methods as part of their own process, and they understood the context. Therefore, the utility and the ways in which they can be integrated into projects becomes more apparent. This leads to learning through the experience/practice process, which re-enforces these new methods. Shaffer [85] calls this *pedagogical praxis*, in which students' involvement in such projects allows them to *"develop epistemological frameworks that organize the skills, habits, and understandings they need to thrive in a complex, post-industrial society."*

Relatability. As the students are developing a single, speculative scenario, it must hang together with narrative consistency and aesthetic realism (the teachers' concern expressed in their 'WhatsApp' group, student's 'Reddit' board, Fig. 9., and the high school's proud announcements of corporate technology sponsorship on the school's website are examples of this). This consistency and appropriateness are usually apparent to the design students who are used to detailing relevant and consistent material. Through this process of deciding between various means of detailing or conveying concepts, they are continually gauging the options, determining what aspects might require priority or emphasis, how aspects might be better structured in order to support the overall understanding. This familiar, reflective, iterative decision-making process also allows them to understand how these new methods, such as backcasting or facilitating and understanding multiple viewpoints, relate and support each other. As Stappers and Giaccardi state, *"Making provokes a particular cognitive activity, one which can be used to make people aware of tacit values and latent needs"* [33].

Communicability. This consistent structure and aesthetics with which design students are comfortable working allow them to detail up a variety of supporting material. This material may be of any appropriate format, i.e., physical objects, digital content, software, visual media. These artifacts have been carefully considered and crafted to support the scenario or possibly constructed to illicit certain responses in others. This collection of artifacts/ materials can easily be communicated and disseminated for others outside of the project to consume. This allows students to broaden the field of critique and allow them to debate their iterations amongst a wider range of opinions. The construction of this material could be considered as part of the *"new technology that reinvigorates Dewey's (1915) idea of linking the school with society"*[85]. The website developed for the future school was a very simple method of collecting a wide variety of material from multiple viewpoints and package it in an easily accessible manner.
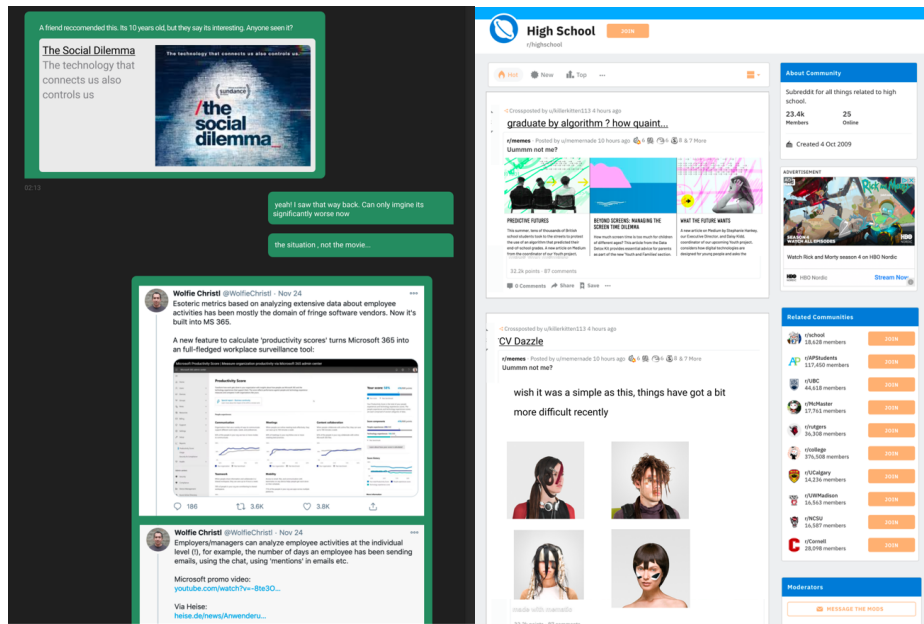
Fig. 9. Images from the school of the Futuring Education project: the first image shows the teachers 'WhatsApp' group and the second the students' Reddit board.

Temporal Assessability. In Transition Design projects, the timeframes may be much longer than 'typical' design projects. This creates a problem in education where that long perspective is simply not available. The speculative genre allows students to provide constructed proposals or outcomes that have been carefully considered, researched, planned, and iterated on based on long-term timeframes, e.g., The Bees project. These proposals can then be discussed and debated and provide a useful approximation of the stages of a Transition Design project.

Empathy. As previously stated, speculative projects often come with a rich array of supporting objects / artifacts to accompany the differing viewpoints. Each of these need to be carefully considered for them to function as a consistent part of the narrative. The considered observation of these multiple, diverse viewpoints allows students to comprehend some of the tensions involved and therefore possibly feel some empathy. Empathy is necessary for students to act as facilitators or mediators in situations dealing with values. As has also raised by Helgason, Smyth, Encinas, and Mitrović [59], there is a balance that needs to be obtained between the designer's skill and their understanding. The students designing SoMe and exploring the concept of echo chambers needed to understand how extreme and opposing viewpoints are developed online and by doing so, where able to acknowledge others underlying concerns or grievances.

Consequentiality. In addition, as the students are required to generate a comprehensive narrative of how this future scenario happened to come into existence, they have begun to see and hopefully understand how the multiple layers of society, technology, politics, human nature interrelate and subsequently construct situations which are often neither desirable but also not explicitly designed or intended. As the authors write, *"These activities can lead to a deeper understanding of, for example, the contextual, political and cultural factors that influence the activity of design"* [59]. This can be seen in the "mission creep" imagined in the high school of the future project. The students developed the idea of the sports teams using camera vision and drone technologies to provide data and feedback to players and coaches about techniques, posture, and tactics. It was then easy to start discussing the drones and cameras being used to monitor students and spaces more generally, for reasons such as security, antisocial behavior, littering, truancy, and others.

In summary, we find that the integrated approach based on SCD and TD offers opportunities to explore socio-technical systems and futures they might create. Education is the environment that safely supports such explorations while honing critical design skills and allows to prepare students for the growing complexity of real-life challenges.

6 Conclusion

In conclusion, the growing complexity of challenges that humanity and our planet face calls for HCI education to consider more complex entanglements between the design of technologies and desired lifestyles. We suggest that integrating components of transition design with speculative and critical design creates an opportunity for students to reflect on the larger and more complex issues through a critical lens. The paper outlines how we designed such a course and provides examples of student projects that illustrate the approach. It explains our teaching strategies and focuses on knowledge construction by combining abstract and critical thinking with engagement in design practice. The latter is the primary way of exploring – the students spend a significant amount of time exploring through making. However, time is also allocated for critical reflections and thinking long-term and at larger scales. To solve the problem with a short duration of time-intensive studio courses, we have been using a 'spiral' model of imparting new approaches: first, a short introduction, followed by a lecture, then after time for practice and reading on the subject, dialogue in plenum. Furthermore, shifting between doing and reflecting and abstract and concrete happens individually at the start of the course and in design teams subsequently. Teamwork facilitates the faster exchange of knowledge and skills and enables students to accomplish more through design practice. We have arrived at six learning characteristics that facilitate the reflection on and understanding of how technology design could shape the future and which futures might be desirable. We believe that this type of coursework might help educate better future technologists.

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