Teaching and Developing Social and Emotional Skills with Technology

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Supporting social interactions is a long-term focus for Human Computer Interaction (HCI) and Computer Supported Cooperative Work (CSCW). However, understanding how social and emotional skills are learned, and how this process can be supported by technology, is an important but underresearched area in HCI so far. To address this gap, we review existing approaches to social and emotions skills learning (SEL) in other fields, with a specific focus on SEL in education, in which a large number of evidence-based programs is widely deployed. In doing so, the primary aim of this article is to provide a foundation and set an agenda for future research on the design of technology that would support, and help teach, social and emotional skills. We identify the key challenges to successful learning shared by SEL programs in education—such as embedding skills learned in class also into everyday situations, promoting reflection, and providing additional opportunities for practice—and outline how these could be addressed by digital technology. Overall, our key argument is that much existing HCI work could be used in support of social and emotional skills learning in education, and possibly other domains, but that the topic has not been explored so far. We also highlight how the focus on supporting SEL would bring novel opportunities and challenges for HCI, as well as provide a basis for a strong HCI research agenda in this space.

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1. INTRODUCTION

Social and emotional skills refer to a variety of skills that are crucial for our everyday life and healthy development [Adi et al. 2007a; Damon and Eisenberg 2006; Weare and Nind 2011], including skills such as those related to emotional intelligence, interpersonal, and communication skills, but also skills such as mindfulness, self-control, and empathy. Understanding how such social and emotional skills are learned, and how this learning process can be supported by technology, is an emerging area of research within HCI (cf. also Slovák et al. [2015a, 2015b]).

The growing interest in this topic is manifested by recent work around social skills learning in autism [Kientz et al. 2013], computerised Cognitive Behavioural Therapy

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[Coyle et al. 2007], positive computing [Calvo and Peters 2014], as well as a number of individual systems aiming to affect particular social behaviour such as discussion dominance or rapport [Balaam et al. 2011; Kim et al. 2008]. Despite this impressive growth over recent years, the existing body of work is still in early stages, with two important limitations: First, most of the research so far is limited in scope, focusing on specific disadvantaged populations, especially the support for people with autism. This leaves out other populations and settings in which social and emotional skills learning is crucial. Second, the majority of the existing work has provided only limited evidence to show the effect of training in real-world situations over a longer term (cf. Kientz et al. [2013, pp. 108–109] for a summary of autism-related research), with projects often focusing on exploratory short-term pilot deployments and preliminary evaluations only.

In contrast, a number of interventions and courses have been developed outside of HCI to specifically support social and emotional skill learning (SEL) in everyday settings, and for a wide range of users across many diverse domains such as school education, clinical settings, and leadership [Barth and Lannen 2011; Bono et al. 2009; Greenberg 2010; Stepien and Baernstein 2006]. In particular, *SEL in school education* draws on 20+ years of history in teaching social and emotional skills through carefully designed, evidence-based programs that support a broad set of social and emotional skills needed for adult life. Moreover, the wide-scale deployments of these programs[1] build on established methodologies to evaluate the effect of such curricula on learners' behaviour, with data showing that such skills are teachable and that the programs can lead to measurable improvements [Durlak et al. 2011; Weare and Nind 2011]. However to date, very little technology—if any at all—is used in the current curricula.

The contribution of this article is to review the SEL curricula used in education and, through this, to point to the unique opportunity for cooperation and mutual enrichment of SEL and HCI research, drawing on the overlap of complementary interests and knowledge around social and emotional learning. From the HCI side, our review of SEL curricula highlights a number of challenges faced by SEL practitioners—such as the lack of support for students' learning outside of SEL training lessons and in everyday situations—that could be addressed by technology. We argue that although much of the existing HCI work has not, so far, been connected to social skills training, it is actually highly relevant and could be further adapted and targeted to support existing SEL curricula. From the SEL side, we show how the knowledge base and existing curricula structure of SEL could support and guide HCI research around social and emotional learning. For example, SEL in education is likely to prove a good test-bed for cutting-edge HCI systems. SEL curricula offer a wide range of well-defined skills to be supported, a controlled real-life context to deploy in, various levels of pre-existing scaffolding to drive learning, and well-established evaluations methods to assess the effects of interventions—all aspects that HCI designers can benefit from when developing, deploying, and evaluating novel technology. Moreover, a focus on SEL challenges can help HCI researchers to decide on what skills, and in which order, we should aim in the first place to support through technology, as well as how best to do so. Overall, this article aims to contribute towards defining a systematic programme of research for HCI in support of social and emotional learning through technology.

The remainder of this article is divided into seven sections. We first focus on SEL in schools as the exemplary domain (Section 2), given its longest history of both academic research and practical applications, and the widest range of life skills. The following three sections form the core of this article by linking the SEL literature in education to examples of, and opportunities for, HCI research. We first identify the key challenges

[1]For example, 44% of a representative nation-wide sample of US teachers reported that SEL is taught on a school-wide, programmatic basis in their school [Bridgeland et al. 2013].

across the existing social and emotional skill curricula from an HCI perspective and point to initial HCI work suggesting how these could be addressed by technology (Section 3). We continue by outlining how such a focus on SEL would raise interesting research opportunities for HCI (Section 4) and suggest the next steps HCI community could make to engage with supporting SEL learning (Section 5). Section 6 steps away from SEL in education to highlight several other domains in which learning of social and emotional skills is crucial (therapeutic, medical, workplace, and everyday life settings). We provide a brief overview of SEL methods and topics within each domain to inspire and guide future work, before summarising and concluding the article (Section 7).

2. LIFE SKILLS COURSES' CONTENTS WITHIN EDUCATION

We start by reviewing the methods, topics, and approaches used by SEL curricula in education to teach social and emotional skills. This provides grounding for the next three sections that link the existing SEL practices and challenges to HCI work.

2.1. SEL in Schools as an Exemplary Domain

Social and emotional learning in education is a mature field, with numerous well-researched and evidence-based approaches, and is particularly interesting for a number of reasons.

First, skills taught in school-based curricula are those that have been identified by psychologists and educators as crucial, not only to development in childhood and teenage years, but more importantly as key skills for adult life [Greenberg 2010]. As such, school-based SEL encompasses the core set of skills needed for all domains of life and into adulthood. They also focus on a large span of ages, from kindergarten to high-school education.

Second, SEL has an extensive 20+ years' history of peer-reviewed programs that have already been deployed to tens of millions of pupils. This suggests the potential for considerable real-world impact for any HCI technology implemented as part of an SEL program. For example, Durlak et al. [2011] review 213 program intervention studies encompassing more than 270,000 students of all ages, with the interventions conducted over several years. Some studies have their effects tracked for even longer periods of time, as is the case for Muennig et al. [2009], who recently presented a 37-year follow-up study on the results of a randomised controlled trial of High/Scope Perry Preschool Program conducted in 1962. Moreover, federal programs support further uptake of such curricula in the United States [CASEL 2013].

Third, recent academic reviews have analysed the evidence base for the effectiveness of SEL programs and find measurable and significant positive effects of SEL in randomised trials, for example, Durlak et al. [2011], Greenberg [2010], and Weare and Nind [2011]. In particular, the social and emotional skills curricula lead to improvements in academic performance and the taught skills areas. For example, Durlak et al. [2011] report an average of 11% improvement in academic performance, and 25% improvement in social and emotional skills, and there is evidence for positive impacts on many other aspects of behaviour such as mental health [Adi et al. 2007a], violence prevention [Adi et al. 2007b; Mytton et al. 2006], conflict resolution [Garrard and Lipsey 2007], and reduction in bullying [Vreeman and Carroll 2007].

2.2. Literature Review Methodology

A large number of systematic reviews of SEL literature already exist, mainly with the focus on meta-analyses of measurable effects and long-term impacts of the curricula (e.g., Adi et al. [2007a], Durlak et al. [2011], Elbertson et al. [2009], Greenberg [2010], Payton et al. [2008], and Weare and Nind [2011]). We build on these and approach

the topic with a complementary HCI perspective in mind, aiming to identify the SEL challenges that could be addressed by technology.

As such, we analysed the contents of selected curricula, in addition to following references cited by the academic reviews mentioned earlier. This analysis was done by first creating summaries of individual curricula, collating these in mindmaps to draw out related topics, methods, and approaches, and finally iteratively identifying the common aspects across curricula and domains. Given the large number of available curricula for the educational domain, we based our review on a set of curricula selected by the "Collaboratory for Academic, Social and Emotional Learning" (CASEL)[2]. CASEL[3] is a nonprofit organisation supporting research and application of social and emotional learning in education, cofounded by leading figures in the academic field.

In particular, we drew on curricula identified in two CASEL "guides": the CASEL [2003] guide reviews 80 SEL programs selected by a rigorous procedure, highlighting 22 of these as particularly well designed. Each of the 80 programs is described, rated on 15 aspects, and linked to academic literature evaluating its effects. The newer version of the guide, CASEL [2013], focuses primarily on preschool and elementary school programs, recommending 23 programs. We first systematically analysed the descriptions of all programs in both guides, and continued with more detailed examination of the programs highlighted in either version of the guide (i.e., 34 programs altogether[4]), as well as the academic literature available for each of these programs as referenced in the guides, as long as it was accessible through the libraries of three major universities (yielding 66 academic articles altogether). We also included any course materials and descriptions of the programs that were available on the internet. Finally, we included a number of books on creating SEL curricula in the context of education [Bar-On et al. 2007; Elias et al. 1997; Pasi 2001; Patrikakou et al. 2005; Zins et al. 2004].

2.3. Methods for Teaching SEL in Education—Experiential Learning

All curricula share an understanding of social and emotional skills as highly complex abilities, drawing also on subconscious processing [Ambady 2010; Lieberman 2000]. As such, social and emotional skills are based on *procedural* rather than declarative knowledge [Kruglanski and Higgins 2007, p. 288]. Moreover, the key focus of most social and emotional skills is to be able to react appropriately even within "hot" moments, that is, situations when the learner is overwhelmed with emotions, and/or the importance of the situation, or just has a very short time to react (e.g., heated conflict). During such moments, the ability of conscious, analytical thought is often diminished [LeDoux 1998; Wyman et al. 2010], emphasising the need for learning skills that operate on a procedural basis.

The core of most curricula is a set of SEL focused, structured classroom lessons [Jones and Bouffard 2012], usually 25–40min long and administered once a week throughout the whole school year (or multiple years). During these lessons, curricula use predominantly active instructional techniques drawing on skill-based and experiential approaches. They employ a wide range of methods such as modelling, role play, performance feedback, dialoguing, positive reinforcement, vignettes, play and games; as well as other approaches such as portfolios, expressive arts, exhibitions, and group projects—see Figure 1 for an extended list. Through these methods, curricula aim to include extensive examples and opportunities for personal experience and practice,

[2]For another set of education-oriented interventions that are however out of scope for this review, see the *Journal of Positive Behavior Interventions* (http://pbi.sagepub.com).

[3]http://www.casel.org/.

[4]Eleven programs selected in the CASEL 2013 guide were already selected in the 2003 edition, leaving 12 newly described ones, leading to 34 programs altogether (22+12).

Instructional methods		
audiotapes	homework assignments	scripts
brainstorming	**modeling**	**simulations**
community service	outside activities	**videotapes**
cooperative learning	**posters**	workbooks
direct instruction	**rehearsal and practice**	worksheets
guest speakers	**role play**	

Fig. 1. A list of instructional methods used in SEL courses, with those used most widely marked as bold text (modified from Elias et al. [1997, p. 109]).

combined with feedback and opportunities for reflection on behaviour and progress. When teaching a complex interpersonal skill such as conflict resolution, curricula break the skill down into less complex subskills and focus first on simple model situations. These can be explored by role play (e.g., specific situations such as asking permission to join a game), slowly building up to more complex, but scaffolded situations (e.g., in-class, teacher-facilitated resolution of a peer conflict), and eventually to encouraging learners to apply the skills out of the classroom in everyday situations. Repeated practice and extensive feedback from the trainer and peers are critical components in every step of the process in the classroom.

Once a skill is mastered within the lessons, the key emphasis is then on its *transfer* out of the classroom into everyday contexts to promote maintenance and generalisation [Bar-On et al. 2007; Elias et al. 1997; Pasi 2001]. This is however one of the current *critical challenges* SEL curricula face, and also one of the main areas in which HCI could support SEL (cf. Section 3.1). Although curricula highlight the need to support opportunities for the learners to practise their new skills in real-life situations outside of the classroom, they have very limited strategies to do so, especially as the scaffolding offered by the teacher in class is no longer available. The current methods used in curricula to support transfer are mainly various activities to increase awareness and remind learners about their skills on the school grounds (e.g., posters around the school), and attempts to enlist the help of their social networks outside of the learning environment such as their parents and other school personnel (e.g., through organising workshops, or sending letters to parents with suggestions how they can reinforce the learning at home). Providing students with activities and exercises to attend to at home or other locations is also common. Overall, however, the curricula struggle to find ways in which to deliver direct support for students outside of the immediate SEL lessons [Bar-On et al. 2007; Jones and Bouffard 2012].

Curricula are clear that the methods used must be developmentally appropriate for the age of the children, and the skills learned. For example, fantasy play or puppets as role models and curricula protagonists have been very successful methods for younger children (e.g., kindergarten to K-3), who can relate to them easily [Webster-Stratton and Reid 2004]. In contrast, group discussions, journal writing, and workshop activities are more commonly used with older children and teenagers [DeJong 1994]. However, specific key methods such as role-playing, modelling, positive reinforcement, and direct and indirect instruction are used throughout in various guises.

2.3.1. Common Theoretical Models. There is no single theoretical model that would be universally agreed on by the existing SEL curricula to ground the learning process [Payton et al. 2000]. Instead, curricula build on several complementary

theories that each have robust evidence of positive effects[5]. Some of the most prevalent theoretical approaches are: (i) systems theory, which views SEL learning as embedded in the broader community and aims to systematically create a comprehensive climate for teaching SEL, not only in the class but also in the school and local communities more broadly; (ii) psychoanalytic theory, which works with how conscious as well as unconscious (unrecognised) emotions shape how we act or learn, and who we are; and (iii) cognitive behavioural theory as a base for primary prevention and the core skill-based techniques such as modelling or role play [Bar-On et al. 2007, p. 65]).

However, despite different theoretical groundings, there is still a considerable overlap among these models in the competencies to be learned (as described in the next section), and a shared set of guidelines on what makes curricula effective. In particular, curricula should take a wide scope both in terms of methods and skills learned, build on a clear theoretical framework, use a comprehensive approach that integrates affective, cognitive, and behavioural dimensions, and promote generalisation of skills [Elias et al. 1997, p. 119]. Additionally, the literature highlights that piecemeal program efforts, such as one-off workshops, are much less likely to be effective [Zins et al. 2004, p. 13] than comprehensive programs.

2.4. Goals of SEL Learning

A set of five core competencies is widely accepted within the educational community [CASEL 2003, 2013; Zins and Elias 2007; Durlak et al. 2011] as a good description of the general goals shared by most of the existing curricula, regardless of underlying theories. We quote these competencies and their brief descriptions as per Durlak et al. [2011]:

—**Self-awareness:** The ability to accurately recognise one's emotions and thoughts and their influence on behaviour. This includes accurately assessing one's strengths and limitations and possessing a well-grounded sense of confidence and optimism.
—**Self-management:** The ability to regulate one's emotions, thoughts, and behaviours effectively in different situations. This includes managing stress, controlling impulses, motivating oneself, and setting and working towards achieving personal and academic goals.
—**Social awareness:** The ability to take the perspective of and empathise with others from diverse backgrounds and cultures, to understand social and ethical norms for behaviour, and to recognise family, school, and community resources and supports.
—**Relationship skills:** The ability to establish and maintain healthy and rewarding relationships with diverse individuals and groups. This includes communicating clearly, listening actively, cooperating, resisting inappropriate social pressure, negotiating conflict constructively, and seeking and offering help when needed.
—**Responsible decision making:** The ability to make constructive and respectful choices about personal behaviour and social interactions based on consideration of ethical standards, safety concerns, social norms, the realistic evaluation of consequences of various actions, and the well-being of self and others.

However, these core competencies comprise complex, interrelated abilities and it is not possible to teach any of the competencies directly—see Figure 2 for examples of the range of skills related to individual competencies. Instead, each curricula helps learners progressively develop these competencies, building up from sets of less complex skills.

[5]This is similar to psychotherapy domain, in which a number of schools co-exist in parallel, each building on different theoretical groundings.

Self-awareness	Label and recognise own and others' emotions. Identify what triggers own emotions. Analyse emotions and how they affect others. Accurately recognise own strengths and limitations. Identify own needs and values. Possess self-efficacy and self-esteem.
Self-management	Set plans and work toward goals. Overcome obstacles and create strategies for more long-term goals. Monitor progress toward personal and academic short- and long-term goals. Regulate emotions such as impulses, aggression, and self-destructive behaviour. Manage personal and interpersonal stress. Attention control (maintain optimal work performance). Use feedback constructively. Exhibit positive motivation, hope, and optimism. Seek help when needed. Display grit, determination, or perseverance. Advocate for oneself.
Social awareness	Identify social cues (verbal, physical) to determine how others feel. Predict others' feelings and reactions. Evaluate others' emotional reactions. Respect others (e.g., listen carefully and accurately). Understand other points of view and perspectives. Appreciate diversity (recognise individual nad group similarities and differences). Identify and use resources of family, school, and community.
Relationship skills	Demonstrate capacity to make friends. Exhibit cooperative learning and working toward group goals. Evaluate own skills to communicate with others. Manage and express emotional in relationships, respecting diverse viewpoints. Communicate effectively. Cultivate relationships with those who can be resources when help is needed. Provide help to those who need it. Demonstate leadership skills when necessary, being assertive and persuasive. Prevent interpersonal conflict, but manage and resolve it when does occur. Resist inappropriate social pressures.
Responsible decision making	Identify decisions one makes at school. Discuss strategies used to resist peer pressure. Reflect on how current choices affect one's future. Identify problems when making decisions, and generate alternatives. Implement problem-solving skills when making decisions, when appropriate. Become self-reflective and self-evaluative. Make decisions based on moral, personal, and ethical standards. Make responsible decisions that affect the individual, school, and community. Negotiate fairly.

Fig. 2. Exemplary list of skills relevant to individual competencies (from http://www.gtlcenter.org/sel-school).

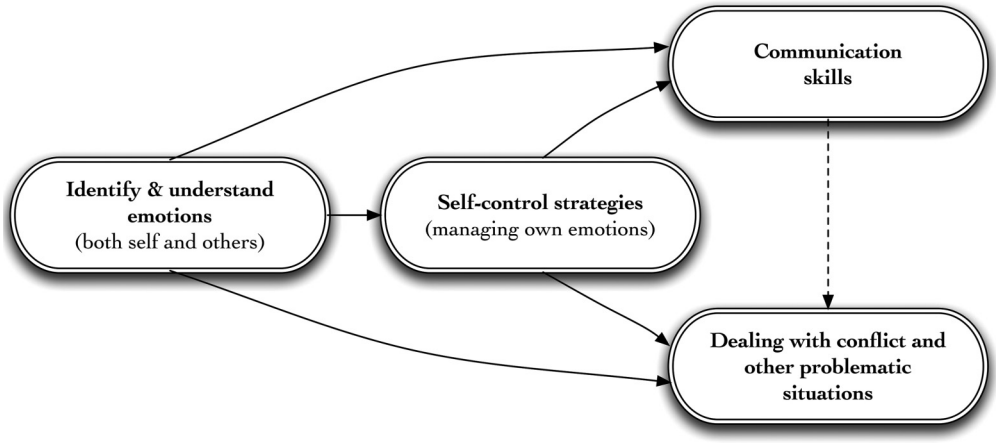

Fig. 3. Summary of the identified key topics in SEL in education and their dependencies.

2.5. How Are the Competencies Taught

We identified four sets of skills that consistently appear in most of the curricula, and across all age ranges. Our goal is twofold: to provide an initial "feel" for progression and topics taught in SEL, and to set up explicit examples that can be used in later sections to tie some of the existing HCI research to the approaches presented here:

(1) identifying and understanding emotions (own and of others);
(2) managing own emotions;
(3) developing communication and relationship skills;
(4) dealing with conflicts and problematic situations.

Each set thus subsumes a number of simple situations or skills (e.g., being able to identify becoming angry) and ways to train these (e.g., training learners to notice physical changes in their bodies, such as associated with feeling angry). Moreover, these topics build on each other in a sequential manner: The ability to identify and understand emotions is a key prerequisite for managing own emotions (without knowing one's own emotions, one cannot control them), which is in turn needed for keeping relationships (appreciating the perspective of another, not jumping to conclusions) and so on. As such, they are taught in the order as shown in Figure 3. We describe each topic in more detail in a respective section later, illustrating the descriptions with examples of specific activities from selected curricula. Figure 4 then maps how the four topics contribute to the core competencies.

2.5.1. Identifying and Understanding Emotions. The ability to identify and understand own and others' emotions is a prerequisite of most other social and emotional skills. A key goal is developing the emotional awareness of learners, which is the ability to differentiate, name, and notice subtle changes of emotions. Curricula[6] aim to train a practice of internal reflection, leading to continuous exploration of how they and others feel. Emphasis is also placed on making the distinction between acknowledging a feeling, and acting on that feeling/urge.

[6]Curricula including content on identifying and understanding emotions are Caring School Community, I can problem solve, Life Skills Training, PATHS, Peace Works, Quest (Violence Prevention Series), Open Circle, RIPP, Responsive Classroom, Second Step, SOAR, Social Decision Making and Problem Solving Program, 4Rs, Competent Kids, The Incredible Years Series, Michigan Model for Health, MindUP, RULER, Social decision making, Steps to respect, Too Good For Violence—21 in total.

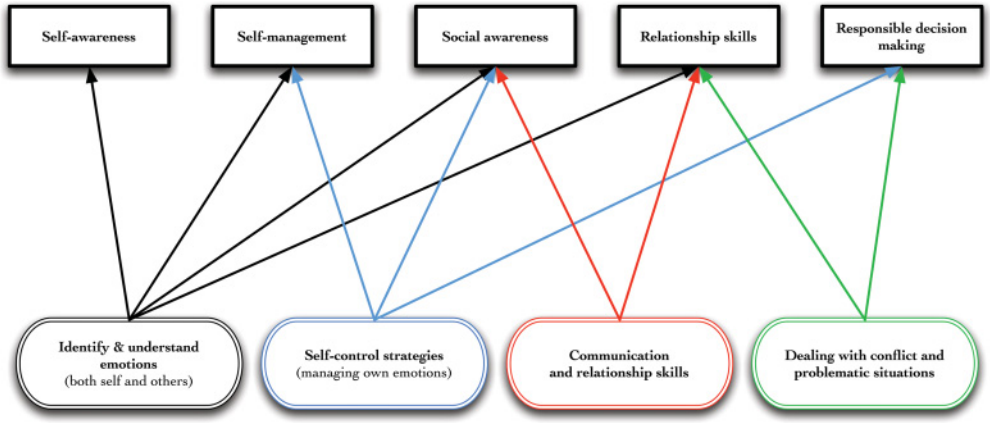

Fig. 4. Mapping of topics to core competencies.

In particular, some of the curricula build on language usage, and especially on how use of language affects our thinking processes. Various exercises focus on developing the ability to identify emotions in both oneself and others, helping learners to become more reflexive and self-aware. As an example, the PATHS curriculum includes physical "Feeling Faces" cards, which the child learners use to signal their current emotional state throughout the day [Domitrovich et al. 2007; Kam et al. 2004]. Similarly, the RULER curriculum uses popular stories to exemplify particular emotions, and to draw out distinctions among subtle variants of a specific one [Reyes et al. 2012]. Another approach aims to support self-reflection by exploring and understanding how our bodies are affected by experiencing particular emotions. For example, children are helped to recognise their own feelings by checking their bodies and faces for "tight" or relaxed muscles, frowns, smiles, and sensations in other parts of their bodies such as butterflies in their stomachs. Matching the facial expressions and body postures shown on cue cards helps the children to recognise the cues from their own bodies and associate a word with these feelings [Webster-Stratton and Reid 2004]. Emotions of others are explored through the ways in which they affect the tone of voice, body language and the like. This is often incorporated as a game, for example, developing the "detective skills" to find out how others feel. Repeated use of similar activities aims to help learners think more often about how they, and others, might feel in various situations.

2.5.2. Self-Control Strategies. Self-control and management of own emotions is a key aspect of many curricula[7] and the techniques used to develop self-control build on emotional awareness.

Various strategies and exercises aim to help participants to relax and/or calm down once a strong feeling is recognised. These are often based on various physical exercises such as muscle stretching and deep breathing techniques. Other strategies draw on verbal labelling, building on psychology and neuroscience findings showing that the act of consciously labelling an emotion by name (rather than "just" being aware of it) facilitates higher cognitive control over the emotional state [Greenberg 2006; Reyes et al. 2012]. Exercises training explicit acknowledgement of emotions, as well as

[7]Life Skills Training, Lion's Quest, PATHS, Peace Works, Productive Conflict Resolution Program, Quest (Violence Prevention Series), Open Circle, RCCP, RIPP, Responsive Classroom, Second Step, SOAR, Social Decision Making and Problem Solving Program, Teenage Health teaching Modules, 4Rs, Al's Pals, Competent Kids, The Incredible Years Series, MindUP, Positive Action, RULER, Steps to respect, Too Good For Violence—24 in total.

thinking about what could be their cause, are often used. Specific strategies for anger management are particularly common, often combining both verbal labelling and physical relaxation exercises. An example is the "Turtle technique" [Robin et al. 1976], which is still used in a number of curricula (e.g., Incredible Years or PATHS). In this technique, children are taught to "withdraw into their shell" (by pulling their arms and legs close their body and closing their eyes) at specified occasions such as when they feel increasingly angry. This is followed by a relaxation phase, in which specific muscle groups are tensed and released. Once this technique is mastered, children discuss appropriate alternative strategies for dealing with stressful situations, now that they are able to consciously reflect and react to them.

2.5.3. Communication Skills. Another set of activities focuses on building good communication skills and supporting positive interactions with others[8]. The skills taught here are aimed at supporting respectful empathic communication and thus implicitly facilitating friendship relationships, and an ability to collaborate and avoid conflicts that could otherwise occur through misunderstanding.

The emphasis is on teaching active listening, which is then used to facilitate teaching empathy. Other teaching strategies also focus on training of specific communication skills (e.g., giving and accepting compliments). Exercises can include games to induce collaborative activities; practise active listening, for example, through listening to someone telling a story and then trying to rephrase it with as many details as possible, and disagree respectfully. These can include ways to subtly reframe a message into a form which is not threatening, such as in Aber et al. [1998], in which students are taught to acknowledge the potential mismatch between their and the other's perception of the situation (e.g., preferably saying "It seems to me you are not listening now," rather than "Why aren't you listening to me!").

2.5.4. Dealing with Conflicts and Problematic Situations. Problem-solving strategies and conflict management are the final topics of the most curricula[9]. Violence prevention is commonly an important additional goal, as many of these curricula are designed for all schools, including those with a high prevalence of aggression and weapon use.

Students are often taught a particular structure of reacting to a problematic situation or a conflict. A key approach is to help students process the situation on a cognitive level, despite the fact that conflicts tend to ignite strong emotions. For example, the PATHS curriculum includes a "semaphore," in which the sequence of red–yellow–green indicates a "stop-think-proceed" process [Domitrovich et al. 2007; Kam et al. 2004]. Such structured sequences always include and emphasise a goal setting and evaluation phase. Moreover, curricula aim to teach children and teenagers to recognise which conflicts might have arisen from misunderstanding, with perspective-taking exercises forming the core approach. An example is exploring win–win negotiation (e.g., in RCCP) in a workshop format and providing suggested sequences for steps to take during disagreements (e.g., in Incredible Years).

[8]Although implicit in many others, this aspect is explicitly highlighted within the following curricula: Michigan Model for Comprehensive School Health Education, Peace Works, Open Circle, RCCP, Responsive Classroom, Second Step, SOAR, Tribes, Al's Pals, The Incredible Years Series, MindUP, Positive Action, Steps to respect curricula—13 in total.

[9]Michigan Model for Comprehensive School health Education, PATHS, Peace Works, Productive Conflict Resolution Program, Quest (Violence Prevention Series), Open Circle, RCCP, RIPP, Responsive Classroom, Second Step, SOAR, Social Decision Making and Problem Solving Program, Tribes, 4Rs, Al's Pals, I Can Problem Solve, Competent Kids, The Incredible Years Series, Positive Action, Social decision making, Steps to respect, Too Good For Violence—22 in total.

2.5.5. Differences Across Grades. Curricula exercises are designed for specific grades/age levels, keeping in mind the developmental changes in abilities of the learners. For example, curricula for K1 students can aim to help the learners label and identify basic emotions such as fear or happiness, K4 students might focus on more complex emotions such as jealousy or embarrassment, and high-school students would be taught to draw on their more nuanced self-awareness to motivate goal-setting and critically assess their behaviour. Curricula also particularly highlight the increasing integration of cognitive, emotional, and behavioural aspects that can be expected of students as they grow older. See, for example, Elias et al. [1997, pp. 133–138] for more detailed information on the progression and detailed changes in skills foci.

3. SEL CHALLENGES AND OPPORTUNITIES FOR TECHNOLOGY SUPPORT

Despite the success of curricula in promoting learning of social and emotional skills to some extent (cf. Section 2.1), the review of SEL literature also highlights areas in which novel approaches are needed, or further improvements are possible. In the rest of this section, we outline three such exemplary topics—embedding of skills into everyday settings, promoting reflection, and providing mixed spaces for practice. Our choice of highlighting these particular areas was motivated by the extent of related HCI work that exists for each of these. This allows us to exemplify the potential for collaboration of HCI and SEL, and specifically point to the existing HCI work that suggests how incorporating digital technology may help address crucial needs in, as well as open new opportunities for, SEL in education.

3.1. Embedding of Learnt Skills into Other Settings

We start with what the SEL literature highlights as one of the key issues with the existing SEL curricula—that is, the lack of support for transfer and "embedding" of the skills students learn in SEL classes into their other real-world interactions, be that still within school (other classes, playground) or everyday behaviour within family and peer groups [Bar-On et al. 2007; Elias et al. 1997; Jones and Bouffard 2012; Patrikakou et al. 2005]. Although such transfer of learned skills is the ultimate goal of all curricula, the current approaches are limited in scope and effectiveness. This leaves teachers (and curricula designers) struggling to directly influence the embedding of skills outside of the SEL learning sessions, be that in other classes, or outside of school completely. For example, Jones and Bouffard [2012] summarise the situation as follows:

> "Perhaps most important, and often overlooked, is the fact that SEL programs are rarely integrated into classrooms and schools in ways that are meaningful, sustained, and embedded in the day-to-day interactions of students, educators, and school staff [...] Most SEL programs focus solely or primarily on what goes on in the classroom, but SEL skills are also needed on playgrounds, in lunchrooms, in hallways and bathrooms – in short, everywhere. These non-classroom contexts provide vital opportunities for students to practice their SEL skills."

Bar-On et al. [2007, pp. 70–71] further highlight the critical role of adults, both in and out of school, in the success of SEL training for students:

> "Many SEL efforts fail because long-term, coordinated plans and school-home partnerships are not developed. [...] [T]he efforts of school-based practice falter because educators are not committed to being ongoing, vital SEL role models. SEL involves not just the students in schools but also the adults in their lives: teachers, parents and the wider community. If these adults lack social and emotional competency, children will quickly notice the discrepancy between behaviors that the adults advocate for children and the actions that the adults take themselves."

We argue that digital technology could support these efforts in at least two ways: first, by extending the learning support and scaffolding for learners beyond the SEL lessons, for example, utilising mobile and sensor-based technology; second, through facilitating a wider community of support for learning of social skills, including the involvement of parents and teachers—not only by connecting them to the learning content in the classroom, but also enabling vicarious learning so that they develop their own social and emotional skills. We outline each in more detail in the following section.

3.1.1. Supporting the Learners—Transitioning the Skills Out of the SEL Lessons. When SEL skills are to be transferred beyond the SEL classroom lessons, the learners can no longer take the advantage of the direct scaffolding normally provided by the teacher and the lesson structure. This brings several difficulties for the learners to reinforce and apply their skills outside of direct SEL training. We particularly highlight the difficulties with (i) identifying moments when the newly learnt social and emotional skills could applicable, (ii) the lack of scaffolding and support to do so, and (iii) the need for "space" to reflect and learn from the experience afterwards.

Identification of teachable moments. When interacting during breaks, other classes, or outside of school completely, the learners encounter many occasions that are relevant to their SEL skills learning. However, the learners may not recognise such opportunities and instead revert to previous, negative behaviours (e.g., an angry outburst rather than a self-controlled reaction), especially if emotions are strong and no external guidance is available [Elias et al. 1997, p. 56]. In such situations, it is thus not only difficult for the learner to apply the skills they have learned, but even to perceive these as such "teachable moments." This is one of the key differences to the SEL class setting, where it is the role of the teacher to facilitate and point out situations in which students could use their (new) SEL skills; helping students reinforce the learnt skills in the process. Curricula designers therefore suggest that all school personnel should *"play an important role in actively encouraging and reinforcing the use of skills and attitudes they see displayed"* (e.g., Elias et al. [1997, p. 56]). This however requires the (possibly untrained) teachers to constantly strengthen and actively encourage use of SEL skills in addition to all their other duties. More critically, there is little opportunity for supporting the learners when the teaching staff are not around (and thus also making the students fully dependent on external guidance, e.g., from parents).

This points to the benefits of (and the need for) technology that could support the learners themselves in noticing and reacting to the relevant situations. For example, learning self-control is one of the key aspects of SEL; it relies strongly on identifying a problematic situation and then to calm down before it is "too late" and emotions are already running high. One opportunity for technology in this setting can draw on the maturing HCI research on in-the-wild stress detection drawing on physiological data or speech prosody, for example, Hernandez et al. [2011], Poh et al. [2010], Pina et al. [2014], Zeng et al. [2009], and Ertin et al. [2011]. We envision that such data could be used to support the learners in becoming aware of their heightened arousal (e.g., through a private tactile reminder such as FitBit wrist vibration), which can serve as a cue to start the self-calming/self-control mechanisms taught in class. Earlier research in HCI suggests that providing such ongoing subtle cues for facilitating awareness, and triggers that remind users to attend to intended activities, can be useful to help users modify their existing behaviours [Consolvo et al. 2009; Obermair et al. 2008]. Moreover, SEL designers have deep understanding of how best to work with such cues and triggers once these are identified. An example of initial work in this direction is Pina et al. [2014], who designed a system for parents of Attention Deficit Hyperactivity Disorder (ADHD) children, delivering in-the-moment cues and strategies to manage stress during everyday activities. Overall, the initial studies point to the potential of

such technologies, but also point to many practical issues to be addressed, including whether such systems are robust and precise enough for immediate inclusion into the SEL curricula, and how could these be best embedded in the existing programs to most appropriately exploit this potential.

Scaffolding and structure to support training of skills. Learning of skills is scaffolded in many ways within SEL training sessions: (i) the scaffolding inherent in the activity itself, such as a prepared scenario for a role play that highlights a particular aspect to focus on; (ii) the teachers' presence and input into the activity, such as prompts guiding the development of the role-play, and feedback to students on their behaviour; and (iii) also the fact that this is a SEL training session, which brings a particular set of foci for the students including the explicit attention paid to SEL skills development. However, much of this scaffolding disappears outside of the SEL learning, even if the situation is still within a class setting (e.g., during a lesson in a different subject).

This points to the opportunities for technology to provide just-in-time prompts, reminders and structuring, for example, through mobile devices, to support the scaffolding of activities and help learners focus attention on SEL skills in play. Examples of such direct scaffolding methods that can be useful out of SEL classes include problem-solving strategies such as the "stop-think-proceed" semaphore in the PATHS program and the sequence of steps to resolve disagreements in the RCCP program, in which each person is invited to share their perspective on the situation in turn. Within HCI, several projects have explored technology support for similar structuring as part of autism therapies. For example, the MOSOCO project [Escobedo et al. 2012; Tentori and Hayes 2010] exemplifies how mobile phones can help children on the autistic spectrum structure, but also their neurotypical peers, to structure and practise their social skills outside of lessons, and how the system can help elicit feedback from their peers. Similarly, HygieneHelper [Hayes and Hosaflook 2013] and SocialMirror [Hong et al. 2012] help scaffold everyday activities for people with autism. Although the social aspects supported in these systems are relatively basic when compared to the full range of skills taught as part of SEL, they nonetheless raise the question about whether similar approaches might be possible for more complex behaviours. Initial work has, for example, explored the use of similar technology to deliver personalised strategies for coping with stress in everyday life for a general population [Paredes et al. 2014], and Mamykina et al. [2008] designed MAHI, a mobile-based scaffolding system for newly diagnosed diabetes patients that extends the in-class lessons by facilitating participants' ability to track, reflect on, and analyse their everyday experiences with diabetes, leading to improved feeling of control over the disease.

Another example for possible scaffolding through technology is the crucial importance that the initial phases in all curricula place on the ability to be aware, acknowledge, and importantly also label emotional experiences over time. We saw curricula using methods such as FaceCards while in class (PATHS), or even structuring the whole curriculum around this skill (RULER). The power of mobile technology to prompt and collect such emotional reflection on-the-go presents opportunities to further extend such emotional awareness into other settings, and a number of projects have already explored related techniques in various contexts in the existing HCI work. In one such example, Matthews and Doherty [2011] developed a ubiquitous application to support emotional awareness training for psychotherapy clients, using mobile phones to elicit and support reflection on current emotional state regularly over the course of the day. As part of other initial work, Munson et al. [2010] integrated the Three Good Things, a well-known positive psychology intervention, into a social networking site, meshing it with users' daily habits around these sites, and thus facilitating social and emotional awareness through technology. Although these projects did not focus on the specifics of emotional training in SEL (e.g., distinguishing between a particular set of emotions

depending on age, or exploring the set of activities that led to that particular state), the design mechanisms behind these applications could likely well be transferable to the SEL settings.

Support opportunities to stop-and-learn from experience. Providing opportunities for post hoc reflection on one's own behaviour is a crucial part of experiential learning, helping learners make sense of their experiences [Cohen 2001; Moon 1999]. As such, SEL class-based activities include explicit time to reflect on own experiences, for example, in the form of a debriefing or discussion after a role play. However, such post hoc reflection might be difficult for situations outside of the SEL training scenarios, in which the teachable moment is intertwined with other continuing activities that may prevent immediate reflection (e.g., resolving a conflict around what game to play during recess, which once finished, leads into the game right away). Students may end up not reflecting at all, or, if they do, find it difficult to recall the situation and their own reactions well (e.g., Pasi [2001, p. 55]).

Although only limited work exists in HCI around supporting such processes for social and emotional learning specifically, the growing focus in HCI on supporting reminiscence and reflection in other contexts suggests ways in which technology could support learners in collecting traces of aspects of their experiences to ground later reflection, for example, [Fleck and Fitzpatrick 2009], [Isaacs et al. 2013], [Marcu et al. 2012], [Sanches et al. 2010], and [McDuff et al. 2012]. SEL sessions in current curricula already include discussions around SEL-related issues that students experienced in the meantime[10] and such collected data could be incorporated to ground the discussion and learning. Although we provide a more detailed discussion of other HCI work around supporting reflection in Section 3.2, one direct example of using such recorded data to support SEL learning comes from the literature around Video Interaction Guidance (VIG) framework. A number of studies provides evidence of how guided, post hoc reflection of micro-moments, selected from video clips of everyday activities, can promote social skills learning (see, e.g., Kennedy et al. [2011] for a summary). Although primarily developed to support parents of children with behavioural issues, it has since been applied to promote learning for various groups, such as teachers, psychologists, and counsellors, and might be a valuable addition to the existing curricula. Importantly, novel systems could draw on and extend the VIG framework to support the learners themselves in capturing such micromoments for their later reflection and analysis.

3.1.2. Social Support—Community Building. Literature around SEL curricula highlights the importance of a supportive atmosphere, not only in the school but also at home, which is crucial to successful learning [Bar-On et al. 2007; Pasi 2001; Patrikakou et al. 2005]. Support from the parents as well as learners' peers is thus needed, but difficult to promote in the existing curricula. Although there is only limited work in HCI that addresses supporting such links between school and home, we argue later that the extensive knowledge HCI has gained in other settings around promoting the development of support networks [Barak et al. 2008; Massimi 2013; Skeels et al. 2010] and local communities [Ganglbauer et al. 2014; Lewis and Lewis 2012; López and Butler 2013; Massung et al. 2013] makes it plausible that HCI will be able to contribute here as well.

Peer support. Interaction with, and perceived support from, peers are both crucial for school-age learners, especially when they are in their teenage years. Systems

[10]For example, the teachers following the PATHS curricula keep a "Problem box" on their table. During the day, students experiencing problems can write them down and place the note into the box. The resulting issues are used once or twice a week to seed problem-solving meetings [Kam et al. 2004].

utilising the learners' broader social network could help motivate and engage participants to keep up with their SEL goals. Although the existing HCI research has looked at leveraging such social influence in other contexts, such as sustainability [Gustafsson et al. 2009; Thieme et al. 2012] or physical activity [Gasser et al. 2006; Lin et al. 2006], similar approaches might also be successful in the contexts of SEL learning. Social support can also be facilitated for peers outside of the immediate social network, as is the case with online social networks and support groups. These have been extensively studied and used [Barak et al. 2008; Newman et al. 2011], especially in the context of patients with life-altering diseases such as cancer [Skeels et al. 2010], and those undergoing other stressful periods in life (e.g., smoking cessation [Ploderer et al. 2013]). Such work points to the potential of online support groups to provide emotional and information support. However, social support groups have so far mainly been used for high-stress situations, in which users come to discuss their issues and share information and experiences with others. As such, sharing of experiences and support is also understood to be an important part of learning in the SEL curricula, it is possible that similar methods for promoting social support and encouragement are also viable for (parts of) social and emotional skills learning.

Parental involvement. Facilitating parental involvement constitutes another critical issue for the existing SEL curricula [Patrikakou et al. 2005]. The teachers implementing the SEL curricula experience similar difficulties with lack of opportunities to directly support, influence, and collaborate with parents, making it a major unmet need within SEL. Although some curricula organise specific workshops and training activities for the parents to help them undertake their SEL support role outside of the classroom, it is often difficult for parents to get involved for a variety of reasons: the sessions take place face-to-face at a specific time/location, and require specific travel, scheduling, and other overheads for the parents as well as for the teachers; parents often report time limitations [Bender et al. 2011]; and there is also often a lack of perceived value and interest [Lewin and Luckin 2010].

This points to the opportunity to design systems that allow parents to engage and support the SEL learning of their children without necessarily having to attend specific sessions, for example, through games or other scaffolded interactions. Although there is limited work in HCI on support for parents around social and emotional learning, there is an example of similar support for a traditional academic subject, maths, in which Luckin [2008] developed the Homework system to link between the school lessons, teachers, and parents and so facilitated the involvement of the parents in learning activities with their children that continued the learning from the class. Future work looking at facilitating parents' involvement with SEL might also draw on the existing research around supporting shared play activities, for example, Raffle et al. [2010]. In the scope of autism-related systems, Hong et al. [2012] present another example, exploring how a social network can support a person with autism in drawing on advice, help, and interactions with an extended network of close others, rather than relying on a single primary care-giver and/or the trainer, and Kientz et al. [2009] deployed a system to support tracking infants' social behaviour, supporting early detection of possibly autism-related disorders. Such systems exemplify how digital technology might be designed to promote sharing of the expert role of the SEL teacher with parents and the extended family in the home context.

Moreover, given the importance of providing appropriate role models, the parents themselves would at times benefit from developing particular aspects of social and emotional skills. Such vicarious learning for parents might be designed as part of the parent–children interaction described in the previous paragraph. Alternatively, work by Pina et al. [2014] and Paredes et al. [2014] suggests short, mobile-phone-delivered interventions as a potential option. Finally, as already mentioned before, the

VIG framework (see, e.g., Kennedy et al. [2011] for a summary) provides experimental evidence of how guided reflection of micromoments can promote parents' social skills learning. Although this method is so far focused mainly on face-to-face interventions with a trained VIG guide, the relatively short span of time needed for the intervention (3–4 guided reflections) suggests that similar approaches might possibly to be incorporated into the curricula, especially, if similar interaction could be supported remotely, for example, as part of the curricular homework assignments.

3.2. Promoting Reflective Skills

The ability to reflect on own and others' emotions, thoughts, and behaviour is the foundation for experiential learning [Moon 1999]. It underpins all skills taught in SEL [Bar-On et al. 2007; CASEL 2013; Cohen 2001, 2006; Pasi 2001] and is also recognised as one of the protective factors against later maladjustments [Zins et al. 2004]. As such, learning how to be reflective is a necessary core skill for the students, and one that is generalisable across settings and situations.

Although existing SEL learning processes are successful in helping students develop their reflective abilities to some extent, prior work on supporting reflection in HCI suggests that digital technology has the potential to further extend and augment such training (cf. [Baumer 2015]). As already discussed in Section 3.1, providing the learners with previously unavailable cues around, and feedback on, their behaviour could promote, elicit, and scaffold reflection. In the rest of this section, we showcase the possible connections between HCI and SEL by selecting three topics—support for emotional awareness, mindfulness and relaxation, and communication skills—as exemplary areas in which initial HCI work has already explored supporting reflection on aspects directly relevant for SEL learning. Altogether, most of the systems referenced later provide indications that they can support and deepen reflection around *specific* emotional or social experiences for the users. However, this also opens questions around if and how similar approaches can be utilised to support the *development of reflective abilities* more generally, with the aim of promoting a lasting change that stays even after the technology is taken away.

Emotional awareness. Developing emotional awareness is the foundation of all SEL curricula, with specific focus on helping students identify and label their emotions. A number of HCI research projects demonstrated how digital technology can open novel pathways for people to explore and deepen their understanding of their own emotional experience. As one option, researchers have argued for the value of presenting ambiguous cues, which can nudge people to engage, interpret, and reflect on their experiences (e.g., Boehner et al. [2005], Gaver et al. [2003]). For example, AffectiveDiary [Höök et al. 2008; Sengers et al. 2007; Stahl et al. 2008] inspired users' reflection by presenting cues based on a combination of sensor data, and other projects use movement to explore emotional experiences [Mentis et al. 2014]. Early HCI work also suggests that systems could draw on sensor data to track and visualise users' emotional changes over time (as inferred from the sensor data), possibly helping the users draw out patterns that they may not notice otherwise. One example is AffectAura [McDuff et al. 2012], tracking multiple devices to offer users information on their emotional state as an aid to support post hoc recall. Overall, similar systems could support the learners in the early steps of each SEL curricula, when the reflection on emotional states is a crucial and necessary step before moving on to further topics.

Mindfulness and relaxation. An increasing number of curricula incorporate mindfulness techniques, as well as other approaches to support students in greater awareness of their body. These include calming and relaxation exercises (such as those related to

the Turtle technique), but also aspects such as "checking for tense muscles" as part of raising emotional awareness (e.g., Incredible Years [Webster-Stratton and Reid 2004]). Initial work in HCI has drawn on the opportunities of technology to highlight bodily changes, supporting self-awareness in the moment. For example, Moraveji et al. [2011] support greater awareness of one's own breathing, helping the user to maintain a calm and relaxed state. Similarly, Sonic Cradle maps respiration to changes in sound to encourage the participants to reach a state resembling mindfulness, and guiding them through the process, and Thieme et al. [2013] report on a design exploration of technology to support mindfulness for individuals with severe mental health issues. Each of these examples points to ways in which technology can help guide and motivate users to pay close attention to the present moment and become aware of their bodily changes. The external support and scaffolding such technologies could bring to SEL curricula is likely to benefit particularly those learners who would otherwise encounter greatest difficulties in reaching such levels of attention and self-awareness.

Communication skills. Many curricula teach particular communication skills and interaction strategies, drawing on exercises to support attentive listening, perspective taking and collaboration. Prior work in HCI suggests ways in which technology might again provide novel cues for students' reflection on such activities. In particular, a number of papers show how relevant aspects of interaction might be tracked in real time, and how providing feedback on these can positively affect an interaction. For example, DiMicco et al. [2007] and Kim et al. [2008] explore how increased awareness of speaking behaviour within an interaction (e.g., through a visualisation) can affect and shape group dynamics. There are also indications that even subtler elements of interpersonal interaction may be addressed. For example, Balaam et al. [2011] show how feedback based on nonverbal behaviour can affect and increase perceptions of rapport. Although Balaam et al. [2011] used Wizard of Oz techniques to select the indicators, there are already several systems that aim to automate similar tracking [Hagad et al. 2011; Sun et al. 2011]. Similarly, Daily [2010] uses physiological data to provide a posteriori feedback on group discussion in classes, suggesting that such feedback can deepen reflection of the shared experience and empathy. Together, these projects highlight the opportunities to track and provide relevant aspects of social interaction to learners as cues to trigger further reflection and learning around communication skills.

3.3. Mixed Spaces for Practice

As Elias et al. [1997, p. 55] notes, although repeated rehearsal provides benefits to any learning,

> "there is one main difference between SEL and many academic subjects. While SEL entails the learning of many new skills, it may also require the unlearning of habitual patterns of thought and behavior. For instance, students rarely come to class having repeatedly practiced an incorrect version of the multiplication table, but they may have become well schooled in not waiting their turn or not listening carefully to others."

Providing extensive opportunities for practice using many different instructional modalities (cf. Figure 1) and in as many contexts as possible is thus fundamental for SEL curricula. Drawing on earlier HCI research around games, augmented reality, and VR, we provide several examples of how technology could bring novel opportunities to enhance and improve the training.

In particular, we point to the opportunities to create "mixed spaces" through technology for practice—environments that combine the safety and scaffolding inherent

in existing class-based activities (e.g., a role-play scaffolded by the teacher), but with increased autonomy for the learners, and allowing students to practise social and emotional skills in a wide range of novel model situations. We outline next several SEL topics in which initial work in HCI exists.

Self-control. As one option, the existing work suggests how the combination of physiological sensors and a computer game could support the practice and learning of self-control and calming down skills. For example, Bouchard et al. [2012] explored a combination of a first-person shooter game and short biofeedback training that limited the field of view in the game based on changes in arousal as measured by skin conductance. They provide evidence for how such a biofeedback loop, together with calming exercises, helped soldiers not only to better manage their stress during the game, but also how these coping skills were better able to be transferred into real-world training situations; soldiers who have undergone such biofeedback training were significantly better than those trained by traditional techniques. Similarly, Mandryk et al. [2013] used an analogous biofeedback-driven graphical overlay on existing games to support learning by children with a Fetal Alcohol Spectrum Disorder. Although the system has not been fully evaluated yet, the team reported a sustained engagement from the learners over a 12-week deployment. Overall, these and similar examples suggest how including such game-based self-control training into SEL curricula can take advantage of the strong engagement and controlled stressors that computer games can offer, while allowing learners to explore their reactions in a safe space and fail without serious consequences.

Promoting perspective taking. Perspective taking is one of the key relationship skills that curricula teach, especially as a way to support effective conflict resolution or prevention of bullying. Initial work on "serious" games suggests that game environments could help develop such perspective taking across a broad range of contexts, and do so in an engaging way. For example, Hailpern et al. [2010] designed an instant messaging system to support the relatives and friends of patients with aphasia in understanding the distortions of speech induced by this disorder, showing that interaction through such a system can increase empathy for the experiences of those suffering from aphasia [Hailpern et al. 2011]. Taking a more design-oriented approach, Rusch [2012] aimed to facilitate a similar understanding of depression, and Rubin-Vaughan et al. [2011] developed and deployed an online interaction consisting of a series of games that help children practise their social skills, including perspective taking or making friends, with a specific focus on bullying prevention exercises. Although still in initial stages, the existing work suggests that similar approaches could be incorporated into the curricula, allowing students to experience situations from perspectives they would not have access to otherwise.

Communication skills and collaboration. The existing research also points to several areas in which computer-mediated experiences could support communication and collaboration skills. For example, initial work suggests utilising the recent advances of embodied, interactive agents to support practicing of particular skills, such as negotiation across cultures [Core et al. 2006], medical communication skills [Johnsen et al. 2005], or preparing for a job interview [Hoque et al. 2013]. In both of these, the learner interacts with an agent in a pre-prepared scenario, and is given feedback on their behaviour (e.g., nonverbal behaviour such as smiles or speech prosodics) to support further reflection and learning. Ulgado et al. [2013] present a similar system aimed at supporting practice for learners on the Autism Spectrum. Each of these provides novel support for practice on specific skills that SEL curricula teach. They benefit the students in offering additional external feedback and support that can be accessed

without the need for direct involvement of teachers, parents or peers, and that happen in "safe" simulated spaces.

Prior research has also looked at the possibilities of novel interfaces such as multi-touch tabletops to scaffold cooperation and communication behaviours through placing constraints on available activities (e.g., Yuill and Rogers [2012]). Although most of the work aiming at supporting the learning of such skills looks at augmenting the therapeutic approaches with autistic children (e.g., Piper et al. [2006], or [Zarin and Fallman 2011]), initial work suggests that similar approaches might translate also to interactions of neurotypical children (e.g., [Antle et al. 2013; Cao et al. 2010; Hinske et al. 2009; Kharrufa et al. 2010]) and the more complex cooperative behaviours that the SEL curricula aim for there.

4. SEL-ENABLED OPPORTUNITIES FOR HCI

The previous section highlighted areas in which digital technology could be particularly helpful in supporting social and emotional learning in education, suggesting specific opportunities to support SEL through the appropriation and adaptation of the existing HCI work with the SEL contexts.

We now move on to argue that a focus on SEL also presents HCI researchers with a unique opportunity to jump-start the research on technology for supporting social and emotional interaction more broadly. In particular, although we have seen many examples of how HCI work may support SEL learning, most of the mentioned systems are (i) still in the stage of research prototypes with little empirical evidence of them leading to actual lasting effects and (ii) have been mostly designed as isolated, one-off solutions rather than as part of an integrated program that is needed for sustained change [Zins et al. 2004, p. 13]. Cooperation with SEL programs could help address both these limitations. In the rest of this section, we first outline how the structure inherent to SEL curricula can provide HCI with a "test-bed" to develop, test, and deploy novel technology supporting social and emotional interactions. Second, we discuss how building on the existing knowledge within the SEL community can further guide HCI researchers in this space.

4.1. SEL Training as a Test-bed for Novel Technology

HCI researchers can draw on the evidence-based, structured learning processes within SEL curricula as an excellent context for deployment of emerging HCI technologies. The SEL curricula bring a wealth of carefully designed SEL content in which novel HCI systems can be embedded, thus offloading a crucial aspect that can otherwise make or break the system and/or limit the uptake. HCI researchers can also build on a continuum of activities and contexts with various levels of scaffolding, starting from highly structured activities in class with the teacher present, to completely unstructured, in-the-wild settings in the playground or out of school. Finally, designing to support SEL curricula offers the opportunity of large impact and scale. Successful technologies can utilise existing distribution channels to thousands of schools, as well as the large-scale evaluation practices common in the SEL community.

For example, the in-class context of an SEL lesson is likely to be particularly well suited for initial technology exploration, as it allows us to develop for real-world scenarios, but within a relatively constrained and manageable environment. Novel systems can thus utilise (or be directly designed for) the tightly scaffolded interactions in class, such as exercises and skills learning progressions, as well as assume a specific use of space (e.g., a dedicated part of the classroom), and a teacher facilitating the interaction between students and technology. Moreover, such settings also point to particular user roles the system can support, such as the trainer's expert role (augmenting and enhancing rather than replacing their skills), the students' learner role (directly supporting

the individual learners), and/or the peer role (e.g., facilitating peer feedback or group reflection on examples).

SEL curricula also provide a strong motivation for a number of other, more challenging contexts, with increasing demands on the robustness of developed technology. One such step can be extending SEL into the school environment more generally. This can be by supporting in-class learning in other academic subjects or students' interaction during the breaks. In both cases, there is still a fixed, controlled space in which to deploy the technology and in which a teacher can lead the scaffolding to some extent, but already supporting behaviour not tied to specific exercises. Moreover, one can utilise the fact that all interactions take place on the school grounds, allowing additional technology to be deployed at strategic points (such as in a main hall, in the playground, and so on), or invite students to use a specific technology as part of their learning process (such as providing each student with a Sociometer-like badge [Kim et al. 2008]). The support for embedding learned skills can also be extended to the home and other out-of-school contexts in which making assumptions about the other interactants, roles, or locations is more difficult, but in which the support for reinforcement of SEL learning is even more crucial. Such lack of structure makes it a particularly challenging design space for thinking about how to support the embedding of SEL skills. Across all of these different outside-of-SEL-class contexts, the challenge is not only how to support the learner in the moment, but also how to close the loop so that experiences from out-of-class interactions can be brought back into the SEL class to facilitate further reflection and learning.

Overall, the lessons learned from developing systems targeted at SEL curricula can likely be transferable to domains other than education, inspiring novel HCI applications in additional areas in which supporting social and emotional interactions is relevant, such as workplace collaboration, family communication, or CSCW in general (see also Section 6).

4.2. SEL to Guide HCI Focus and Agenda Around Social and Emotional Skills Technologies

HCI, as a domain, has currently only an emerging understanding of how technology can be best used in support of the learning and teaching of social and emotional skills. In contrast, the SEL literature offers a large body of knowledge, including a wide range of well-defined skills to be progressively learned and supported, as well as established methods for evaluating skills acquisition on the part of the learner, or the overall effectiveness of the (technology) intervention. Cooperation with SEL experts will thus help orient HCI researchers to those aspects of social and emotional interaction that can most likely benefit from technology support and plausibly deliver significant positive impacts for learners, teachers, and parents, creating the basis for a strong HCI research agenda in this space.

For example, in the context of Affective Computing (AC) and Social Signal Processing (SSP) fields, researchers can utilise SEL curricula as a significant real-world application domain, with a large set of challenges that could be tackled by novel AC/SSP technology. The importance that SEL training places on tracking and feedback of emotional and social aspects for the learners, and the difficulty to do so without the scaffolding of the teacher, presents one such example. Research in this direction could draw on the existing SEL knowledge to identify those social and emotional aspects that are relevant to detect in this context, as well as how best to present them to learners, leading to clear and well-motivated AC/SSP research questions around if and how such aspects can be sensed and interpreted with technology. Work along these lines is likely to also contribute to the existing debate within HCI as to where should such sense-making happen and by whom [Boehner et al. 2007; Sengers et al. 2007]. This continuum can range from leaving the sense-making entirely to the user and/or the facilitator,

possibly cued with nonprocessed sensor data (e.g., as per SenseCam systems [Fleck and Fitzpatrick 2009]), to providing full interpretation by the system (e.g., as in arousal detection for people with autism [Picard 2009]). In particular, even if some aspects cannot be reliably and fully interpreted by technology, it might still be possible and in many cases actually preferable (cf. [Boehner et al. 2005; Mentis et al. 2014]) to support the users by providing "reasonably" preprocessed data they can view, interpret, and explore. Again, although such research questions will be inspired by the work with SEL, they are likely to have wider repercussions also in other areas such as HCI than those directly focused on social and emotional learning.

5. NEXT STEPS—HOW CAN WE DESIGN FOR EXPERIENTIAL LEARNING IN SEL?

This section identifies several significant open issues that designing technologies for SEL will likely encounter. These provide pointers to possible next steps that the HCI community can take to start engaging with support for SEL learning.

5.1. What Challenges do Learners Face?

Although there is a large body of literature in HCI examining the needs of learners and teachers for classic academic subjects (e.g., maths, sciences, language learning) to inform design, there is little understanding about what specific issues students, teachers, and parents face around SEL curricula, that is, what is the everyday work to practically put SEL curricula to work, what is easy/hard to teach/learn, what are the practical strategies people have evolved that could be exploited for design, and so on. Although the majority of SEL curricula provide training workshops as part of curricula deployment in new schools, and have trained thousands of teachers, presumably imparting some of this as practical practitioner knowledge, none of the SEL academic papers, online resources, or books we reviewed addressed this issue deeply enough to allow us to identify specific challenges that could be translated to guidelines for technology design. The history of CSCW research in particular points to the critical importance of deeply understanding the reality of everyday situated practices, not just relying on the procedure manual version, to inform design decisions (e.g., in relation to technology support for healthcare [Forsythe 1999; Fitzpatrick and Ellingsen 2012]).

So although the SEL literature can suggest broad areas in which technology could address existing challenges that curricula designers struggle with—such as the embedding of skills and developing reflective abilities, as outlined here—there is a clear need for ethnographically informed and/or participatory studies to unpack the specific issues that students, teachers, and parents face during the learning process. As a practical strategy, for example, it could be interesting to collaborate with a school that is just about to deploy a new SEL curricula and to conduct deep qualitative (and even action research) studies of the process following the perspectives of the various stakeholders and participants. It could also be beneficial to conduct interviews and participant observations with the training departments of established curricula[11] who can share their experiences from across multiple school contexts.

Once an understanding emerges of the practical situated issues, or even as part of this understanding process, there might be a role for technology (or cultural) probes to help explore the possibilities of technology in this context, helping to better ground, and articulate the opportunities of technology when communicating with students, teachers, parents, and curricula designers (e.g., [Balaam et al. 2010; Hutchinson et al. 2003; Kjeldskov et al. 2007; Lewin and Luckin 2010; Marcu et al. 2012; Vetere et al. 2005]). However, this would need to be carefully handled because of the sensitivity of the

[11]For example, CASEL website or guides [CASEL 2003, 2013] can provide contact details to highly rated curricula.

skills concerned and that teachers have little capacity for additional work. Participatory design processes directly involving children (cf. Druin [2002], Walsh et al. [2010], and Yip et al. [2013]) are also likely to be a particularly effective approach in this space.

5.2. Tentative Design Factors

Accepting that there is still much to understand, we can still offer some tentative principles that can help guide initial studies and design thinking for technologies to support SEL learning. We do so drawing on our understanding of the SEL literature, and the experiential learning literature more broadly [Fleck and Fitzpatrick 2010; Griffith and Frieden 2000; Kolb et al. 2001; Moon 1999].

Design to empower self-driven learning. Finding ways of empowering learners to explore various facets of their behaviour is likely to be a crucial design consideration for many systems. This can, for example, include promoting the feeling of safety to be self-critical and positively learn from their own mistakes, while encouraging self-esteem and confidence in their own development. Such exploration will likely also involve supporting learners to collaboratively discuss and cocreate interpretations of the social interaction, with a specific focus on sharing their perceptions of the others' behaviour. In addition, other aspects of SEL (such as skills around self-control) point to the importance of personal devices that balance providing cues for the learner and not openly giving away information about their emotional state without their control. Wearable devices that offer opportunities for private feedback (e.g., the subtle vibration of FitBit wrist bands) could exemplify one possible way to do so. Designers will also need to consider age constraints and the related differences in learning goals (cf. Section 2.5.5), particularly the extent to which learners can be fully independent in their exploration or if stronger scaffolding will be needed, for example, from parents for younger learners.

Design to "teach and disappear." Although formal SEL curricula may span long time periods, it is a progressive learning process with the ultimate aim to facilitate the development of new skills that persist even after the course is finished. The aim of much of the SEL technology will likely be similar: to scaffold and help the learning of skills during the curriculum program and so that they will also persist *after* the technology is taken away. This provides interesting challenges to design, such as designing for support that can be phased out in structured ways, that is, for technology that gradually recedes into the background as the learner becomes more capable herself.

To our knowledge, there is only limited work in HCI so far that would explicitly aim to promote such progressive *learning of skills*, by a short-term scaffolding that is later taken away (see MACH [Hoque et al. 2013; Pina et al. 2014], or [Bouchard et al. 2012] for several exceptions), as opposed to providing continuous support of specific activities (e.g., MeetingMediator [Kim et al. 2008]) that may affect interaction at a particular meeting, but not necessarily lead to skills development, or long-term changes once the technology is no longer available. Further research is thus needed to understand how we can more systematically design for such "teach and disappear" technologies, implying a core quality of technologies that can be adapted in structured ways over time; this is a topic in which we could likely learn from the existing SEL knowledge, at least in terms of how the content/support focus should evolve.

Design to support engagement. Finally, facilitating engagement and supporting motivation of the learners is important across all learning, whether in SEL or core academic topics. A large body of literature in HCI shows the potential of technology and design to enhance users' engagement with a wide range of aspects, including education for children (e.g., Bers [2010] and Connolly et al. [2012] and the many papers from the

Interaction Design and Children conference). However, there is less literature on promoting the parents' engagement with their child's learning (see, e.g., Lewin and Luckin [2010] for an exception, or Raffle et al. [2010] for work on shared play). Given the importance SEL curricula place on such support from parents, and especially as the parents might need to develop and improve selected social and emotional skills themselves, strategies to make the system engaging to parents and children alike will likely pose challenges to designers.

5.3. Roles for HCI

We expect that a close cooperation between HCI researchers and curricula designers, teachers and learners will be crucial for successful design and development of supportive technologies in the domain of SEL, at least in the early stages when key challenges are set and goals defined. This is similar to the research around autism therapy support [Kientz et al. 2013] and online Cognitive Behavioural Therapies [Porayska-Pomsta et al. 2011], which exemplifies a fruitful collaboration between the respective domain and HCI experts. As an example of such a possible mode of collaboration, Coyle et al. [2007] suggest a two-stage process in the area of talk-based therapies, in which the first exploratory part is led by HCI with cooperation from experts from the other domain, aiming to iteratively develop and run initial evaluations of promising systems to the point "where they are shown to be usable by the target end users, are agreed to have clinical validity and are predicted to have therapeutic benefits." Stage 2 then focuses on larger scale evaluations and the roles exchange: the lead is assumed by the curricula experts with HCI researchers in a collaborating role, and receiving feedback on the system's use in real-world practice. This brings a continuum of research approaches, starting with nonrobust research prototypes deployed for exploration of feasibility and preliminary efficacy with small participant numbers, and eventually leading to real-world deployment—cf. Kientz et al. [2013, pp. 105–106] for an analogous discussion of technology for autism support.

In terms of HCI engagement with SEL, we suggest a combination of the Coyle et al. [2007] model of multistage cooperation with curricula designers, complemented with another stream of more independent, smaller, exploratory studies that try to push the boundaries of what might be possible to do with technology in the first place. In other words, we can see benefit in parallel research on two areas: (i) aiming for large scale, real-world impact with technologies/ideas that are already matured in HCI, in close cooperation with curricula designers, and large interdisciplinary projects; and (ii) a more exploratory HCI process, that draws on the existing curricula and the challenges, bringing novel, untested technology, and exploring a broad range of viable approaches that eventually feed into the first stream.

6. BROADER IMPLICATIONS—SEL IN OTHER DOMAINS

This review has focused primarily on SEL in education and argued that the established and evidence-based curricula and constrained learning contexts of SEL in education provide a good focus for HCI to explore SEL technology support. However, social and emotional skills are also key in a number of adult domains such as talk-based therapy, medicine, business, and everyday settings. The core underlying social and emotional skills needed in these domains are similar to those we identified for SEL in education for young learners, and are also often the focus for targeted training and support programs. In particular, such programs share similar approaches in drawing on experiential learning, presence of an expert facilitator who provides a structured program to varying degrees, and targeting analogous core competencies such as emotional regulation, reflection, or communication skills; although these might be taught in specific ways, as relevant to respective domains. Finally, and also similar to SEL in education,

the existing courses again use little-to-no technology to support the training. As such, it is plausible that technologies could support some of the key challenges here as well, and that technologies developed for SEL in education might well be transferable to these other settings.

To inspire and seed future work that would explore these possibilities, we briefly introduce some exemplar noneducation domains. The associated online appendix then provides additional details, outlining the broad impacts achieved through SEL training, commonly used methods, and key topic areas.

Talk-based therapeutic settings. A crucial part of talk-based psychotherapy aims to support the development of social and life skills, often for clients disadvantaged by cognitive or emotional deficits or going through difficult life situations at the time. The literature in this domain focuses on two main aspects. First is the psychotherapy itself, that is, strategies to support learning and improvement on the part of the clients (e.g., Duncan et al. [2010]). The second aspect concerns the training and development of the skills needed by the therapists/counsellors themselves, with the emphasis on supporting the learning process for the trainees leading to sophisticated combinations of class-based learning and practice with real clients (under supervision of an experienced therapist) [Asay and Lambert 1999]. See Coyle et al. [2007] for a succinct review of the most common psychotherapy schools and links to further resources; Hill and Lent [2006] for a review existing literature on teaching counselling and psychotherapy students, showing significant positive effects of particular training methods; and Slovák et al. [2015b] for an example of supporting counselling skills development by technology.

Clinical settings. Social skills, such as communication skills and empathy, are increasingly recognised as core clinical skills in the medical community [Barth and Lannen 2011; Kalet et al. 2004; Makoul and Curry 2007; Rider and Keefer 2006]. Improvements in such skills have been shown to enhance patient satisfaction, increase adherence to therapy, and promote patient willingness to divulge sensitive information that may assist diagnosis as well as reduce the risk of subsequent litigations [Brown 2008; Stewart 1995]. Most curricula focus on one of three areas: (i) university courses for medical students [Satterfield and Hughes 2007; Stepien and Baernstein 2006]; (ii) general courses and support for practising medical personnel [Rao et al. 2007]; and (iii) specialised courses for specific groups of medical personnel, such as in cancer care or end-of-life care, in which specific skills related to empathy and communication are even more important (e.g., when giving bad news to patient) [Barth and Lannen 2011]. Most of the courses are available for doctors, with courses also offered for nurses and other health professionals. Peer-reviewed evidence exists for the effectiveness of many of the interventions in this domain for improving the targeted skills (see the online appendix for more detail).

Workplace- and business-related settings. A focus on emotional and social skills teaching also has a long history in the workplace, for example, Bailey and Butcher [1983a, 1983b], appearing under a wide range of labels such as interpersonal skills, soft-skills, or, more recently, emotional intelligence and developmental workplace coaching. Social and emotional skills training is included as part of professional educational programmes such as for MBA and undergraduate business students; it is also offered as part of ongoing professional development in the workplace, for example, many companies offer soft-skills courses or coaching to their executives and increasingly also to other staff. Academic literature shows positive effects of such training (such as improved leadership, team-building, or self-management skills), but the existing evidence is not as strong as for SEL in education. Some of the reasons are that the training programs have often been developed on a purely commercial basis and outside

of the academic community and detailed information about the content of the programs is often not available for intellectual property and/or competitive advantage reasons [Clarke 2006; Riggio et al. 2003; Walter et al. 2011].

Everyday life skills. Everyday life skills courses comprise a wide range of fragmented topics and methods. As such, we only briefly point to several illustrative examples in which social and emotional intelligence skills are taught in, and for, everyday life settings. These are often framed as various life skills courses for the general population such as interventions supporting interpersonal skills (e.g., improving empathy for couples [Angera and Long 2006; Long et al. 1999]) or interventions based on meditation, yoga, and more recently Mindfulness Based Stress Reduction [Kabat-Zinn 2003], all aiming to support and improve personal well-being (e.g., Grossman et al. [2004] and Marchand [2012]). Moreover, the growth of life coaching (e.g., Green et al. [2006]) and consultation services, most commercially based, as well as the wide usage of self-help books, point to the increased recognition by people of the value of positive self-driven change, and interpersonal and emotional regulation skills. Altogether, these examples draw out the large scope of everyday life skills learning, and the value people place on them.

7. CONCLUSIONS

This article points to the potential of mutual cooperation between HCI and social and emotional skills learning (SEL), beginning with education, and benefiting both disciplines. We outlined the key challenges for current SEL approaches, including the lack of support for transfer and "embedding" of skills from the SEL lessons into students' interaction, encouraging parental involvement, as well as enhancing the support for development of reflective abilities and novel environments for practice. The review of the existing HCI research shows there are strong indications that technology could help address many of these challenges. We drew on the existing HCI work in a wide range of areas such as ubiquitous computing, emotional awareness and reflection, sensor-based tracking, social networks, design, and (serious) games. As such, HCI involvement in this space has the potential for strong, real-world impacts, especially given the wide (and ever increasing) penetration of SEL programs in our schools, workplaces, and everyday life. We also highlighted how the focus on SEL provides new challenges for HCI, as well as a structure to further guide and support HCI research around social and emotional interactions—both as a "test-bed" to develop cutting-edge technology in, but also as a "knowledge base" we can build and learn from as we shape this emerging research area for HCI. Overall, this article suggests that social and emotional learning points to a novel, complex, intriguing research space, which has a high potential to enrich HCI research and practice.

AUTHORS' STATEMENT

This work is not, and has not been, submitted for a review in any other venue. No part of this work was previously published or has any direct relationship to our existing/submitted papers.

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