Teaching and Developing Social and Emotional Skills with Technology

PETR SLOVÁK, Vienna University of Technology
GERALDINE FITZPATRICK, Vienna University of Technology

Abstract

Social and emotional skills refer to a range of interpersonal and life skills that are crucial for virtually all our interactions in everyday life. Teaching and learning such skills has a long history, with a large number of evidence-based programs across many domains such as education, business, medical or therapeutic contexts.

However, very little technology gets used in these programs, despite its potential to enhance and complement the existing approaches. The primary aim of this paper 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. [[add focus mainly on education]]   To this end, we review the literature on social and emotional learning courses within school education, identifying similarities among curricula and shared challenges to successful learning. We then link these to HCI research and the potential for both fields to be mutually enriched. Our key argument is that much existing HCI work can be directly relevant to social and emotional skills learning (SEL) in education (and other domains), but that the topic has been under-researched so far within HCI. We argue how such technology could fundamentally extend and enhance the possibilities available to social skills curricula designers in other domains, and help address some of the key challenges they face [[too much focus on on challenges + need?]]   ; as well as pose novel opportunities, challenges and well-motivated practical problems for HCI.

1. [[TEMP:]]   KEY ARGUMENT

Supporting social interactions is a long term focus for HCI. However, understanding how social and emotional skills are learned, and how this can be supported by technology, is an important but underresearched area so far.

This paper reviews the approaches to teaching and learning of such skills in other domains, with specific focus on the long history and experience around social and emotional learning in education.

The contribution of this paper is unpacking the ...

In doing so, we hope to raise ...

2. INTRODUCTION

Social and emotional skills refer to a range of skills that are crucial for our everyday life and healthy development [Weare and Nind 2011; Adi et al. 2007a; Damon and Eisenberg 2006]. We define the term broadly here to include skills such as those related to emotional intelligence, interpersonal and communication skills, and also skills such as mindfulness, self-control and empathy. The importance of such skills for personal competence and well-being is acknowledged both in research and industry [Durlak et al. 2011; Greenberg 2010; Stepien and Baernstein 2006; Barth and Lannen 2011; Carey et al. 2011; Bono et al. 2009]. Social and emotional skills are particularly valued in diverse domains such as education (from kindergarten to university education), leadership, social work, psychotherapy, and medical/clinical settings.

[[This is particularly important for schools as ... societal blah from Cohen2001 and others? around how many students have obvious SEL problems and how teaching could help with these.]]

There are an increasing number of interventions and courses specifically designed to support social and emotional skill learning (SEL) in these areas, substantiated by a large body of peer-reviewed, scientific literature showing that *such skills are teachable* and *interventions can lead to measurable improvements*. However, very little digital technology gets used in the current curricula. This opens opportunities to explore if and how HCI could support social and emotional learning within this domain.

There is also a growing interest in Human Computer Interaction (HCI) on research relevant to teaching or influencing social and emotional skills[1]. In particular, a large body of work has recently focused on autism (e.g., [Escobedo et al. 2012; Porayska-Pomsta et al. 2011; Zarin and Fallman 2011; Tentori and Hayes 2010; Gotsis et al. 2010; Hong et al. 2012]), and on using technology to enhance or facilitate psychotherapy [Coyle et al. 2011; Matthews and Doherty 2011; de Sá et al. 2010; Hancock et al. 2010]. Prior literature also includes smaller scale systems aiming to influence particular social behaviour such as discussion dominance, or rapport (e.g., [Narumi et al. 2009; Piper et al. 2006; Balaam et al. 2011; Kim et al. 2008b; McAtamney and Parker 2006; Schroyen et al. 2008; Kim et al. 2008a; Toups and Kerne 2007; Kreitmayer et al. 2012; Daily 2010; Munson et al. 2010]). Wider interest in emotional and social skills within HCI is also exemplified for example by CHI workshops on 'Interaction Design and Emotional Wellbeing' (CHI'12), 'Patient-Clinician Communication' (CHI'13) or 'Enabling Empathy in Health care' (CHI'14); as well as a Special Interest Group (SIG) on Work-life Balance.

Given this, it is timely then that the potential of technology to support social and emotional skills training and development is explored in a more thorough way. This paper reviews literature from education to business to medicine, where various forms of social and emotional skills teaching are key, and connects these to existing work in HCI. In doing so, we identify shared aspects and differences across the SEL domains, using these to draw out structure for future work and show potential for mutual enrichment of SEL and HCI research fields. The overall aim is to take the first steps towards a more principled approach to defining a systematic programme of research for HCI in support of SEL.

In particular, we argue that there are core methods and challenges to teaching social and emotional skills which are shared across all domains; and that these raise new opportunities for HCI research to explore if and how state of the art technologies can help address the challenges in SEL, as well as help support SEL more generally. Moreover, we argue that although much of existing HCI work was not, so far, connected to social skills training, it is actually highly relevant and could be beneficial for augmenting existing curricula. We then point to particular opportunities for further research into this topic, outlining the potential of such mutually enriching connections in more detail.

The remainder of this paper is divided into seven sections. The next two sections provide a detailed overview of social and emotional learning (SEL) curricula. We first focus on SEL in schools as an exemplary domain (Section 3), given it has the longest history of both academic research and practical applications, and addresses the widest

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[1]Research on using technology to support learning in more classical academic subjects such as mathematics, programming, physics or languages has a longer history within HCI, including a number of well-established journals, e.g., Computers & Education. As further discussed in Section 2.3, while we reference selected articles, we do not review this literature in detail as it is mostly focused on declarative, content-based learning, rather than procedural skills-based learning, which is key for SEL.

range of life skills. Section **??** then provides a brief overview of SEL methods and topics within other domains (workplace, medical, psychotherapeutic, and everyday life settings), pointing to relevant reviews and additional literature for each. The following three sections link the SEL literature to particular examples of, and opportunities for, HCI research. Section **??** identifies the key challenges across the existing social and emotional skill curricula from an HCI perspective, Section 4 ties these to potential technology support, and Section **??** maps out the design space for HCI. Finally, Section 6 summarises and concludes the paper.

Results overview. Our review shows that although the interpretation and context of specific taught skills differs across the domains, there are substantial similarities in the methods used and the challenges that face curricula designers; and that these could be supported by technology – see Table 1 for an overview. [[We can now make this much more specific – supporting reflection, collaboration, ...?]] We also outline how all interventions will need to build on the emphasis that social and emotional skills interventions place on experiential learning. This then brings the related aspects of the need for substantial *practice* and *cueing reflection??*, the key importance of the *transfer of learned skills* from facilitated sessions into everyday real world settings and the *need to motivate and engage* learners.

We use these learning principles as an initial structure to guide designers and researchers in thinking about ways to support SEL in each of the diverse domains; and show how this fits well with, and could easily benefit from, existing HCI work on ubiquitous computing, social signals processing, behavioural change, and "into the wild" research (see Table **??** on page **??**).

Multi-level paper structure. The text is structured to allow for several ways in which readers can approach the paper. We provide a detailed overview of the SEL literature as well as the examples of potential technology support. This is meant to serve as an initial 'guidepost' for readers interested in learning more about the specific subtopics, and as an argument base for the interpretations we make, but could be deemed as too detailed for others. For this reason, we keep all such detail in the third level subsections (e.g., 2.4.X or all third level subsections in section 4) and the paper can be read also by skipping these entirely. Similarly, readers interested only in the key implications for HCI can jump directly to Sections **??** to **??**, leaving out the review of SEL literature.

	Challenges	Methods	Topics and skills taught
Education (Sections 2.1 to 2.5)			**Four core areas:** • identify and understand emotions • self-control strategies • communication skills • dealing with conflict and problematic situations
Workplace settings (Section 3.1)	**Four learning principles** (in bold) and the associated key **challenges:** • providing timely **feedback** (currently post-hoc, coming from trainer/peers) • creating opportunities for real-world **practice** (currently limited mostly to in-session training) • **embedding learnt skills into everyday life** (very little is possible for curricula designers at the moment) • facilitating learners' **engagement and motivation**	**Key methods,** based on **procedural learning** approaches: • supporting personal experience and opportunities to try out the skills in practice • using model situations, role-plays • slowly building to more complex situations, preferably based on real-world experiences of the learners • feedback from others is key during practice	**Diverse topics around 'emotional intelligence'** • leadership skills • cooperation and communication skills • self-management and planning • other personal skills, e.g., via coaching
Medical settings (Section 3.2)			**Self-oriented skills:** • stress, coping and life-style management **Interpersonal skills:** • patient-clinician communication • e.g., motivational interviewing • empathic skills
Therapeutic settings (Section 3.3)	Shared across domains	Shared across domains	**Therapy process (supporting the patient):** • wide range of social and emotional skills depends on the patient's issues **Training and skills development of therapists:** • developing detailed self-awareness • active listening and empathy skills • techniques and approaches of the therapeutic approach
Everyday settings (Section 3.4)			**Diverse topics:** • non-clinical interventions, e.g., interpersonal skills courses, mindfulness-based stress reduction • life-coaching and other commercial consultation • self-driven change

Table 1: Overview of the key distinctions and similarities

3. LIFE SKILLS COURSES' CONTENTS WITHIN EDUCATION

This and the next section outline the contents of existing social and emotional skills courses and curricula in domains outside of HCI. We analyse (i) what are the core skills that get taught; (ii) how existing curricula approach this; and (iii) what challenges they face. The goal here is to build an overview of what gets taught and how across the domains, and then use this structure to outline the potential for HCI research (sections **??** and 4). We first outline the reasons why we chose SEL for schools as an exemplary domain (section 3.1), and describe the literature review methodology (section 3.2). We then present the *methods* used in teaching of social skills in education (section 3.3) as well as the key *topics* that get taught (section 3.4), including specific examples from various curricula.

3.1. SEL in schools as an exemplary domain

Social and emotional learning in education is a particularly interesting domain for several reasons, all suggesting that the field can be considered relatively mature, with a number of well-researched and evidence-based approaches.

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]. They also focus on a large span of ages, from kindergarten to high-school education. As such, it to some extent encompasses the core set of skills needed in other life skills domains that tend to emphasise particular subsets of social skills, and consider many others to have already been developed during childhood and thus available.

Second, SEL has more than 20 years' history of peer-reviewed programs, which have already been deployed to hundreds of thousands of pupils. For example, Durlak et al. [2011] reviews 213 programs intervention studies encompassing more than 270000 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 randomized controlled trial conducted in 1962. Moreover, federal programs support further uptake of such curricula in the US.

Third, recent academic reviews analyse the evidence-base for the effectiveness of SEL programs and find measurable and significant positive effects of SEL in randomised trials, e.g., [Durlak et al. 2011; Greenberg 2010; Weare and Nind 2011]. In particular, the social and emotional skills curricula lead to improvements in the academic performance and the skills actually taught (e.g., Durlak et al. [2011] report average of 11% improvement in achievement tests, 25% in social and emotional skills in the 207 SEL interventions reviewed), as well as positive impacts on many other aspects of behaviour such as mental health [Adi et al. 2007a], violence prevention [Mytton et al. 2006; Adi et al. 2007b], conflict resolution [Garrard and Lipsey 2007], and bullying [Vreeman and Carroll 2007]. For more detail see e.g., Weare and Nind [2011] who provide a meta-review of 52 reviews in this domain, concluding that the interventions "had wide-ranging beneficial effects on individual children and young people, on classrooms, families and communities and on an array of mental health, social, emotional and educational outcomes".

[[Fourth, although the existing results are promising, there is still space for improvement, and strong push to do so from the SEL community – which is also why we argue HCI might be useful in this domain.]]

3.2. 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., [Durlak et al. 2011; Weare and Nind 2011; Adi et al. 2007a; Greenberg 2010; Elbertson et al. 2009; Payton et al. 2008]). We build on these and approach the topic with a complementary HCI perspective in mind, aiming to draw out processes, methods and topics commonly used within curricula, and identify the challenges the SEL curricula currently face.

As such, we analysed the contents of selected curricula, in addition to following references cited by the academic reviews above. 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 'Collaboratory for Academic, Social and Emotional Learning' (CASEL)[2], which is a non-profit organisation supporting research and application of social and emotional learning in education, co-founded by the leading figures in the academic field.

In particular, we drew on curricula identified in two CASEL 'guides': 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], focusses 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[3]), 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 schools [Bar-On et al. 2007; Elias 1997; **?**; **?**]

3.3. Methods for teaching SEL in education – experiential learning

Curricula share the understanding of social and emotional skills as highly complex abilities, based 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 ability 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, 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 [Wyman et al. 2010; LeDoux 1998], again emphasising the need for learning skills that operate on a procedural basis.

Curricula thus use predominantly active instructional techniques drawing on skill-based and experiential approaches. They employ a wide range of methods such as modeling, role-play, performance feedback, dialoguing, positive reinforcement, vignettes, play and games; but also approaches such as portfolios, expressive arts, exhibitions, or group projects – see also Fig 1 for an extended list. Through these methods, cur-

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[2]http://casel.org/

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

What instructional methods are used? (circle)

audiotapes	outside activities	workbooks
brainstorming	posters	worksheets
community service	rehearsal and practice	other:
cooperative learning	role play	_____
direct instruction	scripts	_____
guest speakers	simulations	_____
modeling	videotapes	_____

Fig. 1: Instructional methods used in SEL courses (modified from [Elias 1997, p.109])

ricula aim to include extensive examples and opportunities for personal experience and practice, combined with extensive feedback and opportunities for reflection on behaviour and progress. For example, when teaching a complex skill [[such as emotional awareness, curricula would break the skill down into 'digestable' bits, focusing first on simple model situations and exploring these by role play (e.g., specific situations such as disagreement with a peer), and only then slowly building up to more complex situations]] . Repeated practice and extensive feedback from the trainer and peers are critical components in every step of the process.

Curricula are clear that the methods used must be developmentally appropriate for the age of the children, and the skills learned. For example, incorporation of fantasy play or puppets as role models and curricula protagonists has been very successful 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 or workshop activities are more commonly used with older children and teenagers [DeJong 1994]. However, specific key methods such as role-playing, modeling, positive reinforment, or direct and indirect instruction are used throughout in various guises.

The core of most curricula is a set of SEL focussed, structured classroom lessons. However, 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 maintanance and generalisation. Curricula highlight the need to support opportunities for the learners to practice their new skills in real life situations outside of the classroom, but have limited strategies to do so (cf. Section 4.1). Among the commonly used methods are activities to increase awareness and remind learners about their skills on the school grounds (e.g., posters around the school); attempts to enlist the help of their social networks outside of the learning environment (e.g., workshops with or letter campains parents asking them to help reinforce the learning at home); as well as various home exercises for students.

[[This is probably not good enough at the minute – would need one paragraph about the parent/community involvement in more detail, if saying that this is an increasing focus or similar blah. Additionally, this combined the embedding into school life, and embedding into everyday, which is probably not what we want?]]

3.3.1. Common theoretical models. There is no universally agreed on theoretical model among the existing SEL curricula [Payton and Wardlaw 2000] that would ground the learning process. Instead, curricula build on several 'competing' theories that each have robust evidence of positive effects[4]. Some of the most prevalent theoretical approaches are: (i) systems theory, which views SEL learning as embedded in broader

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[4]This is similar to psychotherapy domain, where a number of schools co-exist in parallel, each building on different theoretical groundings [[– however, for SEL it is yet not clear what/if the common factors could be.]]

SEL Competency	SEL Skills Related to Each Competency
Self-awareness	▪ Label and recognize own and others' emotions. ▪ Identify what triggers own emotions. ▪ Analyze emotions and how they affect others. ▪ Accurately recognize 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 behavior. ▪ 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 (recognize individual and group similarities and differences). ▪ Identify and use resources of family, school, and community.

Relationship management	▪ Demonstrate capacity to make friends. ▪ Exhibit cooperative learning and working toward group goals. ▪ Evaluate own skills to communicate with others. ▪ Manage and express emotions 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. ▪ Demonstrate 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`)

community and aims to systematically create a comprehensive climate for teaching SEL in the class but also school and local communities more broadly; (ii) psychoanalytic theory that work 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 base for primary prevention and the core skill based techniques such as modeling or role-play [Bar-On et al. 2007, p.65]).

However, there is a considerable overlap among these models in the compentencies to be learned (as described in the next section), as well as 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 (although the selected theory differs across curricula), use a comprehensive approach intergrating affective, cognitive and behavioural dimensions, and promote generalisation of skills (e.g., [Elias 1997, p.119]). [[In contrast, existing literature suggests that piecemeal programming efforts, such as XXXX, are less likely to be effective – get good references (e.g., [**?**, p.13].]]

[[Outline the theoretical background of PATHS, Incredible Years and RULER. What does this mean for technology?]]

3.4. Goals of SEL learning

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

— **Self awareness:** The ability to accurately recognize ones emotions and thoughts and their influence on behavior. This includes accurately assessing ones strengths and limitations and possessing a well-grounded sense of confidence and optimism.

—**Self-management:** The ability to regulate ones emotions, thoughts, and behaviors effectively in different situations. This includes managing stress, controlling impulses, motivating oneself, and setting and working toward achieving personal and academic goals.

—**Social awareness:** The ability to take the perspective of and empathize with others from diverse backgrounds and cultures, to understand social and ethical norms for behavior, and to recognize 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 behavior 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 of complex, interrelated abilities and it is not possible to teach any of these directly – see Figure 2 for examples of skills related to individual competencies. Instead, each curricula helps learners move towards these skills sets by progressively learning smaller, 'molecular' skills, which is what we turn to now.

3.5. How are the competencies taught

To exemplify how the skills comprising the competencies are taught, and in which order, we draw out a four sets of such molecular skills that consistently appear in most of the curricula, and across all age ranges.

(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 topic thus subsumes a number of simple situations or skills (e.g., being able to identify when becoming angry) and ways to train these (e.g., training learners to notice physical changes in their bodies). 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) etc. As such, they are taught in the order as shown at Figure 3.

We describe each topic in more detail in a respective subsection below, illustrating the descriptions with examples of specific activities from selected curricula. Our goal is twofold: to provide an initial 'feel' for how such skills are taught in this domain; 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. Figure 4 then maps how the four topics contribute to the core compentencies.

3.5.1. 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[5] aim to train a practice

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[5]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
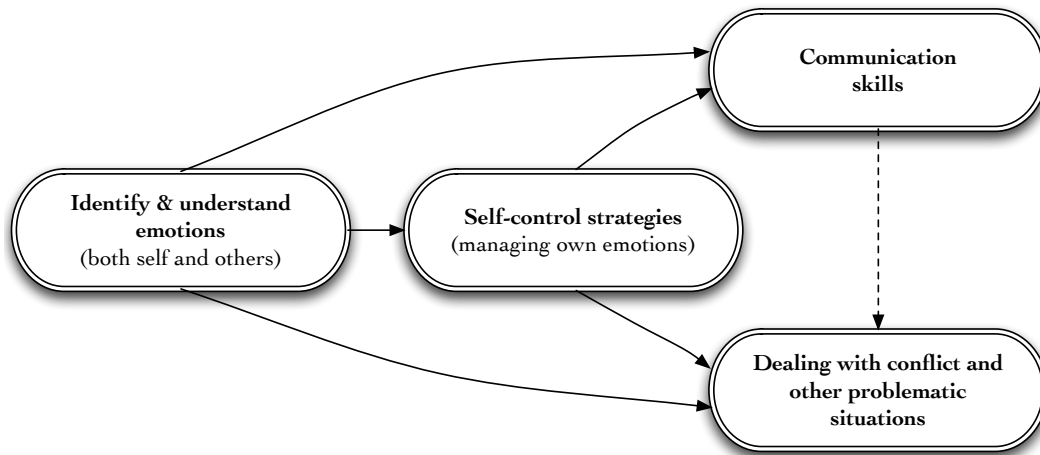
Fig. 3: Summary of the identified key topics in SEL in education and their dependencies.
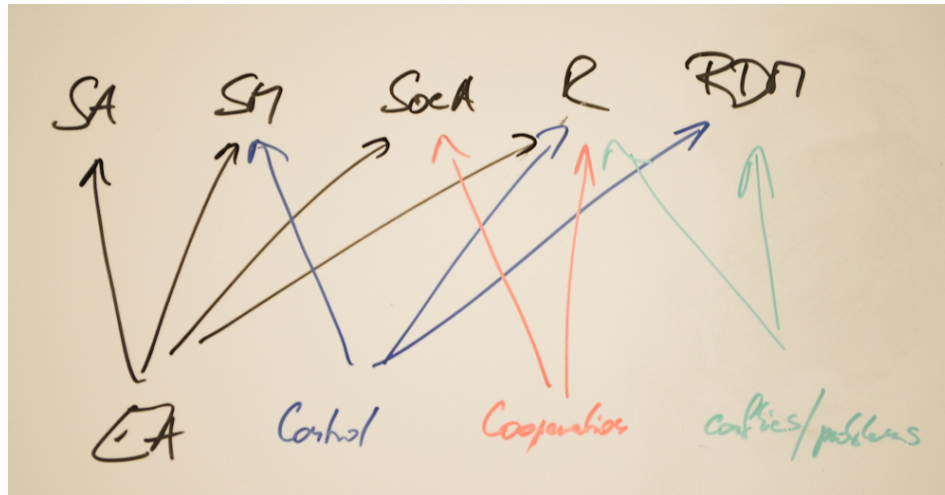

Fig. 4: Mapping of topics to core competencies

of internal reflection, leading to continuous exploration of how we and others feel. Emphasis is also placed on making the distinction between acknowledging a feeling, and acting upon that feeling/urge.

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 [Kam et al. 2004; Domitrovich et al. 2007]. Similarly,

RULER curriculum uses popular stories to exemplify particular emotions, or 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 recognize 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 recognize 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 etc. This is often incorporated as a game, e.g., 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.

3.5.2. Self-control strategies. Self control and management of own emotions is a key aspect present in many curricula[6] and the techniques used to developed 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 physiological 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 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., 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, where specific muscle groups are tensed and released. Once this technique is mastered, children discuss and appropriate alternative strategies of dealing with stressful situations, now that they are able to consciously reflect and react to them.

3.5.3. Communication skills. Another set of activities focuses on building good communication skills and supporting positive interactions with others[7]. The skills taught here aim 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, e.g., through listening to someone

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[6]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**

[7]While implicit in many others, this aspect is explicitly highlighted within the following curricula: Michigan Model for Comprehensive Scholl 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.**

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] where 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!").

3.5.4. Dealing with conflicts and problematic situations. Problem solving strategies and conflict management are the final topics of most curricula[8]. Violence prevention is commonly an important additional goal, as many of these curricula are designed for schools and neighbourhoods 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", where the sequence of red-yellow-green indicates a "stop-think-proceed" process [Kam et al. 2004; Domitrovich et al. 2007]. 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 are workshops focusing on win-win negotiation (e.g., in RCCP) and providing suggested sequences for steps to take during disagreements (e.g., in Incredible Years).

3.5.5. Differences across grades. [[Do we want to highlight anything here?]]

— Make it a very short section (?) + refer to the table in Elias of whereever
— higlight the increasing integration of cognitive, emotional and behavioural aspects
   – give an example of pre-school-K2 being able to label and ... basic emotional such as fear or joy; while high-school students would be, for example, taught to draw on their more nuanced self-awareness to motivate goal-setting and critically assess their behaviour.

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[8]Michigan Model for Comprehensive Scholl 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**

4. SEL NEEDS AND OPPPORTUNITIES FOR TECHNOLOGY SUPPORT

Despite the curricula effectivity to promote learning of social and emotional skills (cf. Section 3.1), the review of SEL literature also highlights areas for improvement. In the rest of this section, we outline three such exemplary areas and point to existing HCI work that suggests how incorporating digital technology may address crucial needs within SEL learning.

4.1. Embedding of learnt skills into other settings

We start with what the SEL literature highlights as one of the key issues with existing SEL curricula – i.e., 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. While such transfer of learned skills is the ultimate goal of all curricula [ref,ref,ref], the current approaches are limited in scope and effectiveness and teachers (or curricula designers) struggle to directly influence embedding of skills outside of the SEL learning sessions. For example, in their Social Policy Report Jones and Bouffard [2012] summarise:

> *"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."*

Similarly, Bar-On et al. [2007, p.70-71] highlights how:

> *"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 effors in at least two ways: first, by extending the learning support and scaffolding for learners beyond the SEL lessons, e.g., utilising mobile and sensor based technology; and second through supporting a wider community around learning of social skills, including involvement of parents, teachers, and peers. We outline each in more detail below.

4.1.1. Supporting learners – Transitioning the skills out of class into everyday situations.
When SEL skills are to be transferred beyond the SEL related activities, 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 re-inforce and apply their skills into these settings. We particularly highlight the difficulties with identifying moments when SEL skills could applicable, the lack of scaffolding and support to do so, and need for 'space' to reflect and learn from the experience afterwards.

Identification of teachable moments. When interacting during recess, non-SEL oriented classes, or outside of school completely, the learners encounter many occassions 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 [**?**, p. 56]. In such situations, it is thus not only difficult for the learner to apply the skills they have learned, but it is also difficult to identify these as 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 moments in which students could use their (new) SEL skills, and giving praise if they do, especially so for younger learners.

It is for this reason that it is suggested to curricula designers (e.g., by [**?**, p. 56]) that all school personnel should *"play an important role in actively encouraging and reinforcing the use of skills and attitudes they see displayed"*. This however requires the (possibly untrained) teachers to constantly re-inforce and actively encourage use of SEL skills; with little opportunities for supporting the learners when the teaching staff is not around (and thus also making the students fully dependable on external guidance).

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 of self-control is one of the key aspects of SEL, and relies strongly on identifying possible situation before it is 'too late' and emotions are already running high. One opportunity for technology involvement in this setting can draw on the maturing HCI research on in-the-wild stress detection from physiological data or speech prosody [**?**; **?**; **?**; **?**; **?**]. We envision that such data can 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 or triggers that remind users to attend to intended activities has been useful to help users modify their existing behaviours [Consolvo et al. 2009; Obermair et al. 2008]. An example of initial work in this direction is Pina et al. [2014], who designed a system for parents of ADHD children, delivering in-the-moment cues and strategies to manage stress during everyday activities.

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 or structuring of activity, e.g., through mobile devices, to support the scaffolding of activities, and focussing attention on skills at hand. An example of such direct scaffolding are the problem solving strategies such as the 'stop-think-proceed' semaphore in PATHS or a sequence of steps to resolve disagreements in RCCP, where each person is invited to share their perspective on the situation in turn. Within HCI, several projects have touched on similar aspects around autism therapy. For example, 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

neuro-typical peers, to 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. While the social aspects supported in these systems are relatively basic when compared to the full range of skills taught as part of SEL, it opens questions whether similar approaches might be possible for more complex behaviours. An initial work has for example explored the use of similar technology to deliver personalised strategies for stress coping in everyday life for general population [Paredes et al. 2014]; and Mamykina et al. [2008] designed MAHI, a similar mobile 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 own emotional experience 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 been already explored related techniques in various contexts in existing HCI work. In one such example, Matthews and Doherty [2011] developed an 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 another initial work, Munson et al. [2010] integrated the Three Good Things, a well-known positive psychology intervention into a social networking site, meshing with users' daily habits around these sites and also scaffolding social and emotional awareness through technology. Although these projects did not specifically focus on the specifics of the 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), application based on similar approach could likely to be transferable to the SEL settings.

Support opportunities to stop-and-learn from experience. Post-hoc reflection on own behaviour is a crucial part of the experiential learning, helps learners make sense of their experiences. As such SEL class-based activities include explicit time to reflect on own experiences, e.g., in the form of a debriefing or discussion after a role play. However, such post-hoc reflection might be difficult for situations outside the SEL training scenarios, where the situation is intertwined with other, continuing activities that may prevent reflection right away (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 own reactions well [ref?].

While only limited work exists in HCI around supporting such processes for social and emotional learning specifically, work around supporting reminiscense and reflection support suggests ways in which technology could support learners in collecting traces of aspects of their experiences to ground later reflection. In one such example, Fleck and Fitzpatrick [2009] explored the use of SenseCam to support reflection of budding teachers around their teaching style and abilities. The authors report how the resulting images, automatically captured during the lesson, grounded the reflection process by supporting teachers to return to their experiences, and promoted a rich understanding of own and others activities. Similarly, [[SenseCam work by [Marcu et al. 2012] around autism – supporting interactions of parents and autistic children]] .

Moreover, other existing work exploring systems triggering reflection on emotional aspects of everyday life might also suggest approaches to support SEL relevant learning. For example, AffectiveDiary combined biometric data, movement and mobile phone use to present the users with intriguing ambiguous visualisations, facilitating sense making and reflection on their everyday activities [Stahl et al. 2008]. Other work looked at using collected data to promote reflection around stress [Sanches et al. 2010] or work activities (e.g., [McDuff et al. 2012]). As SEL sessions in current curricula already include discussions around SEL-related issues that students experienced in the meantime, such collected data could be incorporated to ground the discussion and learning.

4.1.2. Social support – community building.

Literature around SEL curricula highlights the importance of supportive atmosfere in the school but also at home, crucial to sucessful learning (cf. the initial quote by [Bar-On et al. 2007]). Support from the parents as well as learners' peers is thus needed, but difficult to promote in the existing curricula. Although limited work in HCI addresses supporting such links between school and home so far, we argue below that the extensive knowledge around social networks [ref] and technology support for communities [ref,ref] gained in other settings, makes it plausible HCI will be able to contribute here as well.

Peer support. Interaction with, and perceived support from, peers are crucial for school-age learners, especially when approaching teenage years. As such, systems utilising learners' broader social network could help motivate and engage participants to keep up with the SEL goals. While existing HCI research has looked at leveraging such social influence in other contexts, such as sustainability [Gustafsson et al. 2009; **?**] or physical activity [Lin et al. 2006; Gasser et al. 2006], similar approaches might be successful also in the contexts of SEL learning. Social support can be facilitated also peers outside of the immediate social network, as is the case with online social networks and support groups. These has been extensively studied and used (see e.g., [Barak et al. 2008; Newman et al. 2011]), especially in the context of patients with chronic diseases (e.g., cancer [Skeels et al. 2010]), and other stressful periods in life (e.g., smoking cessation [Ploderer et al. 2013]). The findings point to the potential of online support groups to provide emotional and information support. Whereas social support groups have been mainly used for distress situations, where users come to discuss their issues and receive information or experiences from others, it would be interesting to explore if a similar model of social support and encouragement is viable for (parts of) social and emotional skills learning.

Parental involvement. Parental involvement constitutes a major aspect, and many curricula organise specific workshops and training activities for the parents. However, as these take place at a specific time/location, requiring specific travel, scheduling and other overheads for the parents, it is often difficult for parents to get involved due to time limitations [Bender et al. 2011], or lack of perceived value [**?**].

Designing systems to allow parents to engage and support the SEL learning of their children, e.g., through games or similar, are thus likely to be beneficial. Although the work on such parental support around social and emotional learning is limited in HCI so far (as opposed to e.g., systems supporting parents' and childrens' play activities, e.g., [**?**]), Luckin [2008] developed the Homework system that serves as a link between the school lessons, teachers and parents, facilitating the involvement of the parents in home learning activities of their children. In the scope of autism related systems, Hong et al. [2012] presents another such 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 highlight how digital technology can be designed to promote sharing of the expert role of the SEL teacher with parents or the extended family.

4.2. Promoting reflective skills

The ability to reflect on own and others' emotions, thoughts and behaviour is the foundation for experiential learning [**?**], and as such underplays all skills taught in SEL [Cohen 2001; 2006; Pasi 2001; **?**; **?**; **?**]. Moreover becoming reflective is a skill that is widely generalisable across settings and situations; and is one of the protective factors against later maladjustments [**?**]. Reflection for example plays a key role in identifying and understanding emotion, with curricula utilising various tools and exercises to support the learners in doing so (e.g., the Feeling Faces cards, verbal labelling). Similarly, reflective processes are crucial precondition for self-control (e.g., becoming aware one is getting angry), or relationship skills such as perspective taking. While existing SEL learning processes are successful to the extent that students develop their reflective abilities to some extent, prior work on supporting reflection in HCI suggests that digital technology has the potential to markedly extend and augment such training – for example by providing the learners with novel cues around, and feedback on, their behaviour that can promote, elicit, and scaffold reflection (e.g., [**?**; **?**; **?**; **?**; **?**; **?**]. In what follows, we outline three topics where initial HCI work looked at issues directly relevant for SEL learning: emotional awareness; mindfulness and calming technology; and communication skills.

Emotional awareness. Developing emotional awareness is the founding part of every SEL curricula, with specific focus on helping students identify and label the emotions they are experiencing. A number HCI research projects demonstrated how digital technology can open novel pathways for people to explore and deepen their understanding of own emotional experience. As one option, existing systems, such as AffectAura [McDuff et al. 2012], draw on sensor data to track and visualise emotional changes over time (as modelled from the sensor data), possibly helping users draw out patterns that they may not notice otherwise. Alternatively, researchers have argued arguing for the value of designing to present cues ambiguously to nudge people into interpreting and reflecting on their experiences (e.g., [Boehner et al. 2005; Gaver et al. 2003]). For example, AffectiveDiary [Stahl et al. 2008; Sengers et al. 2007; Höök et al. 2008], inspired users' reflection by presenting cues based on combination of sensor data, and other projects use movement to explore emotional experiences [Mentis et al. 2014]. As a more detailed example, highlighting the possible combination of techology and existing SEL practices, Subtle Stone [Balaam et al. 2010] presents students with options to indicate their current emotion through an ambient, ambiguous visualisation. The approach closely resembles the Feeling Faces used in the PATHS curriculum and elsewhere in providing students with tangible objects to scaffold emotion identification. However, the use of technology provides additional benefits, such as real-time streaming (and aggregation) of emotions selected by each students to the teachers' desk; as well as the opportunity for the students to convey their emotions to teachers privately (e.g., by keeping SubtleStone, in the box, out-of-sight of their peers). Moreover, SubtleStone could likely support more than "just" a moment-to-moment reflection tool, e.g., by enhancing the Feeling Faces interaction with tracking of changes over time, and thus supporting students on post-hoc reflection on their emotional states over longer periods.

Mindfulness and calming technology. 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., SecondStep [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] supports greater awareness of one's own breathing and helping the user to maintain a calm and relaxed state. [[Add 1 sentence re [Vidyarthi and Riecke 2014] and [Thieme et al. 2013], both as examples of supporting meditation states through technology.]]
[[anything from Autism??]]

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 available for students' reflection on such activites. In particular, a number of papers show how relevant aspects of interaction might be trackable in real-time, and how providing feedback on these can positively affect an interaction. For example, DiMicco et al. [2007] and Kim et al. [2008b] explore how increased awareness of speaking behaviour within 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] shows how feedback based on non-verbal behaviour can affect and increase feelings 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 [Sun et al. 2011; Hagad and Legaspi 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. Jointly, 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; but also serve as a scaffolding to promote deeper discussion with the group, cf. Section 5.2 below.

4.3. Mixed spaces for practice

As **?**, 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 on p. 7) and 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 of technology systems to create 'mixed spaces' 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 larger autonomy for the learners, and allowing students to practise social and emotional skills in a wide range of novel model situations. We outline several such topics with existing HCI work below.

Self-control. As one example, existing work suggests how combination of physiological sensors and a computer game could support practice and learning of self-control and calming down skills. As an example, Bouchard et al. [2012] reports a short biofeedback training with a first-person shooter game (limiting visibility based on changes in arousal as measured by skin conductance). They provide evidence how such biofeedback loop together with calming exercises helped soldiers not only better manage their stress during during the game, but also how these coping skills then transferred into real-world situations (army exercise), where 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 of children with a Fetal Alcohol Spectrum Disorder. While the system has not been fully evaluated yet, the team reported a sustained engagement from the learners over a course of 12 week deployment. More generally, work 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, allowing the learners to fail without serious consequences.

Promoting perspective taking. Initial work on 'serious' games suggests that these can support perspective taking abilities, important part of relationship skills taught by the curricula, do so in an engaging way. For example, Hailpern et al. [2011] designed a game that helps relatives and friends of patients with aphasia to increase awareness and understanding of the aphasia disorder, and how it must feel for the patients themselves; and Rusch [2012] aimed to facilitate a similar understanding of depression. In another example, 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.

Communication skills and collaboration. 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 in [Core et al. 2006], 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., non-verbal behaviour such as smiles or speech prosodics) to support further reflection and learning. Ulgado et al. [2013] presents a similar system aimed at supporting practice of learners on the Autism Spectrum. Each of these provides novel support for practice on specific skills that SEL curricula teach, benefiting the students in offering additional external feedback and support, that can be accessed without the need for direct involvement of teachers, parents or peers. 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]). While most of the work looking at supporting the learning of such skills look 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 neuro-typical children (e.g., [**?**; Antle et al. 2013; Cao et al. 2010; **?**]) and the more complex cooperative behaviours that the SEL curricula aim for there.

5. OPPORTUNITIES FOR HCI

Previous section highlighted areas where digital technology could be particularly helpful in supporting social and emotional learning in education. We also provided examples of existing HCI work suggesting that successful support of SEL could be possible. We now move on to outline some of the opportunities and challenges the context of social and emotional learning opens for HCI research.

5.1. SEL training as a test bed for systems looking at social and emotional interaction

We start by suggesting that the SEL in education could presents a unique test-bed and guidance for HCI research around technologies to support social and emotional skills learning more generally; but also around other SEL curricula include a continuum of activities with various levels of scaffolding present: starting from tightly scaffolded interactions in class with the teacher present, to completely unstructured, in-the-wild settings at the playground or out of school. Moreover, curricula also bring a wide range of well-defined skills to be learned and supported (e.g., from identifying basic emotions to complex leadership skills), as well as evaluation methods for judging skills progression. We argue that that this curricular structure can guide and enhance HCI research looking at aspects of social and emotional interaction. As one example, we outline below how designing to support SEL in education could motivate and advance the development and testing of real-world systems based on Affective Computing (AC) and Social Signals Processing (SSP) research. Despite the recent advances, AC and SSP systems are still mostly developed and tested in the laboratory settings [**?**; **?**; **?**]. Moreover, there is an increasing critique from both outside and within the AC and SSP fields that calls for the need of defining plausible real-world applications (e.g., [Pantic et al. 2011; Vinciarelli et al. 2009]), the corresponding broadening of emotional and social states to focus on [Calvo and D'Mello 2010; Vinciarelli and Pantic 2012], and also a clearer empirical support for how these can be deployed as part of actual and deployed systems [Boehner et al. 2005].

We argue that SEL in education provides not only a wide range of real-world problems where successful AC/SSP applications would be beneficial, but also offers a unique context for development and testing of initial prototypes. For example, as in-class settings marry the benefit of direct application into, and testing within, real-world scenarios, with the possibility to do so in a well constrained and manageable environment and with a facilitator who can be an expert in both the content taught as well as the (technology) tools they use. Moreover, curricula are well structured, with carefully designed exercises and progression of skills development, which can provide grounding for the design work and ease initial development of technology. In particular, this leads to a limited, quite controllable setting for technology deployment, e.g., a specific location in the classroom which is used for role-play exercises, or as part of a specific other practice setting such as a digital game (cf. Section 4.3). It also points to particular user roles that can be designed for, such as supporting the trainer's expert role (augmenting and enhancing rather than replacing their skills), facilitating peer feedback or group reflection on examples, and directly supporting the individual learners. Such 'controlled' training spaces also bring the potential for collection of data corpuses needed AC and SSP approaches need for training of algorithms, based on of real-world learning processes, as opposed to the current practice of instrumentally designed laboratory tasks or interactions in between actors.

However, the emphasis curricula place on embedding of skills out of classroom learning is likely to motivate further development of the technology to eventually, phased out into less controlled settings. These might be systems supporting SEL skills in (i) in-class learning in other subjects, i.e., still a fixed, controlled space to deploy the technol-

ogy in and a teacher leading the scaffolding to some extent, but already on behaviour that is not tied to specific exercises; (ii) students' interactions during breaks and other times when they are still on school property but not in any specific lesson, e.g., taking advantage of the fact that the interactions are still localised on the school grounds, allowing additional technology to be deployed at strategically localised places (such as a main hall, playground etc.) that all users are students who can be given the specific technology as part of their learning process (e.g., giving each student a [[Sociometer-like]] badge and asking them to); and finally (iii) in students' interactions outside of school (where little assumptions about other interactants or locations can be expected).

More generally, it is likely that focus on SEL skills support will inspire and guide HCI community in which aspects of social and emotional interaction might be best explored further. In particular, supporting social and emotional skills courses can thus raise many well-motivated research questions around which aspects can be sensed and interpreted at all. This highlights also a question of the level of interpretation the AC/SSP systems can reasonably provide for which social aspects. One way of viewing this is the continuum from leaving the sense-making activity entirely to the user and/or the facilitator, possibly cued with non-processed sensor data (e.g., as per Sense-Cam systems [Fleck and Fitzpatrick 2009]), to providing full interpretation by the system (e.g., as in arousal detection for people with autism [Picard 2009]). Even if particular concepts cannot be reliably and fully interpreted by technology, it might still be possible, and in many cases actually preferable (e.g., [Boehner et al. 2005; Mentis et al. 2014], to support the users by providing a 'reasonably' pre-processed data they can view, interpret and explore on.

Finally, employing a particular technology as part of a *learning process* is likely to bring a different approaches users might take regarding the use and exploration of the interaction with the system. For example, one would expect students consciously learning their negotiation skills to attend to the system differently (e.g., more likely to reflect on experience afterwards) than if the same system aimed to support a real negotiation processes at a work-place.

5.2. Supporting (social) reflection

— Reflection plays a key role in learning all social and emotional skills – and the ability to be reflective is an important social and emotional skill by itself [Cohen 2001; **?**; **?**]. Reflective processes processes can be directed at feelings and thoughts of an individual, as is the case for aspects such as self-awareness or mindfulness.

— However, an important part of learning (particularly social) skills is the ability to explore and reflect on the thoughts and feelings of others; as exemplified by the weight curricula assign to attentive listening exercises, or various approaches to prevent or work through misunderstandings. In particular, students need to learn to understand how their own actions might have affected the partners thoughts and feelings, despite the fact that these might not be directly observable and may need to be collaboratively established.

— While HCI has already focussed on such individual reflection (cf. Section 4.2), mainly aiming to cue or facilitate reflection on individuals' behaviour and mental states (e.g., [Sas and Dix 2011; Stahl et al. 2008; Thieme et al. 2011; Isaacs et al. 2013]), the understanding of reflective processes as a collaborative social activity is relatively rare in HCI [Fleck 2012; Prilla and Knipfer 2012], and is arguably an area ripe for more detailed study [Baumer et al. 2014]. [[Extend some of the arguments from Baumer2014? + add things from Mentis2014]]

— [[What would this mean for design/support – suggest some of the design considerations from CSCW, just geared towards education? – Use [Mentis et al. 2014] to

support the idea of helping users co-construct their experience to support mutual understanding]]
— Focus on supporting SEL in education thus presents HCI researchers with an interesting reflection case that is complementary to existing reflection research in CSCW and HCI.
— [[Moreover, initial research sugggests social reflection is not relevant only for SEL, but also for other aspects (e.g., coordination work in hospitals [**?**], or decision making [**?**])]]   Further exploration of the interpersonal reflection processes crucial for students' social and emotional learning can thus contribute to exploring options for technology support for social reflection in other social situations, as a relevant part of learning and sense-making.

— Moreover, existing work around reflection in HCI focuses on providing technology-based cues to support reflection on specific aspects of life, but are not necessarily designed towards helping the users to develop their reflective abilities more generally – [[e.g., when the tool would be taken away would people be still able to reflect; have they learned a transferable skill]]   .
— As SEL approaches reflection as a learnable skill and have strategies for doing so, cooperation with SEL curricula would open opportunities and inspiration to design for learning of reflection as a skill – generating knowledge possibly transferable to other contexts where reflection is important.

5.3. Design considerations around SEL – support

Factors:

— Designing for experiential learning
  — Can we make an argument that while a lot is known about what the learners (and probably teachers/paretns) need while supporting learning of usual topics such as math/sciences, very little is known about the needs of these groups within SEL. ==¿ especially as the existing literature in SEL does not discuss these deeply...
  — Need for participatory approaches to understand the needs of students/parents/teachers. Area ripe for inclusion of technology and cultural probes (and similar approaches) to explore the settings and possible use of technology?
  — Draw on Lewin2010 and Luckin to argue the potential is there but a need to carefully scaffold for parents' interaction and involvement
  — as experiential learning – design to empower explorating, safety to be self-critical and learn from own mistakes; but still aiming to develop self-esteem and confidence.
  — Points to the importance of personal, private devices that balance providing cues for the learner with giving away information about their emotional state etc.

— Taking advantage of learning process:
  — The training experiences have a particular quality of being "real" and "not-so-real" at the same time: often asking participants to practise and try new skills out in a "safe place" (e.g., through role play), where potential failures in interaction are actually a valuable basis for reflection and learning, and the expert trainer can immediately assist if problems appear. In this sense, such in-session training is a 'real' situation in terms of the learning setting, but fictional and 'unreal' for the participants, and also a situation that is specifically open to, and designed for, external feedback and reflection.

— [[FIX –]]   **Designing to "teach and disappear"**

— Most social and emotional skills courses, irrespective of domain, run only for a limited time. This can often be as short as a few hours or a weekend; or span longer time periods, but possibly limited to several hours every week (e.g., as in K9 school curricula). In both cases, the aim is to facilitate development of new skills over the duration of the course, and it is crucial that the skills become embedded enough to persist even after the course is finished. Although it might be relevant for some cases to develop technology that allows to extend or supplement the course duration, the ultimate goal of technology is likely to scaffold and help learn skills that will stay available *after* the technology is taken away. This provides interesting and novel challenges to designing systems, especially with the potential to enriching approaches used in behavioural change and related fields. Additionally, such a focus calls for designs that can adapt and follow the learning curve of students, always supporting the next 'zone of proximal development' [Vygotsky 1987].

— [[combine with **Need for cooperation and knowledge sharing with curricula designers** The learning principles identified earlier—together with curricula descriptions available in literature—are likely to help initial explorations of the design space. However, developing systems either in collaboration with curricula designers, or directly for specific existing curricula will be crucial for real-world usefulness and deployment of the developed systems. Coyle et al. [2007] have discussed this issue with respect to designing for the mental-health domain; Porayska-Pomsta et al. [2011] address the challenges of similar interdisciplinarity in designing for autism. We will argue in the next section how their approach can be extended to the whole setting of social and emotional skills, and return to the methodological challenges brought about by such interdisciplinary cooperation.]]

— age approapriate skills to be supported (and interactions)

— use the table from Elias to give examples with a reference – e.g., basic behaviours to make friends (SecondStep Kindergarden) vs. leadership skills (RCCP examples for teenagers)
— However, this is already section 3.5.5 so perhaps just refer to that? Or combine with the methods.

— [[FIX –]]   **Complexity of curricula – need for adaptability and modularity** Another challenge is posed by the complexity of curricula, the wide range of skills that are usually taught and the developmental/progressive nature of skill acquisition. This suggests the need for modularity of the designed systems and preference for highly versatile and re-usable designs that can be adapted for teaching many aspects within the curricula and personalised to individual learning paths. Cost-benefit ratio and robustness of the system will be also important, both in terms of durability and reliable sensing in difficult real-world environments, regardless of context and setting. These will be especially crucial if the aim is to deploy technology as a part of existing curricula. Technology will also need to adapt to the differences among domains and settings, and the related variances in the length, focus and breadth of curricula, even when supporting a concept important across the domains (such as self-reflection). For example, we expect differences between designing for young learners (such as in education curricula and psychotherapy for adolescents) and for adult learners (e.g., in business and medical domain courses); and differences in supporting social skill acquisition for professional versus personal motivations. **[[G: could reference here something from the PAL project and their AIRS platform and/or the MyRoR platform as technical architectures specifically aiming to support such adaptive modularity]]**

5.4. Roles for HCI

The complexity, scale and dependencies of such large-scale projects necessarily affect ways in which we as HCI practitioners can engage. An extensive discussion of similar issues in related domains is already available. For example, Coyle et al. [2007] suggests a two stage process in the area of talk-based therapies, where 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 two 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 systems use in real-world practice. Fitzpatrick and Ellingsen [2012] discuss similar issues in their review of CSCW systems in medical settings, arguing for the need to engage with and raise awareness of CSCW (and HCI related) issues with many of the stakeholders.

We suggest a combination of the Coyle et al. [2007] model of 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) more exploratory HCI process, that draws on existing curricula and the challenges, bringing novel, untested technology and exploring a broad range of viable approaches that eventually feed into the first stream. It is our hope that this article could inspire future work pursuing either of the two direction.

Known issues

— [[Shall we incorporate this into a table that summarises the Challenges section?]]
— [[How can we better include autism literature – and where do we show the differences?]]
— Where do we highlight that most of HCI is not strictly evidenced based and we are quoting it more for inspiration than to claim that technology has been proven to support something? Shall that be right at the beginning of section 4, last sentense before we start with section 4.1?
— Can we at the end of each/most of the review bits saying HCI systems have been doing this and that draw out something about what kinds of tech/approaches seem to be most useful? – I guess not as we don't have any data to do so ... ?

6. CONCLUSIONS

This paper points to the potential synergy between HCI and social and emotional skills learning, benefiting both disciplines. We outline the key challenges for current SEL approaches, show how these could be supported by technology, and highlight the new challenges and opportunities this would pose to HCI. In doing so we have presented a set of structured concepts and characterisations of SEL to help frame an agenda for further research. We provide a summary of the topics, methods, and learning principles, and their associated challenges in SEL across the domains (Table 1); we review HCI research relevant to the respective challenges (Table **??**) and outline the design space and opportunities for HCI (Table **??**).

In particular, the curricula across all domains struggle with providing *timely feedback* (currently post-hoc, coming from trainer/peers); creating opportunities for *real-world practice* (currently limited mostly to in-session training); *embedding learnt skills*

into everyday life (very little is possible for curricula designers at the moment); and *facilitating engagement and motivation*. The overarching challenge across these issues is the need to extend support for out-of-session learning, which is fundamental for social and emotional skills but hard to facilitate for the current curricula. The review of existing HCI research shows there are strong indications that technology can help address many of these challenges; particularly as many HCI approaches that were not connected to social and emotional learning so far could directly contribute here.

HCI involvement in this space has the potential for strong, real-world impacts. Social and emotional skills learning is crucial for diverse domains and ages, such as education (from kindergarten to high-school), business, medical, therapeutic and everyday settings. Good SEL programmes are therefore relevant for an increasingly wide range of potential learners, and not limited to special-needs groups such as autism or psychotherapy patients. Moreover, engaging with these contexts is likely to bring well-motivated problems to tackle for many developing technologies (e.g., 'in the wild' social skills processing), raising novel challenges for future HCI research.

We end by highlighting three selected aspects of SEL we personally find particularly interesting for immediate future work within HCI. These are (i) addressing the support for social and emotional learning in education of neuro-typical children (a domain with a long history, many curricula that are widely applied, but so far under-researched in HCI); (ii) the implications of supporting facilitated learning in SEL (and the differences in design settings it brings); and (iii) finding ways to mesh HCI research and technology support well with the curricula design (building on the long history of research there).

Overall, this paper suggests that social and emotional learning points to a complex, intriguing research space, which has a high potential to enrich HCI research and practice. It is our hope that while the characterisations and distinctions suggested in this paper could be useful for immediate future work into this space, further research will elaborate on, clarify and extend, rather than reify, these.

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Authors' statement

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