

Precursors of 21st century skills are malleable in early childhood but may have little impact on lifetime success

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Abstract

The umbrella-term of “21st century skills” emerged in the early 2000s and gained traction in the following years, fueled by an increasing interest of education stakeholders in the individual readiness for dynamic, digital, and collaborative educational and professional contexts. These skills begin to develop in early childhood and comprise, among others, problem solving, metacognition, self-regulation, creativity, and collaboration. Despite the increasing interest in 21st century skills, relevant research, to date, focused on school-age children, adolescents, and adults, rather than preschoolers. To inspire a greater focus on early education, this editorial opens a collection of articles on the relevant early abilities, termed “precursors of 21st century skills”. The editorial sets the stage for the collection by delving into the origin and the definition of the term, thereafter offering a novel theoretical framework, strengthening the conceptual structure behind 21st century skills based on their function: navigating the information landscape, or the mind, or the social landscape.

Keywords: 21st century skills, kindergarten, preschool, development, social mobility

The modern man – or rather person, honouring the diversity of the contemporary society – needs an exceptional set of skills, in terms of both scope and depth. According to the dominant narratives (OECD, 2015; 2021a), individuals need to continuously develop their skills by engaging in lifelong learning. The stakes are high; these skills are what secures job opportunities, happiness, health, and – ultimately – lifetime success, an umbrella-term that involves individual economic capital, well-being, health, and social prospects (OECD, 2021b), and so it is critical for individuals' survival to acquire and hone them. Although the skills may be acquired and honed life-long, this skill-oriented journey starts at school, or even kindergarten, since early educational curricula are packed with skills (Bobrowicz et al., 2024a). Having access to an increasing population of children enrolled in in early childhood education and care facilities world-wide (OECD, 2006; 2021), education stakeholders have a unique opportunity to equalize life opportunities across children from diverse backgrounds through, expectedly, fostering relevant skills. Given that 21st century skills necessarily draw on cognitive and socioemotional abilities that start to develop early, before the onset of early schooling, this Special Issue gathers recent, cutting-edge research on the development of these early abilities.

The present editorial aims to contextualize 21st century skills and their precursors in early childhood by (1) shedding some light on the relevance, conceptualization, and critique of this umbrella-term, (2) introducing the developmental antecedents of 21st century skills, and, finally, (3) offering a novel theoretical framework for future research endeavours in learning and individual differences. Whether precursors of 21st century skills should be investigated and supported in education, and critically for this Special Issue, in early childhood education, is a matter of beliefs. The belief that underpins the Special Issue assumes that individual interests of the developing child, should be at the core of their early education, and that education should offer each child a shot at lifetime success, regardless of

their sociodemographic background. Of note, this is not where equipping everyone in the society with 21st century skills might lead, as elaborated further in the editorial.

The content and the purpose of education is always a matter of beliefs, and these beliefs should not be mistaken for facts. The belief that fostering 21st century skills in education will equally serve all citizens, or that it equally serves the interests of all stakeholders, such as individuals, states/societies, and the labor market is shared by some (OECD, 2005), but not others (Ananiadou & Magdalean, 2009). Therefore, on the meta level, the present editorial aims to trigger the reader's critical thinking and interest in not only the development of, but also the premises behind 21st century skills. The editorial opens a collection of articles focusing on the individual differences, the environmental impact, and the social impact on the precursors of 21st century skills, i.e., early abilities such as problem solving, metacognition or socioemotional skills that, later in development, fall under the umbrella-term of 21st-century skills. These early abilities are subject to individual differences, as shown by Gulz and Haake (2024) in a playful computerized intervention focusing on attention and perseverance in vulnerable learners, Saleem and colleagues (2024) in a longitudinal study on learners' characteristics and the learning environment in early childhood education and care facilities, and Haman and Lipowska (2024) in a field study on preschoolers' arithmetic skills. The precursors of 21st century skills further impact individual learning, as reported by Fukkink and colleagues (2024), taking a closer look at the longitudinal impact of the physical and social aspects of childcare on school adjustment, Clifford and colleagues (2024), investigating children's socioemotional and self-regulation skills at the backdrop of shared reading and reminiscing, Nikkola and colleagues (2024), examining the link between childcare quality, creativity, and self-directed learning, and finally, Marks and colleagues (2024), elucidating how family behaviours correlate with child's episodic foresight.

21st century skills: frameworks and significance

The umbrella-term of “21st century skills” was prompted by the needs of U.S. employers reported in the early 2000s (Boisvert for NRC, 2011; Casner-Lotto & Benner, 2006). That a demand, political or social, would shape subsequent psychological research, is neither surprising nor new, given that research on cognitive ability and personality repeatedly supported assessment and selection for vocational, military, and educational purposes in the last century (Bobrowicz et al., 2024b). Keeping in mind that the term was not backed with theory or empirical findings in the early days may, however, prevent the reader from musing on the relatively poor definition of this term and a lack of consensus on its definition across relevant frameworks (Kyllonen, 2012; Voogt & Pareja Roblin, 2010). It is also important because this term directly stemmed from the needs of a particular education stakeholder – the labor market – disappointed with a lack of certain skills among their workforce (Boisvert for NRC, 2011; Casner-Lotto & Benner, 2006). Several surveys conducted in the 2000s among U. S. employers revealed that employees’ skillsets did not match the demand on oral and written communication, teamwork and collaboration, leadership and work ethics, self-reflection and self-management, and, finally, critical thinking and problem solving (Kyllonen, 2012). Crucially, in some surveys, these skills outcompeted foundational skills, such as maths, language mastery, and science in terms of importance (Casner-Lotto & Brenner, 2006).

The consensus on skills that should fall under the umbrella-term of 21st century skills is lacking. Initially, the need for 21st century skills (also termed, for instance, “transformative competencies”; OECD, 2019, or “key competencies”, OECD, 2021a) was noted by big tech companies ahead of the employer surveys. Few years before, AOL, Cisco, and Microsoft joined forces with the U.S. Department of Education to foster 21st century readiness in K-12

education (Partnership for 21st Century Skills, 2002). Another partnership, between Cisco, Intel, and Microsoft engaged in a similar enterprise at the end of 2010s (ATC21S; Binkley et al., 2010), in parallel with an expert group of researchers commissioned by the National Research Council of the National Academy of Sciences (2005-2012; NRC, 2012). With multiple parties involved in the discussions, unsurprisingly, divergent frameworks of 21st century skills emerged (Lamb et al., 2017; Voogt & Pareja-Roblin, 2010). Most frameworks concurred on collaboration, communication, digital, social/cultural skills, creativity, critical thinking, and problem solving, but few on such capacities as learning to learn, self-direction, planning, flexibility and adaptability, or perseverance/grit (Lamb et al., 2017; Voogt & Pareja Roblin, 2010). Further, the expert groups put forward diverse metacategories to which these capacities would belong, with a quadripartite structure suggested by one of the partnerships (Ways of Thinking, Ways of Working, Tools for Working, Living in the World; Kyllonen, 2012) and a tripartite structure offered by the National Research Council (cognitive, interpersonal, and intrapersonal skills; 2012).

The frameworks of 21st century skills diverged not only on the content, but also rationale behind fostering such skills in education, along with the emphasis on interest of different education stakeholders such as individuals, societies, and the labor market. While, among five major frameworks (Voogt & Pareja Roblin, 2010) one explicitly mentioned true equity in the access to the digital world (En Gauge; Lemke, 2002; Voogt & Pareja Roblin, 2010), one, to my best knowledge, mentioned equality of society-wide access to lifetime success in the rationale behind learning 21st century skills. Typically, across the other frameworks, the emphasis was either clearly put on the demands of the labor market and the workforce's skillset (ATC21S & EU; Voogt & Pareja Roblin, 2010), or remained rather vague despite referencing benefits for individuals and societies (OECD; Voogt & Pareja Roblin, 2010). Of note, the referred analysis was also commissioned by a tech company, Kinnesnet,

supporting the use of ICT in the Dutch schooling system (Voogt & Pareja Roblin, 2010).

Overall, interests of individuals, societies/states, and the labor market were mentioned across the frameworks, and it seems that the authors implicitly assumed that the interests of these education stakeholders are aligned with one another. In other words, that all these stakeholders should equally desire and would equally benefit from fostering 21st century skills in education. This, however, may not be the case.

Before outlining why fostering 21st century skills in education may neither be equally desired by, nor beneficial to, nor equally aligned with the interest of all educational stakeholders, a brief look at the average hourly wages of employees in the U.S. is needed. Between 1979 and 2007, these wages barely changed, in fact decreased, for men with less than a college degree. Simultaneously, the wages increased for men with at least a college degree, and by 2007 their wage was 2.5 times higher than that of men with less than a college degree. These patterns were similar among women. As the supply of college-educated people has increased between 1979 and 2007, it is unlikely that the gap has not been driven by a lower supply (and a higher demand, leading to higher wages). This led to a conclusion that in 2007 a particular set of skills relevant for contemporary jobs, rather than simply educational attainment, has driven the gap in college-high school earnings in the U.S. (Murnane for NRC, 2011). More and more jobs may require complex communication and expert thinking skills, acquired in college and above, which have been incorporated into the umbrella-term of 21st century skills. In this narrative, the college-high school earnings gap has not been questioned, assuming that people with more advanced skills should in fact earn more than others (which is a matter of beliefs). Of note, those who achieve a college degree or above in the U.S. do not have a heterogeneous sociodemographic background and were predominantly born to relatively well-off parents (Byun & Kim, 2014; Hanson, 2024; Wyner et al., 2007). Therefore, the increasing gap may also be viewed as a decreasing window of opportunity for

individuals from worse-off classes to access the highly paid jobs and acquire the relevant skills (assuming that skills, in fact, matter for employers' decision making in recruitment).

What would acquiring 21st century skills in education mean for individuals, societies/states, and the labor market is rather a matter of speculation than evidence. There is no evidence that teaching 21st century skills in formal education actually equalizes access to lifetime success across citizens from diverse sociodemographic backgrounds and across societies. It may endow individuals who would otherwise not have access to certain opportunities with higher social mobility and a shot at climbing up the social ladder, but, unfortunately I was not able to find any tangible evidence that would support this. In general, higher skills of children as compared to those of their parents are linked to social mobility, but socioeconomic advantage of the parents and the inherited parental alleles (more favorable or less favorable) is likewise linked to such mobility (McGue et al., 2020). Despite the dominant narratives, intergenerational transmission of advantage and disadvantage, not one's own skillfulness, may be the key factor in social mobility (Balestra & Ciani, 2022; Bonacini et al., 2021; OECD, 2018a,b). Finally, previous evidence suggests that apprenticeships, not training programs or lifelong learning, may boost social mobility for such individuals (Crawford et al., 2011).

Notably, there is no reason to assume that acquiring 21st century skills would increase equity (e.g., equalize pay) society-wide. Assuming that it was, in fact, a lack of 21st century skills that drove the gap in high school-college earnings, let us imagine that those who lacked them have now progressed to the highly skilled, high-earning group. This would result in a higher supply of highly skilled workforce, lowering the demand, and impeding the increase in wages. In principle, this boosts equity, but only in the high-earning group. In the low-earning group, the demand would increase, calling for either AI-based workforce or low-paid workforce relocating from financially struggling countries. Given that education is not free in

many countries (Saykova, 2024), does not provide individuals with the same set of skills around the world (Bobrowicz et al., 2024a), and that lifetime success is strongly shaped by factors beyond individual control, such as intergenerational wealth (Balestra & Ciani, 2022; OECD, 2018a,b), fostering 21st century skills cannot be aligned with the belief in true equity in the contemporary society. Finally, there is no evidence that acquiring 21st century skills other than self-regulation will improve individual or collective wellbeing and health (for findings on self-regulation see Robson et al., 2020). Instead, the quality of social relationships and the social support were found to longitudinally predict individual wellbeing (Schulz & Waldinger, 2023). In principle, 21st century skills might contribute to the quality of such relationships to some extent, but this relationship is speculative and unfounded given the available evidence.

Whether fostering 21st century skills will equally benefit all individuals, communities and societies is questionable. It is, however, profitable for the employers, as fostering 21st century skills in education is more profitable than doing it on the job. Training the workforce on the job would require an allocation of considerable resources, such as time and funding, which, covered directly by the individual and their parents (e.g., in the U.S.) or indirectly by the taxpayer (e.g., in the EU), potentially secure a higher profit for the employers. In fact, recent studies showed that training on the job has decreased over the years, in particular for young workforce (Cominetti et al., 2022), transferring the burden of training onto individuals and perhaps states.

In short, not all stakeholders equally pay for nor benefit from fostering 21st century skills in education, and their interests and needs are not perfectly aligned. In the case of critical thinking, for instance, on the surface it may be equally important for all stakeholders. Yet critical thinking, understood as “the ability to assess the value of a claim or information and come to a conclusion about what to believe or to do about it” (Lamb et al., 2017) requires

time and mental resources that allow the individual to use deliberate, reflective rather than intuitive information processing (Stanovich, 2009). Therefore, reflective processing critically depends on the environment, and relevant skills are not sufficient for deliberate decision making if time and mental resources are scarce. In other words, for individuals to exercise critical thinking, and, for instance, creative problem solving at a workplace and beyond, the working environment needs to change in order to release individuals' time and mental resources (Bobrowicz et al., 2022). Employers and states need to assume responsibility for environments that allow not only fostering but also exercising 21st century skills.

Precursors of 21st century skills

Whether fostering 21st century skills beyond self-regulation in fact bolsters individual shot at lifetime success across social classes remains elusive. Yet, 21st century skills may be fostered regardless, for instance, for the sake of reflective democratic participation (e.g., Ottander & Simon, 2021). According to several metaanalyses, however, selected 21st century skills may be fostered in education (critical thinking: Abrami et al., 2008, 2015; Liu & Pasztor, 2022; creativity: Karwowski et al., 2022; Ruiz-del-Pino et al., 2022; self-regulation: Pandey et al., 2018; socioemotional skills: Goldberg et al., 2018). Given that foundational theories in developmental psychology concur that complex skills observed in late childhood and adolescence are available, albeit in a simple form, to toddlers and preschoolers (Case, 1992; Piaget, 1964; Vygotsky, 1978), investigating and fostering precursors of 21st century skills in early childhood education may be worthwhile. In fact, relevant abilities, such as early problem solving, collaborative learning, critical thinking and digital skills have been readily investigated by several research groups in the recent years (e.g., problem solving: Akcay Malcok & Ceylan, 2021; Diamond, 2018; Hollenstein et al., 2022; Molinini et al., 2021; Voigt et al., 2019; digital skills: Gulz & Haake, 2021; Tecce DeCarlo et al., 2018; van

Bommel & Palmér, 2021; collaborative learning: Syrjamäki et al., 2019; Yliveronen et al., 2021; creative thinking: Nikkola et al., 2022; Reunamo et al., 2014; critical thinking: Heyman, 2008; O'Reilly et al., 2022; civic participation: Astuto & Ruck, 2017; Payne et al., 2019), showing that at least some of these skills are malleable and may be successfully fostered in early education (critical thinking: O'Reilly et al., 2022; digital skills: Benavides-Varela et al., 2020; self-regulation: Muir et al., 2023; socioemotional skills: Barnes et al., 2018; Murano et al., 2020; Verhoeven et al., 2020).

The precursors of 21st century skills were investigated throughout the collection of articles in the Special Issue.

Fukkink and colleagues (2024) investigated the longitudinal contribution of child's temperament and the ECEC setting to child's socio-emotional competence and wellbeing on the onset of formal schooling. In a study with $N = 110$ children, the authors found that difficulties in school transition mediated the effect of early temperament on child's socio-emotional competence and wellbeing after the transition.

Nikkola and colleagues (2024) examined the contribution of children's creative participation to child's creative play, socioemotional competence, self-regulation, and classroom engagement. In this large-scale study with $N = 5047$ children, the authors found that creative participation contributed to child's creative play, socioemotional competence, with several tips on scaffolding playful learning.

Salem and colleagues (2024) examined how the connection between the quality of early childhood education and care contributed, child's creativity and self-directed learning, as well as socio-emotional competence. In a large-scale study with $N = 484$ children, the authors reported that child's creativity and socio-emotional competence were correlated positively, and that child's creativity was further related to onsite professional development opportunities for the ECEC caregivers.

Clifford and colleagues (2024) looked into the longitudinal impact of parent-child shared reading and reminiscing on child's socio-emotional competence and self-regulation. In this intervention study with $N = 55$ parent-child dyads, the authors found that the shared reading and reminiscing module promoted girls' but not boys' participation in classroom activities, as rated by the teachers, and that parent-child reminiscing on negative events positively correlated with children's socio-emotional competence and self-regulation a year later.

Marks and colleagues (2024) studied the contribution of child's parent-reported temperament, personality and family context (organization and autonomy support) to early episodic foresight. In an online study with $N = 162$ children, the authors found that child's openness to experience and autonomy support positively correlated with child's future oriented thinking.

Haman and Lipowska (2024) investigated individual and task-specific differences in early arithmetic and spatial skills. In a study with $N = 119$ children, the authors found that symbolic number representations acquired in the preschool age are connected to more primitive non-symbolic representations of numerosity, and that number and spatial representations are closely interconnected at this age.

Finally, Gulz and Haake (2024) looked into the impact of a playful computer-based intervention on attention and perseverance among vulnerable preschoolers. In two studies with $N = 191$, the authors found that, contrary to teachers' expectations, preschoolers, regardless of reported learning difficulties, were able to practice perseverance and sustained attention in the intervention.

Although precursors of 21st century skills begin to develop early, before the onset of formal schooling, a theoretical framework under which relevant findings could be systematized is currently missing. This is expected, given that there is no consensus regarding

the framework of 21st century skills in general. For this very reason, I propose that considering a function that a given skill serves and the distinctiveness of brain areas/networks implicated in early behavioural manifestation of the skills would be more productive in devising such a framework than direct mapping onto the existing frameworks of 21st century skills. Accounting for these two aspects, the novel framework would comprise skills responsible for (1) Navigating the information landscape, (2) Navigating the mind, and (3) Navigating the social landscape (see Figure 1 for a list of skills in each category). Of note, skills involved in performance on a given task may span these categories, and may vary as a function of time, in line, for instance, with Funke's definition of problem solving (NRC, 2012).

(1) **Navigating the information landscape** allows attaining a goal in the present through processing information acquired from the environment, monitoring the available information, as well as selecting and switching between the information for decision making. Neurodevelopmental studies suggest that these tasks rely on domain-general multiple demand (MD) network (Schettini et al., 2023), and executive attention network (Vink et al., 2020), overlapping in terms of some but not all components implicated in navigating the mind or the social landscape (e.g., Anterior Cingulate Cortex in critical thinking and understanding/interacting with others; Mevel et al., 2019, and Scheider et al., 2022).

(2) **Navigating the mind** supports attaining a goal in the present through using information retrieved from memory and generated through reasoning or mind-wandering. Neurodevelopmental studies suggest that these tasks rely on the hippocampus in the transition from procedure- to memory-based solutions to problems (Qin et al., 2014), and the default mode network (Supekar et al., 2010),

implicated in both episodic foresight (Nyhout & Mahy, 2023) and creativity (Duval et al., 2023).

- (3) **Navigating the social landscape** allows the individual to benefit from both short-term and long-term social relationships. Although the network termed “the social brain” comprises multiple brain areas, the involvement of the temporo-parietal junction (Saxe et al., 2009; Schneider et al., 2022), the anterior insula and the amygdala (Schneider et al., 2022) may distinguish this set of precursors from the two previous sets.

Figure 1. Precursors of 21st century skills: a tentative framework.

| Precursors of 21st century skills | | | |
|-----------------------------------|---|---|---|
| | Navigating the information landscape | Navigating the mind | Navigating the social landscape |
| Function | Attaining a goal in the present. Involves processing information acquired from the environment, monitoring the available information, as well as selecting and switching between the information for decision making. | Attaining a goal beyond the present. Using information retrieved from memory and generated through reasoning or mind-wandering. | Attaining a goal through social interaction. Forging and maintaining temporary and permanent social networks. |
| Brain | Domain-general multiple demand (MD) network (Schettini et al., 2023) Executive attention network (Vink et al., 2020) | Hippocampus (Qin et al., 2014) Default mode network (Nyhout & Mahy, 2023) | Temporo-parietal junction (TPJ; Saxe et al., 2009; Schneider et al., 2022) Anterior insula & amygdala (Schneider et al., 2022) |
| Examples of skills | Problem solving | Episodic foresight | Socioemotional skills |
| | Metacognition | Reasoning | Socioemotional aspects of Self-regulation |
| | Cognitive aspects of Self-regulation | Divergent thinking | |
| | Cold executive functions | Creativity | Hot executive functions |
| | Decision making | | Collaboration and teamwork |
| | Critical thinking | | |
| | Digital skills | | |

The present Special Issue touches upon all three sets of precursors, with one manuscript focusing on a single set of precursors (Haman & Lipowska, 2024) and others bridging these sets (Fukkink et al., 2024; Nikkola et al., 2024; Gulz & Haake, 2024; Saleem et al., 2024; Voigt et al., 2024; Clifford et al., 2024). Some manuscripts further involved traditional literacies, such as mathematics (Haman & Lipowska, 2024) and reading (Clifford et al., 2024). A plethora of individual differences was represented across the studies, from

sociodemographic variables to cognitive and noncognitive variables, such as counting principles knowledge, temperament, social orientation and involvement of the child, social and learning skills, and socio-emotional competence. The diversity of some participant samples was rather high, including children with educational challenges (“vulnerable learners, Gulz & Haake, 2024) and children with diverse ethnic and socioeconomic backgrounds (Saleem et al., 2024). The remaining samples were not as diverse, or the relevant data was missing. In the future, collecting sociodemographic data underpinning the precursors of 21st century skills should become standard, given how much these variables contribute to social mobility and lifetime success. Unfortunately, despite editorial efforts to encourage submissions based on data collected beyond the European and the North American context, such manuscripts are largely missing in the Special Issue. The single study outside of these contexts comes from New Zealand, wherein the sample was predominantly New Zealand European (Clifford et al., 2024). This is worrying, as the conclusion that the precursors of 21st century skills may be fostered in early childhood education cannot be generalized beyond the Global North.

Importantly, most manuscripts accounted not only for individual differences, but also the context of learning, investigating how childcare and caregiver-child relationship in childcare longitudinally influence school adjustment (Fukkink et al., 2024), how parent-child shared reading and reminiscing longitudinally influences child’s behavioural outcomes after the onset of formal schooling (Clifford et al., 2024), how class environment correlates with child’s creative participation (Nikkola et al., 2024), how guidance and scaffolding may interact with child’s attention and perseverance (Gulz & Haake, 2024), how creativity and self-directed learning correlates with childcare quality (Saleem et al., 2024), and how family organization and autonomy support contributes to child’s episodic foresight (Marks et al.,

2024). The strength of the Special Issue lies in the inclusion of the context variables in the presented studies.

Conclusions and outlook

Precursors of 21st century skills may be fostered in early childhood education in the Global North, but data from the Global South is largely missing, in the present Special Issue and beyond. However, the relationship between 21st century skills and lifetime success is not as well-documented as it may seem based on the enthusiastic tone of reports published by major education stakeholders. Children from more privileged backgrounds may have a better shot at lifetime success than children from less privileged backgrounds regardless of having 21st century skills, as skills play only a partial role in such success. The window of opportunity will likely remain open for children from more privileged background regardless of whether they acquire these skills in formal schooling. However, this window will certainly close for children from less privileged background unless they receive an early and sustained support in 21st century skills. Therefore, this editorial promotes fostering the precursors of 21st century skills in early childhood education, but highlights that lifetime success depends on much more than 21st century skills, and is not equally available to all children in the contemporary society.

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