Report presented to

Lü – Interactive Playground

In the context of the

Competency matrix validation project

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Summary

1. Introduction

1. Mandate and objectives

As part of the project to implement an innovative pedagogical approach focused on the development of 21st century competencies, the initial mandate of the Co-DOT laboratory team at Université Laval was to develop a matrix of cognitive and emotional competencies to serve as the basis for Lü – Interactive Playground's pedagogical range of interactive games. The mandate consists primarily of revising the current Lü matrix and, using a scientific and psychometric approach, proposing a refined version of it. Lastly, an empirical validation protocol is proposed as a means of contributing to the scientific credibility of Lü's proposed competency development capabilities.

In response to rapidly changing labor market needs that have led employers to re-prioritize the skills or competencies they seek, it has become necessary to review educational approaches and learning methods to focus more on acquisition of the competencies of the future. In order to establish effective approaches, it is important to clearly define the competence to be learned and identify how they will be integrated into teaching tools.

In the continuous development and improvement of its educational play solutions, Lü wishes to consolidate its approach through scientific bases and empirically validated foundations. To do this, the Co-DOT laboratory team was asked to analyze all the essential competencies of the 21st century through a hybrid approach combining scientific, technical, and strategic aspects while taking into account the values held by the company.

The goals of this mandate are to:

- Identify 21st century competencies to be developed during childhood, their indicators, and their measurement within educational games.
- Use a hybrid approach to analyze the competencies identified.
- Propose a matrix of the selected competencies.
- Empirically validate the ability of Lü's games to develop essential 21st century competencies.

2. Expertise and team

Université Laval's Co-DOT Laboratory (Cognition – Distribution – Organization – Technology; www.co-dot.ulaval.ca), directed by Sébastien Tremblay, conducts innovative research on topics such as the distribution of cognition among individuals and their environments, information organization, and technologies for maximizing human performance. The lab's research program sits at the intersection of the human (cognitive science and ergonomics) and technological (smart and adaptive systems) domains by taking a multidisciplinary approach to understanding cognitive limitations and improving human performance and well-being in a variety of domains ranging from public safety to transportation and recreation. The lab also emphasizes the importance of developing soft skills through the use of innovative tools such as serious gaming. In particular, adaptive serious games—which respond to the player's cognitive and affective states—foster the development of cognitive capacities such as complex problem solving.

The project team is composed of 25 young researchers and students from undergraduate and graduate schools as well as postdoctoral fellows, laboratory engineers, and developers—members of the Co-DOT laboratory whose expertise in the following areas is essential for the success of this project:

- Cognitive sciences
- Ergonomics and human labor
- Human-technology relationship
- Psychometrics

- Educational technologies
- UX UI design
- AI and data sciences
- Cognitive development

3. Context of the Lü – Interactive Playground

Mission and vision

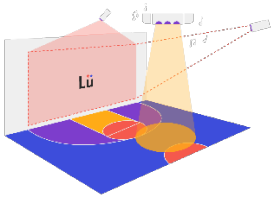
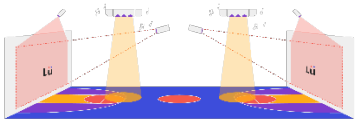
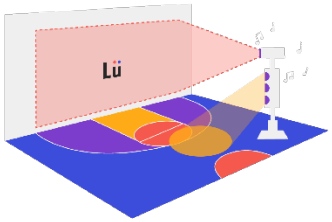
Lü – Interactive Playground is a Quebec company specializing in the design of giant interactive projectors and immersive learning spaces. Its mission is to reinvent physical activity in schools through video games. Lü transforms scholastic environments, such as school gyms, into immersive and interactive spaces using the latest augmented reality technologies and world-class audiovisual equipment (3D cameras, projectors, synchronized lighting and sound systems) paired with a catalog of educational play applications that are designed by education experts and based on the school curriculum. Lü products are designed with the philosophy that every child deserves to grow and develop to their full potential. They also emphasize the need to prepare for the school of tomorrow by embracing new technologies. Through interactive activities, every part of the child is engaged; the head, by enlisting all of the child's intelligences and learning styles; the heart, through memorable and enjoyable experiences that reduce stress and anxiety at school; and the body, by allowing the child to move, play and learn at the same time.

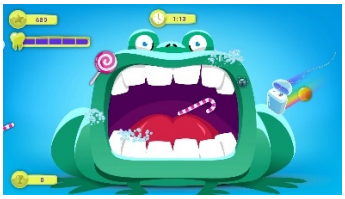
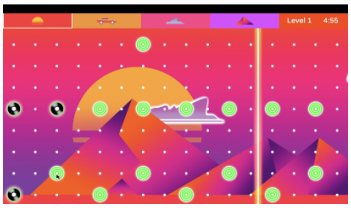
Source: idema.com

Lü's product line and comparable products

Since its creation, Lü has constantly grown and diversified its range of educational play solutions. Initially designed to encourage physical activity in children, Lü's products have quickly become multi-purpose in the sense that they offer a variety of possibilities, including showcasing the school's artistic, extracurricular, and corporate events. Through annual subscriptions, Lü offers its customers different technical configurations (see Table 1) that adapt to their infrastructure and a constantly expanding library of applications for all ages (from 4 to 99 years). A selection of the 50 applications offered by Lü is presented in Table 1; the remainder are in the appendix.

Table 1: Lü products

	Name	Description
Products	ÜNO 	Permanent single wall configuration.
	DÜO 	Permanent double wall configuration. Two ÜNO units are installed back-to-back and synchronized.
	MOBILE 	Portable single wall configuration.

Sample of the applications offered by LÜ	NEWTON 2.0 	Develop mental math capacities.
	BÜLLE 	Develop sustained focus and concentration by reproducing the patterns using various colors.
	STÖRIA 	Place sequences of events in order by organizing images, descriptions, and dates.
	BRÜSH 	Introduction to dental hygiene.
	JAM 	Discover the world of sound and musical composition.
	VÏKA 	Educational microworld to develop students' knowledge of geography.

There are several products on the market comparable to Lü's (see Table 2). All of them offer a variety of educational games, but none of them bring together all the elements that make up Lü's range. FX Game Zone offers the most similar product, but it is not specifically designed to help children develop the competencies of the future. Lü's products also differs from its competitors in that they combine both a mobility component (exercise) and an educational component. Similarly, while competing educational games are available, they require the use of a device (computer, tablet, console, interactive whiteboard, etc.) and do not allow the child to be active as they learn. The other distinctive feature of Lü is that it allows for the development of a complete set of necessary competencies, unlike some of its competitors that are restricted to a certain number of competencies or even a very specific skill such as math (e.g. Dream Box) or coding (e.g. Code Monkey). In addition, the activities are updated regularly to adjust children's learning to real-world developments and customize the activities to the specifics of the target audience (e.g. children with special needs).

Table 2: comparative table of Lü's products and those of its competitors

Name	Physical activity	Sensory systems	AR/immersion	Knowledge building	Competency development	Target audience
Lü	X	X	X	X	X	4–99
Spongelab				X		N.S.
Dream Box				X		5–14
Arcademics				X	X	N.S.
ABCya				X		5–12
Education Galaxy				X		N.S.
Tinybop Schools				X		N.S.
Code Monkey				X	X	N.S.
Classcraft				X	X	5–14
Starfall Education				X		5–8
Hatch				X	X	2–5

7 Generation Games			X	X		N/A
FX Game Zone	X	X	X	X	X	N/A
LUMOplay	X	X	X	X		2–6
BEAM	X	X	X	X		All ages
MultiBall	X	X	X	X		All ages

4. Our approach

In order to develop a matrix of cognitive and emotional capacities to serve as the basis for Lü's educational line of interactive school-based games, a hybrid approach was implemented drawing on cognitive sciences, psychometrics, data sciences, and education sciences. This approach combines scientific and technical perspectives (measurability and interactivity of games) as well as alignment with the company's strategy and values. The objective was to offer Lü a refined list of key competencies to be developed in elementary school students by eliminating conceptual overlap between the competencies identified in the scientific literature. To achieve this, the project uses an interdisciplinary approach, a multi-criterion evaluation method, and semantic network analysis techniques.

More specifically, seven criteria were used, four of which came from the company:

- Frequency of occurrence in the literature: record the frequency with which competencies are cited in scientific articles.
- Construct validity: A semantic analysis was performed to establish similarities between the definitions found in the literature and group together those that are operationalized in the same way.
- Uniqueness of measurement: A hierarchical analysis was also performed to group competencies according to the tasks and measures by which they are assessed.
- Integration into the company's games.
- Feasibility of measuring each of the competencies within the games offered.
- Alignment with the company's mission and values.
- Alignment with the marketing strategy.

The result of this multi-criteria approach is an overall ranking of competencies. This made it possible to remove competencies that did not meet the minimum threshold (e.g. the median). The remaining competencies were then assessed individually by the research team. A final matrix that grouped the competencies into families was proposed at the end of this selection process.

2. The importance of competencies in the field of education

Driven by governments and fueled by the emergence of digital technology and connectivity, the fourth industrial revolution will be at the heart of major changes in society. This revolution is characterized by a significant presence of technology and artificial intelligence in all areas of people's lives, disrupting many standard practices. In addition, technologies continue to evolve at an increasingly rapid pace, bringing with them a set of changes that affect people's lives at different levels.

To adapt to these societal and digital transformations, particular attention has been paid to competencies that have become essential for people to evolve and adapt to dynamic, constantly changing environments. As a result, researchers and experts in several fields have turned their attention to exploring the new competencies inherent to successful Industry 4.0 organizations, also known as 21st century competencies or 21st century skills (Van Laar et al., 2017). Several competencies associated with the cognitive, intrapersonal, and interpersonal development of individuals have been identified in the literature. Some of the most frequently mentioned include: adaptability, complex problem solving, and creativity (Romero et al., 2015) as well as complex decision-making, leadership, team spirit, critical thinking, and productivity (Kaur et al., 2020; Voogt & Roblin, 2012).

In the professional world, these competencies are no longer complementary. Instead, they are considered essential and represent an asset sought by companies that can compensate for a lack of technical expertise. To ensure a match between businesses' needs for qualified personnel and the quality of training provided by schools and universities, this societal transformation must also be accompanied by a reconfiguration of knowledge (practical, emotional, and interpersonal) and a pedagogical alignment in education by placing 21st century competencies at the forefront of students' learning. In order to ensure that young people are best prepared to face the new demands of working life upon graduation, several countries, including Canada, have overhauled their educational programs to focus more on developing competencies. This means that the school's mission is no longer limited to teaching knowledge; it must also develop the

competencies their students need to succeed in their social and professional lives. To achieve these goals, the Quebec education system has put in place a program focused on developing a set of essential competencies for students. This new education program incorporates competencies that are not necessarily subject-specific and that are developed in parallel with basic education. These competencies are therefore considered to be cross-disciplinary in nature and to correspond to the competencies of the future, which are becoming more and more important. These competencies are just as essential in the learning process—that is, in the assimilation and understanding of the subject matter—as they are in the students' future lives.

To date, cross-curricular competencies are not explicitly taught and evaluated in schools. Their development requires additional effort from teachers to design learning activities that foster these competencies. As a result, cross-curricular competencies are developed gradually during practical activities or projects (Richard and Bissonnette, 2001). Pedagogical approaches based on competency development must therefore put students at the center of their learning by getting them to regularly apply and develop their cognitive abilities. By the end of their education, students should be able to make inferences from what they have learned, using their memories to find solutions to problems in response to new situations. This project-based concept of education and learning has given teachers and educators great freedom to design and implement original methods and innovative learning strategies. This is especially true since the digital and virtual age has led to the emergence of a modernized vision of education: Education 4.0, which is essentially focused on the use of unconventional and innovative tools to develop development of cross-curricular competencies in students. These include play-based learning and educational play, which is increasingly being incorporated into the curricula of elementary schools and specialized facilities. Considering that students are more engaged when playing (Arnold, 2014), several new learning and assessment methods focused on interactivity and fun have been designed to develop certain key competencies. According to some studies, educational play has demonstrated satisfactory results in the acquisition

of cross-curricular competencies (e.g. self-awareness, teamwork, adaptability, complex problem solving, dynamic decision-making; Leask, 2009; Pillay & James, 2013). Through play, children learn the rules of conduct, adopt the right attitude, develop strategies, and sharpen their analytical abilities and memories. Serious games are designed to achieve a specific goal (e.g. to put all the pieces of a puzzle together), allowing students to practice their cognitive skills and acquire a body of theoretical knowledge (e.g. the history of a country). In this way, students actively participate in their development and become responsible for their own learning (Loras, 2017; Wareham Morris & McGowan, 2018).

5. Taxonomy of school-based competencies

When designing learning activities and educational tools, stakeholders in schools and specialized institutes rely on a set of competencies. In its Quebec Education Program, Quebec's Ministry of Education defines competencies as "a set of behaviors based on the effective mobilization and use of a range of resources" (Ministère de l'Éducation du Québec, 2000). This definition is similar to the one proposed in the glossary of the European Centre for the Development of Vocational Training (CEDEFOP) of the European Commission, according to which a competency is the "ability to apply learning outcomes adequately in a defined context (education, work, personal or professional development)." These definitions highlight the distinction between abilities, capacities, and competencies. More specifically, competency stems from the repetitive application of knowledge acquired during learning, which generates abilities and the capacity to act effectively in specific situations (Bissonnette and Richard, 2001).

Despite a relatively widespread consensus on essential competencies for the 21st century, there are some discrepancies in the lists produced by organizations and experts in the field. Stakeholders in the professional environment distinguish between technical competencies, which are related to the execution of a specific task, and soft competencies ("soft skills"), which are more cognitive in nature. In parallel, schools distinguish between subject-specific competencies and cross-curricular competencies. Cross-

curricular competencies are formulated in educational programs to match professional expectations of soft skills. As for subject-specific competencies, they allow children to better understand the world around them.

1. 21st century competencies

In response to growing concern about the match between labor market demands and the qualifications of university graduates, several expert organizations and institutions have focused on exploring the key competencies for success in the 21st century and have proposed several conceptual frameworks for understanding these competencies (e.g. Assessment and Teaching of 21st Century Skills, ATC21S, and Partnership for 21st Century Skills – P21). Given the rapidly changing and dynamic environment, the competencies identified as most important vary over space and time (Ananiadou & Claro, 2009; Soffel, 2016). Indeed, a comparison of qualified 21st century competencies in 2015 and 2020 (Soffel, 2016) reveals that some skills (such as critical thinking and creativity) have emerged as priorities in recent years, while others (such as emotional intelligence and cognitive flexibility) have been newly added to the list of most important skills in 2020.

The identification of 21st century competencies has led to discussions within the scientific community where researchers have attempted to identify the conditions that a skill must meet to qualify as "21st century." In sum, the skill must be necessary to ensure professional, personal, and social success while being different from the skills identified in the 20th century (Dede, n.d.). Among the reference documents on 21st century competencies in education, the guide prepared by the Ministry of Education in Ontario mentions several lists published provincially, nationally, and internationally in research and official documents. According to this guide, the most important 21st century competencies are those related to critical thinking, communication, collaboration, and creativity and innovation (see Table 3).

Table 3: 21st century competencies according to the Ontario Ministry of Education Guide

Competency	**Definition** (Fullan and Scoll, 2014)
Critical thinking	Critically evaluating information and arguments, seeing patterns and connections, constructing meaningful knowledge, and applying it in the real world.
Communication	Mastering three fluencies—digital, writing, and speaking—tailored for a range of audiences.
Collaboration	Having the capacity to work interdependently and synergistically in teams with strong interpersonal and team-related competencies including effective management of team dynamics, making substantive decisions together, and learning from and contributing to the learning of others.
Creativity	Having an 'entrepreneurial eye' for economic and social opportunities, asking the right questions to generate novel ideas, and demonstrating leadership to pursue those ideas into practice
Innovation	Realizing new ideas in order to make a useful contribution to a particular field.

Certain competencies, such as critical and creative thinking, have always been at the core of learning and educational approaches (Trilling and Fadel, 2009). That said, these competencies are not taught in their own right, but are rather taught alongside theoretical knowledge (Brinkley et al., 2012). However, in the 21st century, these competencies have gone from being complementary to essential. Consequently, education systems need to place greater emphasis on them and develop them in an explicit and intentional way. This includes adapting current teaching practices to incorporate the development of 21st century competencies as learning objectives.

Computational thinking, which refers to a particular method of algorithmic reasoning based on concepts and processes from computer programming and coding (Tsavara et al., 2018), has also generated much discussion regarding its inclusion as a skill to be developed in educational programs, as people with this skill are able to deconstruct a given problem and identify the most relevant variables and models to provide an

algorithmic solution (Wing, 2006). Although this competency is generally related to the computer science domain, it remains useful in other domains, including everyday life (Wing, 2006) as it is strongly related to cognitive competencies that form practical competencies such as problem deconstruction, parallelism, and sequentiality (Tsavara et al., 2018). Therefore, in considering the importance of this competency and its applicability in different domains, some researchers believe that it will become as indispensable as basic competencies such as reading, writing, and arithmetic (Wing, 2006). In recognition of this, some educational systems have incorporated coding into their curriculum (Tuomi et al., 2018; Brown et al., 2014). In Quebec, despite growing awareness of the importance of coding, no real steps have been taken to integrate it into provincial educational programs, except for some local initiatives by motivated teachers. Tsavara et al. (2018) developed a series of three educational games (Crabs & Turtles) for elementary school students that promote the development of this skill through playful activities that, unlike other educational games, do not take place in a digital environment.

2. Cross-curricular competencies vs. subject-specific competencies

In the professional world, the distinction between technical competencies (related to a specific task) and soft competences (of a cognitive nature and much more general) is more common. However, the Quebec school system distinguishes between cross-curricular and subject-specific competencies.

"Cross-curricular competencies" refer to the development of intellectual reflexes and methodological aptitudes as well as communication and personal and social abilities. These competencies also allow students to adapt to a variety of situations, to continue learning outside of the school environment, and to better understand the world around them. The Québec Education Program announced by the Ministry of Education includes nine cross-curricular competencies, which are presented in *Table 4: Cross-curricular competencies adopted by the Quebec school curriculum*. They are articulated around four categories: intellectual, methodological, personal and social, and communication-related. It is important to note that unlike subject-specific competencies, these cross-curricular competencies are not formally assessed, but they contribute strongly to the integration of

knowledge and thus to success in the school career. Particular attention is paid to these competencies in the design of learning activities because, once students acquire them, they become lifelong abilities. After all, these competencies contribute to the development of intellectual abilities while instilling in children the will to continue learning beyond the school setting and making them capable of adapting to new situations.

Table 4: Cross-curricular competencies adopted by the Quebec school curriculum

Category	Cross-curricular competency	Definition
Intellectual	Using information	Finding information, comparing it and assessing its value or appropriateness, organizing it, processing it, and synthesizing it.
	Solving problems	Exploring possible solutions and formulating different hypotheses in order to find a satisfactory solution or solutions.
	Exercising critical judgment	Putting facts into perspective; building and expressing opinions by considering only the facts.
	Using creativity	Drawing on imagination to use the resources at one's disposal in an original way.
Methodological	Adopting effective work methods	Taking notes, planning work, and establishing appropriate methodological approaches to accomplish a given task.
	Using information and communications technologies	Acquiring technological tools and using them to support learning while evaluating the effectiveness of the use of technology.
	Achieving potential	Recognizing personal characteristics and leveraging personal resources to make the most of one's abilities.
Personal and social	Cooperating with others	Contributing to team efforts and togetherness by participating in classroom activities, using teamwork effectively, and interacting with an open mind.

Communication-related	Communicating appropriately	Adjusting communication based on the reactions of the recipients, becoming familiar with various modes of communication, and understanding the codes and conventions associated with each.

Subject-specific competencies refer to the student's knowledge specific to the five broad areas of learning at the elementary level as formulated in the Quebec curriculum: language, mathematics, science and technology, social studies, the arts, and personal development. In certain areas of learning, subject-specific competencies may vary depending on the cycle (1, 2, or 3, corresponding to grades 1–2, 3–4, and 5–6, respectively). For example, in the area of science and technology, the competencies to be developed in grades 1 and 2 (cycle 1) relate to exploration of the world of science and technology, while in cycles 2 and 3, students should be encouraged to propose explanations or solutions to scientific and technological problems. The content of the learning activities is structured around the knowledge to be acquired by the students in these areas and calls upon cross-curricular competencies that are consolidated in parallel, allowing for better integration of the knowledge.

As their name suggests, cross-curricular competencies acquired in a course have the distinction of being reinvested in other subjects since they facilitate the development and enrichment of subject-specific competencies, including in areas other than the one in which they were acquired. Therefore, and as indicated in the Quebec school curriculum, the various cross-curricular competencies are used in the learning activities of each subject and in interaction with the general areas of training (Ministère de l'Éducation du Québec, n.d.). Deemed indispensable in the job market, students gradually acquire cross-curricular competencies beginning in preschool, ensuring that they are well equipped to succeed in the professional and social world. To do this, it is important to ensure that these competencies and teaching methods are adapted to the real world and keep up with technological and societal developments.

3. Executive functions

Unlike the basic cognitive processes that develop almost naturally in individuals from birth, executive functions are involved in more complex situations that require prioritization and identification of actions to be taken. Taking a methodological approach similar to that of this report, Packwood et al. (2011) were able to propose an organization of executive functions by reducing conceptual and psychometric overlap (see Table 5). They encompass a set of competencies, such as planning, cognitive flexibility, and inhibition of automatic behaviors, in order to exercise control over goal-directed actions. The conceptualization of executive functions is widely discussed in the literature and results are quite heterogeneous, leading to conceptual overlap as demonstrated in the systematic review by Karr et al. (2018). These authors suggest that this expanding number of executive functions can be reduced to three components: inhibition, flexibility, and working memory. It is recognized in the literature that executive functions promote the development of the capacity to adapt to new situations (Shallice, 1988), the establishment of associations, and the inference of environment-specific rules to better anticipate the future. For this reason, executive functions have been considered by several researchers to be essential for the development of social-emotional competencies in children (Riggs et al., 2006) as well as subject-specific competencies such as reading (Cartwright, 2012).

Table 5: Organization of executive functions according to Packwood et al. (2011)

Competency	Description
Inhibition	The ability to think before acting; this ability to resist the urge to say or do something gives us time to evaluate a situation and how our behavior might impact it.
Working memory	The ability to remember information when performing complex tasks. It incorporates the ability to draw on past learnings or experiences to apply them to the current situation or project into the future.
Emotional control	The ability to manage emotions to achieve goals, accomplish tasks, or control and direct behavior.

Initiation	The ability to start projects without undue procrastination, in an efficient and timely manner.
Sustained attention	The ability to maintain attention to a situation or task despite distractibility, fatigue, or boredom.
Planning/prioritization	The ability to create a roadmap to reach a goal or to complete a task. This also means being able to make decisions about what should and should not be focused on.
Organization	The ability to create and maintain systems to track information or materials.
Time management	The ability to estimate how much time is available, how to allocate it, and how to meet deadlines. This also entails a sense that time is important.
Flexibility	The ability to revise plans in the face of obstacles, setbacks, new information, or errors. This means an adaptability to changing conditions.
Metacognition	The ability to step back and take an overall view of a situation. This is the ability to observe how one solves a problem. It also includes self-monitoring and self-assessment.
Goal-directed persistence	The ability to have a goal, pursue it to completion, and not be discouraged or distracted by competing interests.
Stress tolerance	The ability to thrive in stressful situations and to cope with uncertainty, change, and performance demands

2. **Initial Lü matrix**

The initial matrix adopted by Lü for the design of their educational applications includes a set of competencies inspired by the Quebec school curriculum, the International Baccalaureate (IB) pedagogical standards, as well as references such as Dawson and Guare's book (2009). A total of 31 competencies (see the matrix in the appendix) serve as the basis for the development of educational games. These competencies are related to the fundamental elements of the child's global development such as executive functions, motor skills, school subjects, and social and emotional competencies.

While Lü's initial matrix includes different competency domains for children to develop, this project focuses on the cognitive side with an emphasis on executive functions and 21st century competencies that are most important for children to develop.

Figure 1: Initial Lü matrix

Compétences Lü
Computational thinking
Collaboration
Creativity
Communication
Exploiter l'information
Résoudre des problèmes
Exercer son jugement critique
Mettre en œuvre sa pensée créatrice
Se donner des méthodes de travail efficaces
Exploiter les technologies de l'information et de la communication
Actualiser son potentiel
Coopérer
Communiquer de façon appropriée
Response inhibition
Working memory
Task initiation
Emotional control
Sustained attention
Planning/Prioritizing
Organization
Time management
Flexibility
Metacognition
Goal-directed persistence
Stress tolerance
Self-awareness
Self-management
Social awareness
Relationship skills
Responsible decision-making
Agency

3. Concept validity

As research has progressed and official documents have been published, several taxonomies have been proposed to distinguish between the various essential 21st century competencies. It is true that work drawn from a variety of disciplines has contributed to the knowledge of essential competencies, but the terms used to label competencies in the taxonomies proposed in the literature appear to differ (as do the use of the words

"competency" and "skill" in English). Consequently, establishing a framework that integrates all of the proposed competencies will involve consideration of a large number of competencies, but which ultimately relate to a smaller number of clearly distinct competencies. This contributes to the proliferation of taxonomies used to describe the concept, caused by a conceptual overlap that occurs when multiple terms are used to describe the same competency. As a result, the expansion of the list of competencies does not necessarily mean the existence of more competencies, but rather a conceptual and semantic redundancy that makes the notion of key competencies ill-defined and non-specific to the requirements of the 21st century. Moreover, the number of terms used to designate competencies leads to much confusion in their general conceptualization and a lack of consistency in their organization. It is therefore important to be mindful of how these lists are used as they can create unnecessary complexity, especially if they are used to develop pedagogical tools or instruments to measure these competencies (Packwood et al., 2011).

In order to develop a list that truly reflects the essential competencies of the 21st century, it is therefore necessary to identify and quantify this proliferation and determine the extent of the conceptual and semantic redundancy between competencies. It is also important to establish an organization of competencies in order to propose a taxonomy of key competencies to be developed by elementary school students. To do this, a multi-criterion analysis of all the competencies identified in the literature and the reference documents was performed.

3. Approach

A hybrid evaluation framework combining scientific, strategic, and corporate-value perspectives was used.

1. Scientific perspective

The research-based approach is based on scientific knowledge and rigor. For this project, a corpus of articles (*n*=158) on the competencies to be developed in school-age youth was compiled. The literature was reviewed to identify the definitions and instruments used to assess each of the competencies. By relying on concrete facts validated by the scientific community, while presenting a survey of the literature on the subject, this initial perspective provides empirical support for the approach. However, there is no guarantee that the competencies that are of central importance today will still be so in a few years. By the same token, this approach may omit or give less importance to intangible or hard-to-measure competencies (Briscoe & Hall, 1999).

1.1. Documentary research

The methodological approach was based on four central questions:

1. What is the state of the literature regarding the most important social and cognitive competencies to develop during childhood?
2. How do we assess 21st century competencies, executive function, and social-emotional competencies in school-aged children?
3. What are the implications of developing good social and cognitive competencies?
4. What are the implications of a lack of social and cognitive competencies?

Searches were conducted using four widely used digital databases to cover all relevant literature and scientific journals: PsycINFO (http://www.apa.org/psycinfo/), Education Resources Information Center (ERIC) (http://www.eric.ed.gov/), PubMed (https://pubmed.ncbi.nlm.nih.gov/), and Google Scholar (https://scholar.google.ca/).

In the initial search, permutations (see Table X) of various relevant keywords (e.g. school-aged children, executive function*s*, 21st century skills, social-emotional skills, assessment, and involvement) were used. The reference lists of the selected articles were also consulted to target other articles that a search engine might have missed.

Table 6: ***Literature search and keywords used***

Concept(s)	Search terms (synonyms/related terms)
Child	Children OR School-aged children OR Middle-aged children OR Students OR Pupil OR Preadolescent children OR Learners OR Elementary students
	AND
Executive functions	Inhibition OR Working memory OR Task initiation OR Sustained attention OR Organization OR Flexibility OR Time management OR Planning/Prioritizing OR Metacognition OR Goal-directed persistence OR Stress tolerance OR Problem solving
	OR
21st century skills Twenty-first century skills 21st century competencies 4 Cs	Complex thinking OR Creativity OR Computational thinking OR Communication
	OR
Social-emotional skills	Self-awareness OR Self-management OR Social awareness OR Relationship skills OR Agency OR Learning to learn OR Responsible decision-making

	AND/OR
Assessment	Measurement OR Evaluation OR Implication OR Outcomes OR Task
	AND/OR
Serious games	Gamification OR Game-based learning OR Exergames OR Videogames OR Gamified lesson

Next, all titles and abstracts were meticulously reviewed to retain only those articles deemed relevant. Each selected article had to: a) propose an empirical or theoretical framework; b) be published between 1990 and 2020; c) be written in English or French; d) mention one or more competencies contained in the original matrix in any section (i.e. the title, abstract, keywords, or main text); and e) focus on children and adolescents between the ages of 5 and 17. This resulted in a corpus of 231 articles. In a subsequent step, all of the publications were reviewed to note the definitions of the competencies and the methods used to assess them.

1.2. Scientific and psychometric evaluation

In order to contribute to the scientific credibility of the company's interactive game products and to promote the development of soft competencies and executive functions in elementary school children, it was first necessary to conduct a scientific and psychometric evaluation process.

Frequency of occurrence:

All the articles in the corpus were first consulted to calculate the frequency of occurrence of each competency. The frequency of occurrence refers to the number of publications

that have made mention of a concept. For example, a competency that has been mentioned in five different articles will have a frequency of occurrence of five. This step provided an initial overview of the competencies most (and least) often cited in the literature. Some competencies stood out because of their higher frequency of occurrence. Others were distinguished by their low frequency of occurrence.

Latent semantic analysis:

Latent semantic analysis (LSA) is a process at the intersection of linguistics, computer science, and artificial intelligence that identifies relationships between a set of documents and the terms they contain. Using a mathematical technique called vector semantics, LSA produces a semantic representation of a text by assigning a weight to each term or expression in a text. Thus, it becomes possible to quantify the semantic proximity between definitions by assigning them a similarity measure, called the cosine. The cosine metric varies between -1 and 1, where 1 corresponds to exact semantic proximity.

Using a singular value decomposition method, LSA aims to condense a very large data matrix of words by context along 300–500 dimensions. These dimensions represent the frequency with which a word appears in a document and each word, phrase, or text becomes a weighted vector. LSA takes into account the tracking of words that are semantically similar, but may not be morphologically related (e.g., the word “mouse” scores higher against “cat” than “dog” or “house”). The corpus used for the LSA is composed of three college-level psychology textbooks and includes nearly 14,000 documents and over 30,000 terms.

The similarity between the resulting vectors for words and contexts, as measured by the cosine, was found to closely mimic human judgment of meaning similarity. For example, after practicing with approximately 2,000 pages of English text, the LSA scored similar to the average test taker on the synonym section of the Educational Testing Service’s Test of English as a Second Language (TOEFL; Landauer & Dumais, 1997), and after

practicing with a psychology textbook, it achieved a passing score on a multiple-choice test (Landauer, Foltz & Laham, 1998).

Evaluation of the level of redundancy between the definitions given to the executive functions makes it possible to group together those that are operationalized in the same way. The evaluation, therefore, offers the advantage of a more accurate estimate of the proliferation of executive functions by taking into account the terms used and how they are defined.

First, in the interest of economy, some competencies that are too conceptually similar have been grouped together. This process led to the consolidation of competencies: 1) *use creativity* and *creativity*; 2) *communicate appropriately* and *communication*; 3) *cooperate with others, collaboration,* and *teamwork*; 4) *emotional regulation* and *affective regulation*; 5) *relationship skills* and *interpersonal skills*; 6) *cognitive flexibility, task switching and shifting*. Next, an LSA was conducted to target the most representative definition; that is, the definition that has, on average, the highest cosine among all definitions. This was done for each competency that had multiple definitions. Third, the definitions chosen for each competency were included in an LSA. This process led to a 48 x 48 semantic proximity matrix.

After the LSA, a mapping analysis using Gephi software was conducted to investigate the spatial distribution of competencies. To do this, the semantic proximity matrix was first converted to a distance matrix using Euclidean distance. In practical terms, the objective of this preliminary step was to convert the “1s” of the diagonal of the original semantic proximity matrix into “0s.” The diagonal of the initial matrix is composed of 1. These similarities are trivial since each competency is identical to itself (cosine of 1). Two map network metrics were calculated to obtain complete information about the role of each competency in the model: weighted degree and common centrality. The weighted degree

is based on the number of links for a competency, but weighted by the weight of each link. The common centrality of a competency is calculated as a function of the number of times a competency falls midway between two others. A high common centrality indicates that the competency plays a connecting role between several competencies. Removing this competency may therefore eliminate the connection between two competencies. Finally, the competencies were grouped into families based on the modularity of the network. The resolution parameterization was set using an iterative network estimation process intended to create families of the most homogeneous size possible. As a result of this process, a resolution of 0.97 was chosen. For reference, the higher the resolution (set to 1 by default), the stricter the grouping criteria and so the fewer families will be created. The network mapping was modeled using the "Circle Park Layout" algorithm available in Gephi 0.9.2.

Hierarchical analysis

Hierarchical cluster analysis is a statistical procedure that attempts to identify groupings (clusters) of relatively homogeneous variables based on predefined characteristics. In this case, the goal was to identify families of competencies based on the tasks (e.g. neuropsychological tasks) and measures (e.g. self-reported questionnaires) with which they were assessed. The analysis was performed with the royalty-free software RStudio (R Core Team, 2020) using the hierarchical clustering method in K-means. This method aims to group a data set into k clusters, where k represents the number of clusters defined *a priori*. Each cluster is represented by its center (i.e. centroid), which is the average of the points assigned to the cluster. Prior to the cluster analysis, a contingency table was constructed to relate the totality of the identified tasks to each competency, resulting in a 20 (competencies) x 193 (tests) table. This approach yields a dichotomous measure, where 1 indicates that a competency is assessed by a specific task and 0 indicates that a competency is not assessed by that same task. The contingency table is then standardized and converted into a Euclidean distance matrix. This matrix represents the distance between competencies based on the similarities of the tests used to assess them. The

elements were grouped using Ward's method, as it minimizes the variance between clusters at each step by ensuring that the clusters are as distinct as possible (Ward, 1963). The Gap statistic was used to determine the optimal number of clusters to be modeled by the algorithm.

2. Technical, strategic, and value-based assessment according to the company's values

During the process, employees were given the opportunity to comment on the proposed list of competencies, including the feasibility of incorporating them into the game content, their measurability, and their alignment with their company's values and marketing strategy. Using a questionnaire, they were asked to rate each of the four criteria on a scale of 1 to 10.

The first criterion corresponds to the feasibility of integrating each competency within the games produced by the company. It consists of knowing whether one of the available games is designed to assess a specific competency or has content that is conducive to evaluating that competency. The second criterion refers to measurability, or the feasibility of measuring each competency within the available games. The latter refers, for example, to game analytics that can measure the competencies in the matrix. The ability of these games to lend themselves effectively to the observation of measurable behaviors associated with these competencies is also a consideration. The third criterion is the degree to which the competencies align with the company's marketing strategy. That is, it involves assessing whether the competencies meet a need or demand in the education field. The fourth and last criterion refers to the alignment of the competencies with the company's values and vision. The objective is to verify that the competencies are in line with the aim of helping every child develop and mobilize all of their intelligences and learning styles.

4. Results

4.1 Frequency of occurrence

Table 7 shows the results of the frequency of occurrence analysis for each competency.

Table 7: ***Frequency of occurrence of the 10 most cited competencies following analysis of the corpus.***

Competency	**Frequency of occurrence**
Problem-solving	88
Collaboration	57
Creativity	55
Communication	55
Use creativity	55
Communicate appropriately	55
Cognitive flexibility	49
Working memory	48
Planning/Prioritizing	48
Critical thinking	43

4.2 Semantic overlap

The most representative definitions for each competency are presented in the appendix. These definitions were chosen based on the LSAs and are those with the highest average cosine.

The ASL results from the full matrix show, in general, that the competencies have strong indices of semantic proximity to each other. Indeed, the average of all cosines is 0.74 while the lowest average cosine is 0.61 and the highest is 0.80.

The results of the semantic mapping analysis can be viewed here: https://jogag287.github.io/Semantic-Graph/Network_graph/network/. This model includes six families of competencies. The majority of the competencies have a similar weighted degree, which is reflected by nodes of generally similar size. Some competencies, however, stand out because of their low weighted degrees; this is the case, for example, for “risk taking” and “achieve potential.”

4.3 Construct validation

The results of the Gap statistic are shown in Figure X. Based on this statistic, the optimal number of clusters to model is 9. The algorithm was therefore trained based on this number of clusters.

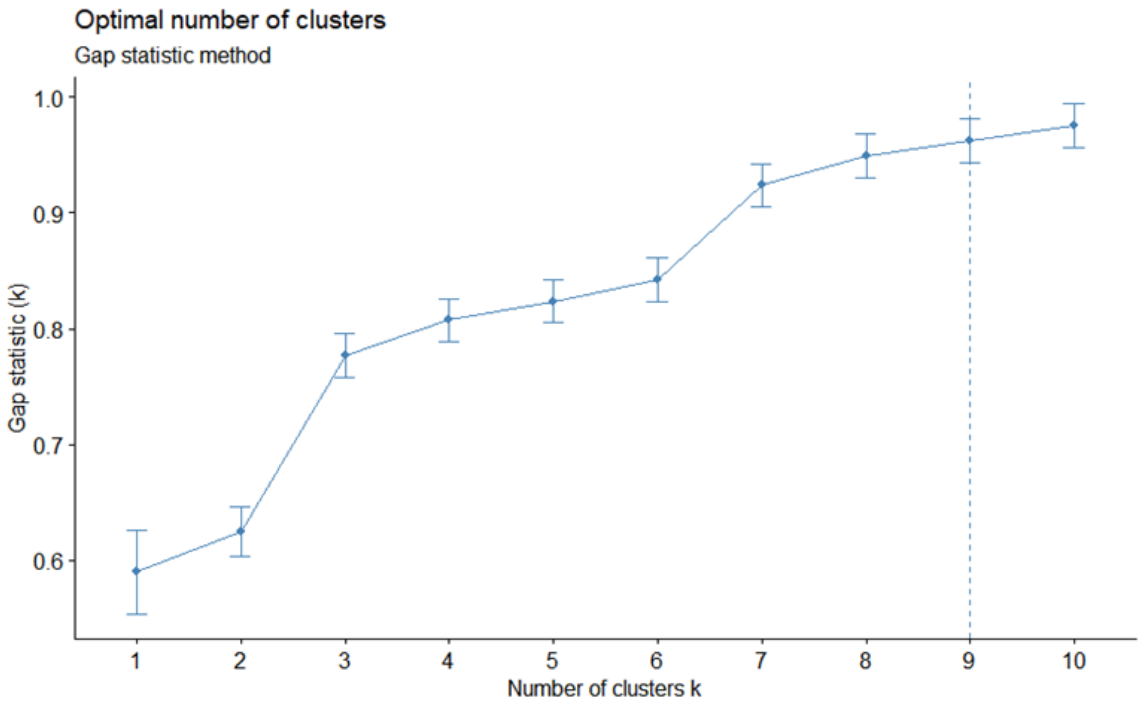


Figure X. Results of the analysis to determine the optimal number of clusters to keep in the analysis based on the Gap statistic

Figure XY shows the distribution of clusters in a reduced two-dimensional space. The results of the cluster analysis are shown in Figure ZZ as a dendrogram. The results in Figure XY provide insight into why "working memory," "cognitive flexibility," and "inhibition" form unique groupings as presented in Figure ZZ. This result is explained by the fact that these competencies are significantly distinguished by the high number of tests identified that assess them: 52, 63, and 41, respectively. For example, the average

number of tests per competency is 10 with a standard deviation of 13. In other words, “working memory,” “cognitive flexibility,” and “inhibition” exceed the standard deviation in terms of test quantity by more than triple. These competencies are therefore potentially perceived as outliers and consequently difficult for the algorithm to classify.

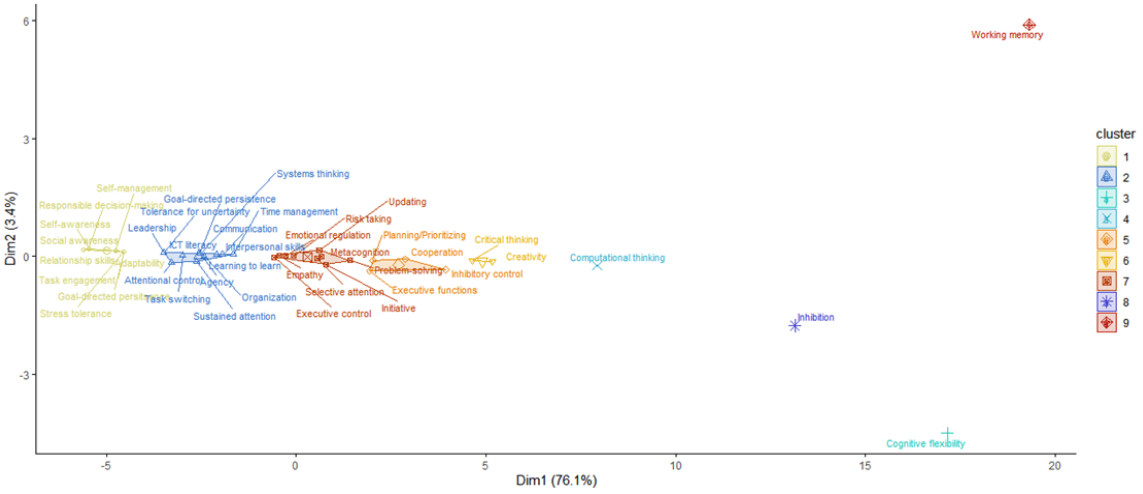


Figure XY. Distribution of groupings in a reduced two-dimensional space.

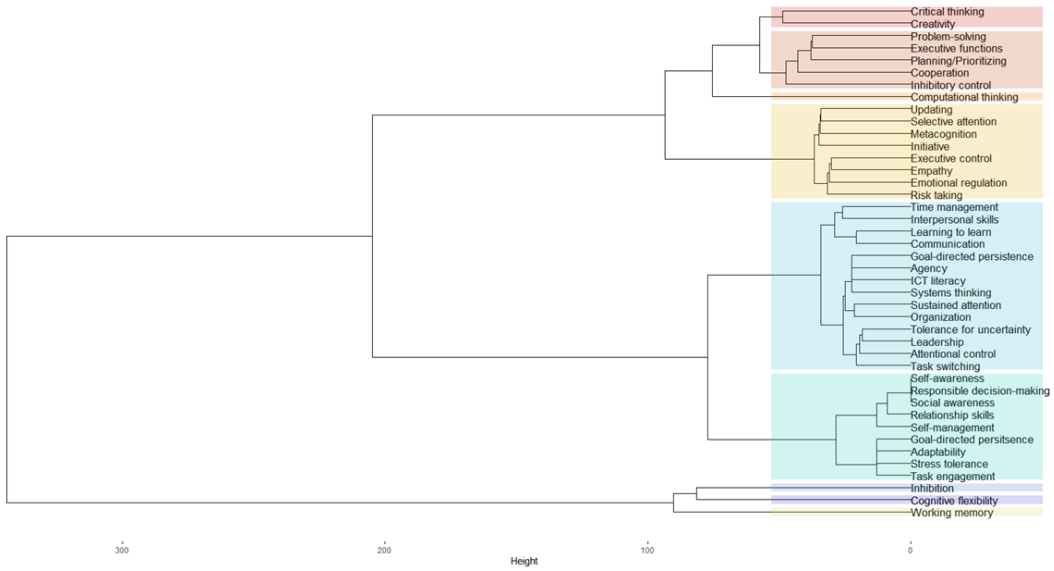


Figure ZZ. Dendrogram from the hierarchical clustering analysis using Ward’s method.

4.4 Technical and strategic assessment according to the company's values

The results of the Lü employee survey (*n*=3) are presented as a mean and a standard deviation in the appended table. The average score for each competency across the criteria: content integration, measure feasibility, mission and values, and marketing strategy can be interpreted as reflecting the presence or absence of consensus among Lü employees. For example, the competencies "cooperating with others," "problem solving," and "executive control" show a high mean score on each criterion and a low standard deviation, indicating the presence of a consensus of responses among employees. Conversely, the competencies "harnessing information" and "harnessing information and communication technology," in addition to having low mean scores, are associated with large standard deviations, indicating a lack of consensus among Lü employees.

Consensus within the Lü team

Competency	Content integration	Feasibility –	Mission and	Marketing strategy
Cooperating with others	9.00 (1.73)	8.00 (1.73)	9.00 (1.73)	9.00 (1.73)
Problem solving	9.00 (1.73)	9.00 (1.73)	9.00 (1.73)	8.67 (1.53)
Executive control	7.67 (1.53)	8.00 (2.00)	8.00 (2.00)	7.00 (1.00)

Lack of consensus among the Lü team

Competency	Content integration	Feasibility –	Mission and	Marketing strategy
Using information	5.33 (4.04)	5.33 (4.04)	6.33 (2.31)	5.67 (1.15)
ICT literacy	3.67 (3.06)	4.00 (3.00)	6.67 (4.16)	6.00 (3.46)

5. Matrix 2.0

5.1 Retained competencies

Each criterion was assigned a standardized metric in order to obtain an overall ranking of the competencies. The first criterion, semantic proximity, is based on the weighted degree of competencies in the model. The frequency criterion is simply the frequency identified in the literature review. The technical, strategic, and values-based evaluation criteria are derived from the respondents' average for each competency. It should be noted, as described in Section 3.2.2, that competencies that are conceptually very similar have been grouped together. This is the case, for example, for the competencies "cooperation," "cooperating with others," and "working in teams." For these competencies, an overall average was calculated based on the averages obtained and presented in Table V. Lastly, the construct validity metric (U) was operationalized by the following formula: $U = \left(\frac{x - y}{x} \right) * (x - y)$, where x represents the total number of tests identified and y represents the number of tests shared with other competencies. The first part of the equation ($\frac{x - y}{x}$) multiplied by 100 represents the percentage of unique tests identified for a competency (i.e. a uniqueness metric). The second part of the equation $* (x - y)$

enables weighting based on the number of unique tests. Thus, the more tests a competency has to evaluate it, the more advantageous its weighting will be.

All criteria were converted to Z-scores using the following formula: $Z = \frac{x - \mu}{\sigma}$, where x represents the raw score, μ represents the average of the criteria scores, and $\boldsymbol{\sigma}$ is the standard deviation of the scores. The standardized scores for each criterion were then added to arrive at a total score for all competencies (see Table VV).

Competency	**Total score**		**Competency**	**Total score**
Cooperation*	11.17		Critical judgment	-0.16
Problem solving*	10.89		Social awareness	-0.19
Creativity*	7.58		Frustration tolerance	-0.79
Interpersonal skills*	4.83		Innovation	-1.29
Critical thinking*	3.65		Adopt effective methods	-1.63
Executive control*	3.56		Time management	-1.68
Task engagement*	3.55		Selective attention	-1.92
Goal-directed persistence*	3.53		Organization	-1.99
Computational thinking*	3.53		Tolerance for uncertainty	-2.07
Leadership*	3.52		Initiative	-2.09
Communication*	2.84		Self-awareness	-2.68
Emotional regulation*	2.67		Stress tolerance	-2.75
Cognitive flexibility*	2.54		Self-management	-2.88
Empathy*	2.35		Risk taking	-2.92

Learning to learn*	1.52		Metacognition	-3.49
Working memory*	1.40		Achieve potential	-4.06
Sustained attention*	1.34		Agency	-4.62
Inhibition*	1.19		Goal-setting	-4.64
Adaptability*	0.68		ICT literacy	-4.91
Attentional control*	0.21		Use information	-6.00
System thinking*	0.08		Updating	-6.24
Planning/Prioritizing*	0.04		Inhibitory control	-6.79
Responsible decision-making*	-0.07		Task initiation	-6.84

Note. *Competency above the median.

The decision whether or not to retain a competency in the final matrix was based on various selection criteria. A first cutoff was made according to the median score, which was -0.12. The median is a measure of central tendency that represents the cutoff point separating a data set into two groups containing the same amount of data. Competencies above the median are indicated in Table VV by an asterisk (*). Next, each competency was evaluated by the research team to confirm its presence in the final matrix. This exercise led to the removal of eight additional competencies, namely: “executive control,” “leadership,” “empathy,” “working memory,” “communication,” “sustained attention,” “attentional control,” and “responsible decision-making.” The choices that led to the removal of these competencies are detailed below.

Executive control: its removal was based on the observation that this competency overlaps several other competencies (e.g. inhibition, working memory, cognitive flexibility, etc.). Indeed, the term “executive control” is often used in conjunction with the term “executive functions” (see, for example, Diamond, 2013 and Spagna et al., 2015). The definition of this competency reflects the fact that it involves several other

competencies: “A subset of cognitive processes involved in the intentional component of environmental interaction; it includes planning, working memory, coordination, and inhibitory control, as well as other effortful processes that must occur under conscious control to avoid making an error.”

Leadership: its removal was based on the observation that leadership is not a competency in itself, but that it emerges when the person has developed several competencies that are found in this matrix.

Working memory: this competency was removed due to its involvement in a vast majority of cognitive activities and processes (Adams et al., 2018). In order to obtain a matrix comprised of competencies that involve distinct processes, working memory had to be removed from the final matrix.

Responsible decision-making, attentional control, sustained attention, communication: these competencies were removed because there is no single test to assess them (single measure of 0). When considering how to develop a matrix of competencies that can be operationalized in the context of a research project, for example, the measurability of a competency is a central concern.

Empathy: this competency was removed since it is conceptually intertwined with interpersonal competencies and emotional regulation. Indeed, studies report a positive link between empathy and emotional regulation and prosocial behaviors such as conflict resolution and the maintenance of quality interpersonal relationships (e.g. Chakrabarti and Baron-Cohen, 2006; Soenens et al., 2007). To avoid conceptual overlap between competencies, empathy was therefore removed from the final matrix.

Goal-directed persistence: This competency was removed because the notion of persistence in goals is already present in the conceptualization of task engagement. For

example, in their definition of "task engagement," Downer et al. (2010) include the concepts of autonomy, personal initiative, independence, perseverance, and self-directed learning in completing a task. In addition, the notion of positive participation present in the definition of task engagement includes the notions of attention, persistence in the task, and desire to learn (Denton & West, 2002).

Following this two-stage selection process, the final matrix comprises the 14 competencies presented in the appendix. It is important to note that the present matrix represents one iteration among several other possible combinations of groupings. Table 8 summarizes the decision of whether to keep a competency in the final matrix.

5.2 Organization

The competencies selected as part of the final matrix were subjected to latent semantic analysis to obtain a Euclidean distance matrix. Subsequently, a semantic mapping analysis was performed. The results are available at: https://jogag287.github.io/Semantic-Graph/Network_graph_2.0/network/. Based on the groupings proposed by the semantic mapping analysis, the following taxonomy was proposed:

List of essential 21st century competencies

Analysis: The ability to infer, evaluate, and make deliberate decisions in order to find a solution or achieve a goal.

Computational thinking: A problem-solving process that includes the characteristics of formulating and solving problems, logically organizing data, analyzing data, representing data through abstractions, and automating solutions through algorithmic thinking.
Critical thinking: Entails a judgement or evaluation for analyzing claims, arguments and evidence and for making inferences using deductive and inductive reasoning to solve a problem or make a decision,
System thinking: The ability to understand how an entire system works; how an action, change, or malfunction in one part of the system affects the rest of the system adopting a "big picture" perspective. It includes decision-making and situation analysis as well as abstract reasoning about how the different elements of a situation interact
Problem solving: An individual's capacity to engage in information processing to understand and resolve problem situations where a solution is not immediately obvious. It includes the willingness to engage with such situations in order to achieve one's potential as a constructive and reflective citizen.

Innovation: The ability to illustrate, analyze, and articulate innovative and useful ideas in an intelligible manner. This process allows people to generate new ideas and solutions, use new methods, and overcome obstacles to achieve a goal.

Creativity: Ability to think differently and create new objects, ideas, and methods, Creativity is related to the production of new ideas on products, services, or processes that are both novel and potentially useful.
Adaptability: The ability and willingness to cope with uncertain, new, and rapidly changing conditions on the job, including responding effectively to emergencies or crisis situations and learning new tasks, technologies, and procedures.
Learning to learn: This competence includes awareness of one's learning process and needs, identifying available opportunities, and the ability to overcome obstacles in order to learn successfully. Learning to learn engages learners to build on prior learning and life experiences in order to use and apply knowledge and skills in a variety of contexts.
Planning/organization: To analyze a situation and develop a mental picture of the actions to be taken. Prior to learning, planning activities take place in order to predict the result or choose strategies.

Interaction: The ability to interact appropriately with others, apply resources suitable to the situation, and adjust as needed to encourage more active participation or increase effectiveness.

Interpersonal skills: Direct or incidental behaviors that allow effective teamwork, sustained collaboration, and a high level of motivation during the completion of a shared task. Skills that allow oneself to nurture an interpersonal connection with others.
Cooperation: To use teamwork effectively, to recognize which tasks can be done more effectively by means of teamwork, to assess his/her participation and that of peers in the team's work. To identify factors that facilitated or hindered cooperation. To identify desirable

References

Adams, E. J., Nguyen, A. T., & Cowan, N. (2018). Theories of working memory: Differences in definition, degree of modularity, role of attention, and purpose. Language, speech, and hearing services in schools, 49(3), 340-355.

Ananiadou, K., & Claro, M. (2009). 21st Century Skills and Competences for New Millennium Learners in OECD Countries. OECD Education Working Papers, No. 41. OECD Publishing (NJ1).

Arnold, B. J. (2014). Gamification in education. Proceedings of the American Society of Business and Behavioral Sciences, 21(1), 32-39.

Brown, N. C., Sentance, S., Crick, T., & Humphreys, S. (2014). Restart: The resurgence of computer science in UK schools. ACM Transactions on Computing Education (TOCE), 14(2), 1-22.

Cartwright, K. B. (2012). Insights from cognitive neuroscience: The importance of executive function for early reading development and education. Early Education & Development, 23(1), 24-36.

Dawson, P., & Guare, R. (2009). *Smart but scattered: The revolutionary "executive skills" approach to helping kids reach their potential*. Guilford Press.

Dede, C. (s.d.). Technological supports for Acquiring 21st century skills. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.632.1213&rep=rep1&type=pdf

Denton, K., & West, J. (2002). Children's reading and mathematics achievement in kindergarten and first grade (NCES 2002-125). Washington, DC: National Center for Education Statistics

Downer, J. T., Booren, L. M., Lima, O. K., Luckner, A. E., & Pianta, R. C. (2010). The Individualized Classroom Assessment Scoring System (inCLASS): Preliminary reliability and validity of a system for observing preschoolers' competence in classroom interactions. Early Childhood Research Quarterly, 25, 1–16.

Fullan, M., & Scott, G. (2014). Education PLUS The world will be led by people you can count on, including you!. Collaborative Impact SPC: Seattle, WA, USA.

Karr, J. E., Areshenkoff, C. N., Rast, P., Hofer, S. M., Iverson, G. L., & Garcia-Barrera, M. A. (2018). The unity and diversity of executive functions: A systematic review and re-analysis of latent variable studies. Psychological bulletin, 144(11), 1147.

Kaur, R., Awasthi, A., & Grzybowska, K. (2020). Evaluation of key skills supporting industry 4.0—A review of literature and practice. Sustainable Logistics and Production in Industry 4.0, 19-29.

Leask, B. (2009). Using formal and informal curricula to improve interactions between home and international students. Journal of Studies in International Education. 13 (2). pp. 205−21.

Ministère de l'Éducation du Québec (2000). Quebec Education Program.

Packwood, S., Hodgetts, H. M., & Tremblay, S. (2011). A multiperspective approach to the conceptualization of executive functions. Journal of Clinical and Experimental Neuropsychology. 24, 1-15.

Pillay, S. & James, R. (2013). Gaming across cultures: experimenting with alternate pedagogies. Education + Training. 55 (1). pp. 7-22. doi: 10.1108/00400911311294924

R Core Team (2020). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Richard, M., & Bissonnette, S. (2001). Comment construire des compétences en classe. Des outils pour la réforme, (condensed book text). Montreal: Chenelière/McGraw-Hilll.

Riggs, N. R., Jahromi, L. B., Razza, R. P., Dillworth-Bart, J. E., & Mueller, U. (2006). Executive function and the promotion of social–emotional competence. Journal of Applied Developmental Psychology, 27(4), 300-309.

Shallice. T. (1988). From neuropsychology to mental structure. New York: Cambridge University Press.

Soffel, J. (2016). What are the 21st-century skills every student needs. In World Economic Forum (Vol. 10).

Trilling, B., & Fadel, C. (2009). 21st century skills: Learning for life in our times. John Wiley & Sons.

Tsarava, K., Moeller, K., & Ninaus, M. (2018). Training computational thinking through board games: The case of Crabs & Turtles. International Journal of Serious Games, 5(2), 25-44.

Tuomi, P., Multisilta, J., Saarikoski, P., & Suominen, J. (2018). Coding skills as a success factor for a society. *Education and Information Technologies*, *23*(1), 419-434.

van Laar, E., van Deursen, A. J., van Dijk, J.A., & de Haan, J. (2017). The relation between 21st-century skills and digital skills: A systematic literature review. Computers in Human Behavior, 72, 577-588.

Voogt, J., & Roblin, N. P. (2012). A comparative analysis of international frameworks for 21st century competences: Implications for national curriculum policies. Journal of Curriculum Studies, 44(3), 299e321. http://dx.doi.org/10.1080/00220272.2012.668938.

Ward, J. (1963). Hierarchical grouping to optimize an objective function. Journal of the American Statistical Association, 58, 236-244.

Wareham Morris, K., & McGowan, J. (2018). Gamified Learning: a rationale for ludo-pedagogy and gamified classrooms. Worcester Journal of Learning and Teaching, 12, 23-31.

Wing, J. M. (2006). Computational thinking. Communications of the ACM, 49(3), 33-35.

Appendices

Applications available from Lü

Application name	Target age	Description
Bülle	7 to 99	Reproduce the mosaic. Work on sustained attention and focus by reproducing the chosen patterns using the different colors.
STÖRIA	6 to 99	Help our robots put sequences of events in order by combining images, descriptions, and dates
BRÜSH	5 to 65	Teach your patients about dental hygiene: stop them from eating too many candies, and help them clean bacteria and tartar from their mouths.
PIXËL	7 to 64	Turn your balls into paintbrushes and let your young artists create their next masterpiece using the free drawing and color-by-number modes!
LÜVIA	8 to 99	Dive into the world of Lüvia and let your knowledge shine! Alone or in teams, take on others to see who will be crowned quiz champion(s)!
SPHYNX	8 to 99	Journey to Ancient Egypt and hunt for the Pharaoh's lost artifacts. Which are the mirages and which are the real treasures? Learn to read and navigate the Cartesian plane to find out!
VÏKA 2.0	8 to 13	The Kraken monster prowls around the villages of the kingdom of Vïka and terrorizes the villagers. Sail your boat to all cities to protect the kingdom by answering questions, but beware of the Kraken's attacks!
LËAF	8 to 65	Lëaf is a cooperative activity in which the players collect the elements needed for photosynthesis.
TWÏNS	6 to 99	This game is all about speed, but it also encourages conscious learning by creating an environment where students can develop their coordination and shape recognition skills, and even pick up a language!
PHŸS	7 to 99	Mozzart the mouse wants his cheese! Team up to solve physics puzzles and help him find it.
GRÜB	8 to 65	Collect the necessary ingredients for a well-balanced meal. Watch out for the bins though—they'll try to slow you down!

PÏLA	6 to 65	This activity has been created to help children work logically and quickly in teams while developing their psychomotor faculties. Spatial orientation and shape recognition are at the heart of this activity.
GAÏA	4 to 99	Welcome to Gaïa's door. The key to this door? Relaxation! In this 12-minute journey, you will perform Jacobson's progressive relaxation exercises. Perfect for cooling down, releasing tension, and reducing stress. Have a nice trip!
DANZA	4 to 99	Move your arms, move your legs, jump, turn, go left, go right… are you warm yet? That's what cardio dance is all about! No need to be a pro, just follow the guide and imitate his movements to the sound of the music.
WAK	5 to 9	These over-trained rabbits will work on your reflexes, your speed and your precision! Play with colors, shapes, or even math and try to get as many correct answers as possible, but be careful! Wrong answers will make you lose precious points!
RELÉ	4 to 13	On your marks, get set, go! Participate in this exciting relay race where each player must run from one cone to the other, throw a ball at the screen, and come back so that the next runner can go. The game lets you play in competitive mode where the fastest team wins, or in collaborative mode where all the teams contribute points by running.
SCALA	6 to 13	Get ready to climb! Scala is a climbing competition that combines speed, accuracy, and teamwork. Each team must try to climb as high as they can without falling and losing precious seconds. Rumor has it that double jumps make climbing faster!
DUNK	6 to 13	Throw balls through the hoop and impress the Dunk crowd! With one wall, practice your throws. With two walls, the red team plays against the blue team! Play in timed or score mode and use the difficulty level to adjust the basket.
CORNER	6 to 13	Kick balls to score goals and impress the Corner crowd! With one wall, practice your strikes. With two walls, the red team plays against the blue team! Play in timed or score mode and use the difficulty level to adjust the goal size.
TOUCHDOWN	6 to 13	Score touchdowns for points and impress the Touchdown crowd! With one wall, practice your plays. With two walls, the red team plays against the blue team! Play in timed or score mode and use the difficulty level to adjust the size of the touchdown zone and goal.
GERM	4 to 99	Defend yourself against the virus! Use the special attack at exactly the right moment when it's available!

GALACTIC	4 to 99	Defend yourself against the asteroids for as long as possible and try to leave your mark with the best score! Watch for small colorful asteroids to earn bonus points and increase the difficulty level for a greater challenge.
MINEWORD	4 to 99	You must spell the name of the animal or object on the podium. Letters must be chosen in the correct order.
JAM	8 to 13	Immerse yourself in the world of Jam, where music gives life to a colorful landscape! Discover the four sound environments in creation mode or take up the challenge of replicating our compositions, which increase in complexity at each level.
NEWTON	8 to 99	Have fun in teams while doing math! Play in timed or points mode and add mathematical operations to increase the level of challenge. With one wall, two teams can play, and with two walls, four teams can play.
PUZZ	6 to 99	Work as a team to rotate the tiles and fix the picture!
CONSTELLO	8 to 99	Will you be able to place the stars at the right place on the Cartesian plane?
SWËT	10 to 99	Each player occupies a column. Standing 2 meters from the screen, they have to throw the ball as high as possible to score points. This activity can also be played with heavier balls to up the difficulty!
ZOO	4 to 5	Throw the ball at the wall and a small animal will appear! If you hit the target again quickly, your pet will grow!
ROAR	8 to 99	You must hit the target in the opposing goal. Players cannot travel with the ball; they must pass it. When a team scores, it triggers a special game that allows players to score additional points, then normal play resumes.
TARGETS	4 to 99	Test the accuracy and speed of your throws by hitting all targets of the same color. Play in score, timed, or “king of the hill” mode. Choose how to move targets and increase the level of difficulty as needed!
WÖRLDS	7 to 64	Wörlds gives you the opportunity to discover new worlds and to fully let your imagination go. Turn your gym into any universe you choose!
TACTÏK	4 to 99	A giant educational board to strategize with your sports team and create activities in your gym.
TEÄMS	4 to 99	Generate up to 6 teams randomly. Enter the number of players and how many teams you want and let Teäms do the work!
BËËP	4 to 99	Push your aerobic capacity to the limit (VO2 max) while exploring space alongside Rob the robot in this interstellar beep test.

DOJO	6 to 99	Made up of short challenges in the form of energetic exercise cards, Dojo gets children moving at the beginning of class and warms them up in an autonomous fashion.
SCOREBOARD	4 to 99	A scoreboard to use with all your games: team names, periods, timer, etc. You'll also find different sounds and lights that kids of all ages just love.
CHRONO	4 to 99	Manage time like a pro using these easy-to-use countdown timers, multiple team stopwatches, and customizable interval timer. Chrono is your personal time assistant to help you better organize your class.
MÖÖD	4 to 99	Introducing Mööd, the new utility that allows you to quickly know how your group is feeling. Students will be able to choose an emotion such as anger, sadness, joy, fear, neutrality, or calm.

Questionnaire (translated from French):

As part of the co-development of the matrix, we are promoting an evaluation framework based on scientific, technical, strategic, and value perspectives.

In order to contribute to the scientific credibility of your interactive game products and to promote the development of soft skills and executive functions in elementary school children, it was first necessary to take a scientific and psychometric approach. An initial list of competencies has been established according to the criteria of psychometrics, knowledge, and scientific rigor.

A feasibility review is required at this stage. It is also important to ensure alignment with your marketing strategy and your company's values and mission.

To do this, please complete the questionnaire below. You will be asked to rate, on a scale of 1 to 10, four (4) criteria which are described below. A comments section is also provided for each competency, as needed.

To summarize, the 4 response criteria for each competency are:

1- Feasibility of integrating competencies into game content

This criterion corresponds to the feasibility of integrating each of the competencies within the games produced by your company.

E.g.:

- **Have any of your games been built to assess this competency?**
- **Do any of your games have content that is conducive to assessing this competency?**

2- Feasibility of measuring each competency

This criterion corresponds to the feasibility of measuring each competency within the games produced by your company.

E.g.:

- **Do any of your games have any analytics that could measure this competency?**
- **Would any of your games lend themselves well to observing measurable behaviors related to this competency?**

3- Alignment with the company's values

This criterion corresponds to the degree to which the competencies match your company's vision.

E.g.:

- **Does this competency relate to your goal of helping every child thrive?**
- **Does this competency relate to your goal of engaging the full range of children's intelligences and their learning styles?**

4-Alignment with marketing strategy

This criterion corresponds to the degree to which the competencies align with your marketing strategy.

E.g.:

Table 8: ***Frequency of occurrence of each competency following analysis of the corpus.***

Competency	**Frequency of occurrence**
Problem-solving	88
Collaboration	57
Creativity	55
Communication	55
Use creativity	55
Communicate appropriately	55
Cognitive flexibility	49
Working memory	48
Planning/Prioritizing	48
Critical thinking	43
Responsible decision-making	42
Innovation	39
Leadership	38
Metacognition	36
Adaptability	34
Teamwork	34
Use information and communication technologies (ICT literacy)	32
Inhibition	30
Learning to learn	28
Cooperate with others	25
Interpersonal skills	24

Self-management	19
Inhibitory control	19
Shifting	18
Executive control	17
Time management	15
Systems thinking	15
Updating	15
Self-awareness	14
Social awareness	13
Sustained attention	12
Goal-directed persistence	12
Risk taking	12
Empathy	11
Selective attention	11
Organization	10
Attentional control	10
Goal-setting	9
Emotional regulation	8
Use information	7
Task switching	6
Task initiation	5
Task engagement	5
Tolerance for uncertainty	5
Computational thinking	4
Emotional control	4
Agency	4
Relationship skills	3

Critical judgment	2
Adopt effective methods	2
Achieve (one's) potential	2
Affective self-regulation	2
Frustration tolerance	2
Stress tolerance	0

Table 9: Definitions chosen based on a latent semantic analysis for each competency.

Critical thinking	Entails a judgement or evaluation for analysing claims, arguments and evidence and for making inferences using deductive and inductive reasoning to solve a problem or make a
Computational thinking	A problem-solving process that includes the characteristics of formulating and solving problems, logically organizing data, analyzing data, representing data through abstractions, and
Cooperation	To use teamwork effectively, to recognize which tasks can be done more effectively by means of teamwork, to assess his/her participation and that of peers in the team's work, To identify factors that facilitated or hindered cooperation, To identify desirable improvements for his/her participation in the next
Creativity	Ability to think differently and create new objects, ideas, and methods, Creativity is related to the production of new ideas on products, services, or processes that are both novel and
Communication	The ability to articulate thoughts and ideas in a variety of forms, communicate for a range of purposes and in diverse environments, and use multiple media and technologies.
Use information	To explore various sources and understand the use of each, to question information sources,
Problem solving	An individual's capacity to engage in information processing to understand and resolve problem situations where a solution is not immediately obvious. It includes the willingness to engage with such situations in order to achieve one's potential as a

Critical judgment	To qualify his/her judgment. To compare his/her opinion with those of others. To reconsider his/her position. To evaluate the respective influence of reason and emotion on his/her approach. To recognize his/her biases. To repeat the whole exercise if
Adopt effective methods	To begin the process, to reflect, before and during the action, on the best way to attain the objective, to adapt his/her work method to the task and the context, to anticipate the requirements of the method chosen and the resources that will
ICT literacy	The ability to understand and to use information from a variety of digital sources,
Achieve potential	Recognize their personal characteristics. Take his place among the others. Use your personal resources.
Inhibition	The ability to deliberately suppress dominant, automatic or prepotent responses in favor of more goal-appropriate ones,
Working memory	Refers to the memory system that consist of two components to temporarily store information the phonological loop and visuospatial sketch pad and one component for the processing or manipulating information the central executive,
Task initiation	Ability to begin projects without undue procrastination, in an efficient or timely fashion.
Sustained attention	The ability to maintain a tonic state of alertness during prolonged and sustained mental activity.
Planning/Prioritizing	Prior to learning, planning activities take place in order to predict the result or choose strategies.
Organization	Seek to work out and illustrate important information and relations by grouping single information into super-ordinate units of meaning in order to be processed and memorized more
Time management	Effective time management requires individuals to learn how to prioritize what to do in the time available.
Cognitive flexibility	The ability to switch between mental sets or tasks, involving in engagement with and disengagement from different aspects
Metacognition	Cognition about cognition, referring to second-order cognitions, Metacognitive processes can therefore control, monitor and regulate learning and cognitive activities in

Goal-directed persistence	Capacity to have a goal, follow through to the completion of the goal, and not be put off by or distracted by competing
Stress tolerance	Association between the cumulative number of life events experienced and various forms of symptomatology.
self-awareness	Capacity of becoming the object of one's own attention. In this state, one actively identifies, processes, and stores information
Self-management	The ability to work remotely, in virtual teams; to work autonomously; and to be self-motivating and self-monitoring. One aspect of self-management is the willingness and ability to
Social awareness	The ability to understand the social and cultural context and to interact with others in a given social context.
Responsible decision-making	Intellectual process leading to a response to circumstances through the selection among alternatives.
Agency	Belief that you are in control of the outcome of the activity.
Learning to learn	To pursue and persist in learning, to organise one's own learning, including through effective management of time and information, both individually and in groups. This competence includes awareness of one's learning process and needs, identifying available opportunities, and the ability to overcome obstacles in order to learn successfully. This competence means gaining, processing and assimilating new knowledge and skill as well as seeking and making use of guidance. Learning to learn engages learners to build on prior learning and life
Affective self-regulation	Refers to the control of short- and long-term emotional states related to the pupils' aspiration level, their hope –for success or fear –of failure, their persistence and epistemic resilience, and their readiness to tune themselves to different task affordances.
Emotional regulation	Extrinsic and intrinsic processes responsible for monitoring, evaluating, and modifying emotional reactions, especially their intensive and temporal features, to accomplish one's goals
Task engagement	To actively and positively participate in classroom activities in ways that are appropriate given the demands of the task
Interpersonal skills	Direct or incidental behaviors that allow effective teamwork, sustained collaboration, and a high level of motivation during the completion of a shared task. Skills that allow oneself to nurture an interpersonal connection with others, and act on such

Tolerance for uncertainty	The set of negative and positive psychological responses – cognitive, emotional, and behavioral – provoked by the conscious awareness of ignorance about particular aspects of
Frustration tolerance	Ability of individuals to respond to adversity or unmet needs positively and is an indicator of how willing they are to take on
Initiative	Ability to move from ideas to actions; Assumes creativity, innovation and risk taking, as well as the ability to schedule and manage projects to achieve goals.
Adaptability	The ability and willingness to cope with uncertain, new, and rapidly changing conditions on the job, including responding effectively to emergencies or crisis situations and learning new
System Thinking	The ability to understand how an entire system works; how an action, change, or malfunction in one part of the system affects the rest of the system adopting a “big picture” perspective. It includes decision-making and situation analysis as well as abstract reasoning about how the different elements of a
Attentional control	Includes the capacity to selectively attend to specific stimuli and inhibit prepotent responses, and the ability to focus attention for a prolonged period; Involves the regulation and monitoring of actions so that plans are executed in the correct
Goal-setting	The ability to develop new initiatives and concepts, as well as the capacity to plan actions in advance and approach tasks in an efficient and strategic manner.
Empathy	Individual’s ability to detect what another individual is feeling, and experience an emotion that is consistent with that feeling.
Executive control	A subset of cognitive processes involved in the intentional component of environmental interaction; it includes planning, working memory, coordination, and inhibitory control, as well as other effortful processes that must occur under conscious
Selective attention	The ability to facilitate the processing of one source of environmental information while attenuating the processing of
Risk taking	The ability to make decisions under uncertainty.
Task switching	Ability to flexibly switch between tasks in the face of goal
Inhibitory control	The ability to suppress prepotent or dominant responses in order to display the subdominant (or desirable) response.

Updating	The ability to monitor and revise the information that is active in working memory,
Leadership	It is a set of competencies; It includes aspects of communication and collaboration, along with a sense of vision for the future and competencies involving working with people.
Innovation	Innovative thinking trains the mind to question things which already exist, to challenge assumptions, and ultimately to think

Technical and strategic assessment according to the company's values

Competency	Content integration	Feasibility –	Mission and	Marketing strategy
	Average (Standard deviation)	Average (Standard deviation)	Average (Standard deviation)	Average (Standard deviation)
Critical thinking	6.33 (3.21)	5.67 (4.04)	9.33 (1.15)	9.00 (1.00)
Computational thinking	5.33 (3.79)	5.67 (4.16)	9.00 (1.00)	8.33 (058)
Collaboration	9.00 (1.73)	7.33 (2.31)	9.33 (1.15)	9.33 (1.15)
Cooperating with others	9.00 (1.73)	8.00 (1.73)	9.00 (1.73)	9.00 (1.73)
Teamwork	9.00 (1.73)	7.33 (2.52)	9.00 (1.73)	9.00 (1.73)
Creativity	6.67 (1.15)	5.00 (3.61)	8.67 (1.15)	7.00 (1.00)
Using creativity	8.33 (1.53)	6.00 (4.58)	9.00 (1.00)	8.33 (2.08)
Communication	8.00 (2.00)	3.67 (2.52)	7.00 (2.65)	6.00 (2.00)
Communicating appropriately	7.00 (2.65)	5.33 (4.51)	8.33 (2.08)	8.33 (2.08)
Using information	5.33 (4.04)	5.33 (4.04)	6.33 (2.31)	5.67 (1.15)

Problem solving	9.00 (1.73)	9.00 (1.73)	9.00 (1.73)	8.67 (1.53)
Exercising critical judgment	5.33 (4.51)	5.33 (4.51)	9.33 (1.15)	9.00 (1.00)
Developing effective work methods	5.00 (4.58)	6.67 (3.06)	7.33 (2.31)	7.00 (1.73)
ICT literacy	3.67 (3.06)	4.00 (3.00)	6.67 (4.16)	6.00 (3.46)
Achieving potential	5.00 (2.65)	4.67 (4.04)	9.00 (1.73)	7.33 (1.15)
Inhibition	7.67 (1.53)	5.33 (2.52)	7.00 (3.00)	6.33 (2.08)
Working memory	5.33 (4.04)	5.33 (4.04)	7.00 (2.00)	6.33 (1.15)
Initiation	5.00 (4.00)	5.00 (4.00)	6.67 (2.89)	5.00 (2.00)
Sustained attention	7.67 (2.52)	7.33 (2.31)	8.00 (1.73)	8.00 (1.00)
Planning	5.33 (4.51)	6.67 (3.06)	7.67 (2.08)	7.33 (2.52)
Organization	5.67 (4.51)	6.33 (3.51)	7.00 (2.65)	7.00 (1.73)
Time management	7.33 (2.52)	6.67 (3.51)	6.00 (2.65)	7.00 (3.00)
Cognitive flexibility	5.67 (1.15)	4.00 (3.00)	8.33 (1.15)	7.00 (1.73)
Metacognition	4.33 (3.51)	4.00 (3.00)	8.33 (1.15)	7.00 (1.00)
Goal-directed perseverance	7.00 (2.00)	8.33 (1.53)	8.00 (1.15)	7.00 (2.00)
Stress tolerance	6.67 (1.15)	5.00 (3.61)	8.67 (1.53)	7.33 (1.53)
Self-awareness	6.33 (2.08)	3.67 (2.52)	8.33 (2.08)	6.33 (1.53)

Self-management	4.33 (3.51)	4.67 (4.04)	8.00 (2.00)	7.00 (1.00)
Social awareness	5.00 (4.00)	5.00 (4.00)	9.00 (1.00)	8.33 (058)
Relationship skills	7.00 (2.65)	5.67 (4.04)	9.00 (1.73)	8.33 (1.15)
Judgement/decision-making	6.00 (4.58)	6.00 (4.58)	8.33 (1.53)	8.00 (2.00)
Agency	5.33 (4.04)	5.00 (4.00)	6.67 (1.15)	6.67 (1.15)
Learning to learn	5.33 (4.51)	5.33 (4.51)	9.33 (1.15)	8.67 (1.15)
Emotional self-regulation	7.33 (2.52)	6.67 (2.89)	9.67 (058)	9.33 (058)
Emotional regulation	6.67 (1.53)	5.00 (2.00)	9.00 (1.00)	8.33 (2.08)
Task engagement	7.67 (2.08)	7.67 (2.08)	8.33 (2.08)	8.00 (1.73)
Interpersonal skills	8.00 (3.46)	5.67 (3.79)	9.00 (1.73)	9.00 (1.73)
Tolerance for uncertainty	5.67 (4.51)	5.67 (4.51)	8.00 (1.73)	7.33 (058)
Frustration tolerance	7.00 (1.73)	6.00 (3.46)	7.67 (1.53)	6.00 (1.00)
Initiative	5.33 (4.51)	5.67 (4.51)	7.67 (2.08)	6.67 (1.53)
Adaptability	5.00 (4.00)	6.33 (2.31)	8.33 (058)	7.67 (058)
Reasoning	5.33 (4.51)	5.33 (4.51)	8.00 (1.00)	7.67 (058)
Attentional control	7.00 (1.00)	6.33 (058)	7.33 (1.53)	6.67 (1.15)
Goal-setting	4.33 (3.06)	5.33 (3.79)	6.67 (2.52)	5.67 (2.08)

Empathy	7.00 (2.65)	5.33 (4.04)	9.33 (1.15)	8.33 (058)
Executive control	7.67 (1.53)	8.00 (2.00)	8.00 (2.00)	7.00 (1.00)
Selective attention	6.67 (2.08)	6.00 (3.00)	6.67 (1.53)	6.67 (1.53)
Risk taking	7.67 (2.52)	7.00 (2.65)	7.00 (2.65)	6.00 (2.65)
Alternating tasks	6.00 (3.00)	5.00 (3.61)	6.67 (3.06)	5.67 (2.08)
Inhibitory control	4.33 (3.06)	4.00 (3.00)	7.00 (2.00)	4.67 (1.53)
Actualization	4.00 (2.65)	3.67 (2.52)	6.67 (1.53)	6.33 (1.15)
Leadership	8.00 (1.73)	6.33 (2.52)	8.00 (1.73)	7.67 (1.15)
Innovation	5.00 (4.58)	5.33 (4.51)	8.67 (1.15)	7.67 (058)
Reallocation of resources	6.33 (2.08)	6.33 (3.06)	6.67 (1.53)	5.67 (1.15)

Table 10: Competencies from the initial matrix and summary of the selection process for each competency that resulted in the final matrix.

Competencies in the initial matrix	Removed	Selection process
Computational thinking	No	Above the median score of the final
Cooperation	No	Above the median score of the final
Creativity	No	Above the median score of the final
Communication	Yes	Does not contain any unique test to evaluate it (uniqueness of the
Use information	Yes	Below the median score of the final
Problem solving	No	Above the median score of the final

Critical judgment	Yes	Below the median score of the final
Adopt effective methods	Yes	Below the median score of the final
ICT literacy	Yes	Below the median score of the final
Achieve potential	Yes	Below the median score of the final
Inhibition	No	Above the median score of the final
Working memory	Yes	Involved in the vast majority of cognitive activities and processes
Task engagement	No	Above the median score of the final
Emotional regulation	No	Above the median score of the final
Sustained attention	Yes	Does not contain any unique test to evaluate it (uniqueness of the
Planning/Prioritizing	No	Above the median score of the final
Organization	Yes	Below the median score of the final
Time management	Yes	Below the median score of the final
Cognitive flexibility	No	Above the median score of the final
Metacognition	Yes	Below the median score of the final
Goal-directed persistence	No	Above the median score of the final
Stress tolerance	Yes	Below the median score of the final
Self-awareness	Yes	Below the median score of the final
Self-management	Yes	Below the median score of the final
Social awareness	Yes	Below the median score of the final
Interpersonal skills	No	Above the median score of the final
Responsible decision-making	Yes	Below the median score of the final
Agency	Yes	Below the median score of the final