STEAM Education for Gifted Individuals

"GIFTLED: Learning by Design Method in My Educational Work"

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Handbook for Teachers

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Abstract

The aim of this book is to help teachers support their gifted learners and nurture their natural abilities in STEAM classrooms. In this respect, this book provides an alternative way to differentiate learning activities that involve a pedagogical strategy and suggest the use of augmented reality (AR) and digital design tools within that strategy to increase the engagement of gifted learners in STEAM education. This engagement encompasses high learner interest, addressing learner diversities, productivity, and a learning process through which the learners construct knowledge according to their skills. For this aim, this book introduces the GIFTLED method to promote the competency of teachers in integrating their gifted students into their STEAM lessons.

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CONTENT

Foreword

"The mediocre teacher tells. The good teacher explains. The superior teacher demonstrates. The great teacher inspires." - William Arthur Ward

Gifted individuals are learner groups who need special support in their education. They have exceptional abilities which can make them great scientists, artists, architects, poets, tennis players, or engineers who can contribute to the development of society supremely. Throughout history, gifted people invented beneficial things including scientific laws, theories, technics, and appliances or they wrote breakthrough novels, or never dying musical pieces. However, in history, they were not always treated in a good manner, even though they were sometimes humiliated or punished mostly due to their extraordinary ideas and work. These exceptionalities were the factors which moved society from one state to one developed other. In this respect, gifted individuals are gifts to society and it is a must for a society to provide opportunities and facilities for the gifted to furnish their skills and talents. In the historical process, numerous strategies have been developed to identify and educate gifted students. As they developed and progressed, they became more fine-grained in terms of considering the differences in personal, cognitive, socioemotional, and learning characteristics of gifted learners. Further, the attempts have included more variety in strategies, including educational technologies, to increase the engagement, motivation, knowledge, skills, and creativity of gifted learners.

In recent years, in the educational policies of many countries, Science-Technology-Engineering-Arts-Mathematics (STEAM) education has been an indicator of educating students for a global, digital, competitive, and industrialized world. As such, as the persons who have exceptional abilities, gifted students have been seen as a championing group for both reaching their potential in STEAM education and producing the ideal STEAM education learner profiles. In this respect, this book offers valuable knowledge and instructional skills for teachers to engage and support their gifted learners in STEAM classes through the introduction of novel instructional strategies and the use of augmented reality and digital design educational tools.

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1 Introduction to GIFTLED Method

Zekai Ayık

A well-designed and effective education is inclusive, productive, and responsive to all the learner differences in the classrooms (Davis et al., 2014, p. 47). Even though the learners are the same age and have many similar characteristics, they are not alike regarding personality, hobbies, social preferences, cognitive abilities, or interests. These differences make the learners unique individuals and determine their potential and limits (Tomlinson, 2017, p. 2). The learner differences also are seen in the learning speed and the ability to think abstractly or conceive complex ideas. Furthermore, students' prior understandings, beliefs, and attitudes about self and school are other important differing factors that a teacher should consider in their teaching practices (Tomlinson, 2017, p. 14).

Considering this reality, teachers need to be aware of varied learner profiles and needs and provide students with plenty of learning options. This awareness should lead to creating a learning space where knowledge is clearly and powerfully organized (Erickson, 2006), students are highly active and engaged in the learning process (Hattie, 2012; Tomlinson, 2017), students feel a sense of safety and community, and where assessments are rich and varied and yield meaningful feedback (Black & Wiliam, 2010). What is more, according to Tomlinson (2017, p. 14) learning happens optimally if the learning experiences push and encourage the learner a bit beyond his or her independence level. Accordingly, if too little, as when a learner goes to work on knowledge and skills already mastered, or achieved little if learning takes place. If the challenge is too great, and tasks or works are far beyond a student's current point of mastery or potential, the outcome is frustration, not learning. Besides, learning in the classroom should take place best if the motivation of the learner increases and feels a kinship with interest in, or passion for the subject (Wolfe, 2010).

Teachers can meet this challenge arising from learner differences mentioned above if they draw on the best available pedagogical knowledge regarding teaching and learning and context knowledge based on the needs of different learners (Shulman, 1986). This is a matter of the fact of how people learn. Teachers can address the instructional requirement and make plans if they know the characteristics of different learners and their learning needs and if they make their instruction differentiated in a way responsive to these differences (Tomlinson, 2017). As such, in all kinds of educational experiences and for successful learning whatever the success criteria are, learner differences must be considered, and the pedagogical strategies should be fine-tuned according to the needs originating from learner differences.

1. Gifted Learners

Gifted learners are one of the groups with significant learner differences, styles, and characteristics in comparison to their peers in the classrooms. Numerous studies up to date have explored the learning, attitude, and socio-emotional characteristics of gifted learners and pointed out how they are different from their peers and among themselves. Gifted individuals are different regarding their traits, aptitude, and behaviour. They are different in several traits including cognitive, creative, affective, and behavioural aspects (Hyde et al., 2011). The differences in traits encompass motivation (evidence of a desire to learn), interest, communication skills (highly expressive with words, numbers, or symbols), problem-solving ability (effective strategies for recognizing and solving problems), memory (large storehouse of information on the school or non-school topics), inquiry and curiosity (asking questions, experimenting, explore), insight (quickly grasps new concepts; sees connections; senses deeper meanings), reasoning (logical approaches to figuring out solutions), and creativity (Hyde et al., 2011). Furthermore, Sternberg (2005) posits that gifted learners have analytical, creative, and practical skills. According to Renzulli (2005), gifted students have high IQ, creativity, and task commitment. Gagné (2004) asserts that gifted learners have superior natural abilities (gifts) regarding intellectual, creative, socio-affective and sensorimotor skills and these abilities are the drivers of abilities to fulfil or perform a task (Further information about giftedness and characteristics of gifted learners is given in Chapter 2).

If the gifts as natural abilities are nurtured and supported through an appropriate developmental process, they evolve into talents which are well-trained skills characteristic of a particular field of human activity performed in an occupational field such as engineering, arts, or architecture (Gagné, 2004). In this respect, many scholars the importance of addressing the special needs of gifted learners for mainly two reasons. First, gifted individuals have special learning needs which must be addressed, otherwise can cause negative attitudes toward learning, a decrease in motivation, talent losses, academic failures or even quitting school (Renzulli, 2016). Therefore, the gifted learner will be in a disadvantageous situation if their special needs are not addressed in the classroom. Secondly, gifted individuals are important persons for economic development and human resources for countries (Besançon, 2013). Also, Renzulli (2016) adds "that the major purpose of gifted education is to increase the world's reservoir of creative and productive people —the people who will become the inventors, authors, scientists, artists, entrepreneurs, and the business, political, social, and economic leaders of the future". Therefore, providing appropriate educational experiences for gifted learners will contribute to the development of society in many fields such as science, arts, technology, literacy, and engineering. However, Gubbels et al. (2014) note that the underachievement of gifted learners is most profound in STEAM fields such as science and technology.

2. Addressing the educational needs of gifted learners

Studies in the field of gifted education are at a strong consensus which highlights that meeting special educational needs depends on applying differentiation strategies over their teaching practices. Teachers should be aware of the remark of Feldhusen (1989, p. 9) who says that "the differentiation is sparked by the realisation that it's no longer possible to look at a group of students in a classroom and pretend they are essentially alike". Therefore, to make teaching responsive to a range of diversity in classrooms and ensure that all students learn and grow, differentiation strategies should be deployed as pedagogical and philosophical approaches to instruction (Brigandi et al., 2019). In a single sentence, differentiation is viewed as "teachers proactively and intentionally strive to differentiate curriculum, instruction, and assessments using student data to modify the content, process, product, and learning environment based on student readiness, interests, and learning profiles" (Brigandi et al., 2019, p. 365). The principles of effective differentiation strategies are well explained in Chapter 3. As such, appropriate differentiation strategies consider gifted students' needs, interests, abilities, readiness levels, and learning profiles. Suppose a teacher aims to provide differentiated instruction. In that case, she should "create learning opportunities within a high-quality curriculum, to maximise the probability that all students will become engaged in learning, experience efficiency of learning, and experience cognitive growth" (Renzulli, 2016, p. 602). In this wise, to make the instructions responsive to gifted learners' differences, a teacher provides multiple options for taking in information, making sense of ideas, and expressing what they learn, which is developing products so that each student can learn effectively (Tomlinson, 2017).

Teachers should employ various differentiation strategies such as accelerating, curriculum compacting, or enrichment to address the different learning needs of gifted learners in the classroom. Enrichment is the most preferred and explored option for differentiation. Earlier definitions of enrichment posit that enrichment strategies aim to promote higher levels of thinking and creativity in a subject field and allow students to explore that subject in depth (Kim, 2016). Enrichment strategies essentially are delivery methods for achieving process and content goals of the curriculum. Process goals include developing such skills—or processes—as creative thinking and problem-solving, critical thinking, scientific thinking, and others (Davis et al., 2014) (see Chapter 10). The content goals engage the subject matter, projects, and activities within which the processes are developed. As such, in an enrichment strategy, addressing the need of gifted learners refers to nurturing and developing gifted learners' skills including thinking skills (creative and analytical abilities), learning skills, research skills, and affective skills (personal and social skills). This means that enrichment provides more challenges regarding cognitive and affective experiences. In the end, in a subject matter or any field of education, a teacher chooses an appropriate enrichment strategy which involves an appropriate pedagogical approach, content, activities, and assessment to support and fulfil gifted students' abovementioned skills (which will be described extensively in Chapter 4) for increasing engagement and learner potential.

3. Supporting Gifted Learners in STEAM Education

In the age of technological advances, globalisation and knowledge, global education curricula emphasize STEM (Science, Technology, Engineering, and Mathematics) education in schools. The main aim behind this endeavour is to educate the next generation of students/learners to become technology literate and take interest in subjects or fields such as science, technology, engineering, and mathematics in the face of increased economic competition (Khine & Areepattamannil, 2019, p. iii). Therefore, educational policies across the world incorporated STEM into their agenda for a long time, and many efforts have been made to support teachers for appropriate and effective STEM education (Tytler, 2020). (Khine and Areepattamannil (2019)suggest that, along with the progress in the STEM curriculum, teachers employ instructional strategies to help new generations function well in the future society and equip them with twenty-first-century skills that include creativity, innovation, and entrepreneurship.

Recently, STEAM is blended with another letter in the acronym, which is Art. Art is integrated into the curriculum and evolved into STEAM. According to Spector (2015, p. 5), STEAM refers to "the inclusion of the liberal arts and humanities in STEM education; some STEAM conceptions simply use the 'A' to indicate a fifth discipline area—namely, arts and humanities''. The main aim was to include the fifth discipline to provide a well-rounded approach to education through which more learners will be engaged and bring creativity, innovations, and design to life and enhance society's products (Sickler-Voigt, 2023). The recruitment and retention of students in STEAM careers and the development of STEAM skills and appreciation is a worldwide focus (OECD, 2016). STEAM education promotes a deeper understanding of the interdependent nature of STEAM disciplines, supports deeper levels of problem-solving, creativity and higher-order thinking (Morris et al., 2021) and links to application in an authentic context. (Further information about STEAM will be presented in Chapter 4). Since STEAM plays a crucial role in national development, economic productivity, creativity, innovation and societal well-being (Tytler, 2020), educators need to provide learning opportunities which require the integration of STEAM skills and include all learners with supporting their skills and potential (Morris et al., 2021) (20).

Integrating gifted learners as high-ability individuals is a crucial task and this endeavour has a dual face. First, STEAM learning aims at the promotion of higher-order cognitive skills, creativity, production of authentic content, problem-solving, or inquiry, these pedagogical aims suit well as essential elements of educational experiences for gifted learners. These pedagogical elements should support engagement, creativity, and autonomy over the depth and breadth of the content, interests, self-efficacy, and production for gifted learners. Therefore, appropriate STEAM learning may be a good differentiation strategy for the gifted-(Mun & Hertzog, 2018). Second, STEAM education could be more effective and successful in reaching its eventual aims mentioned above if gifted students are well engaged in STEAM education since they are considered as most capable students regarding the abovementioned skills (Morris et al., 2021). (More information will be presented in Chapter 4)

Since gifted individuals are successful learners of productive STEAM, and STEAM is a good opportunity for gifted students if they are supported in their skills, encouraged in interest, and demonstrate their potential, teachers in classrooms should employ strategies for integrating gifted learners in STEAM education. But researchers (e.g. Morris et al., 2021) show that there are barriers to the integration of gifted learners for effective STEAM education. These barriers generally limit their ability to engage in in-depth and advanced STEAM learning experiences and pursue STEAM occupations. One evidence of this situation is the underachievement revealed by PISA (2009). Gettings (2016) critiques current STEAM education practices since the content fields are divided and explored separately like traditional approaches. It was highlighted that appropriate strategies should be deployed for supporting creative problem-solving, individual learning, task commitment, and social responsibility by engaging students in high-level thinking and synthesizing meaningful content across disciplines (Wilson, 2018). VanTassel-Baska and Hubbard (2016) posit that if teachers employ appropriate pedagogical strategies, quality STEAM lessons can be performed. Therefore, the most crucial way to increase the engagement and success of gifted learners in STEAM lessons is to embrace effective differentiation strategies including enrichment (Morris et al., 2021). Teachers should be supported end equipped with effective pedagogical knowledge and pedagogical content knowledge for maximum engagement and support for their gifted students in STEAM education.

Regarding the arguments and knowledge proposed so far, the GIFTLED project and its consortium aim to develop an enrichment method and resources which will help teachers for support and better engage their gifted learners in STEAM education. The differentiation strategy will be over the process and environment (tools) elements of the gifted STEAM education curriculum. In this respect, the project proposes a new pedagogical approach and the use of innovative technologies for teachers of the gifted. In the next sections, we will explain the specific pedagogical approach and use of augmented reality (hereafter AR) and digital design tools (hereafter DDTs) in the STEAM education of gifted learners. At the end of this chapter, we will explain the GIFTLED Method.

In this proposal, three intersecting points to explain. First, pedagogy is conceived as the methods employed by teachers to instruct and teach learners and defined by Cope and Kalantzis (2015, p. 71) as a knowledge process since "it involves a critical and iterative (re)consideration of students' knowledge and abilities as a teacher carefully calibrates the distances between the learner's known lifeworld and the transformational possibilities of the to-be-known. Secondly, Reis et al. (2021, p. 2) defines enrichment pedagogy as the teaching methods that respond to students' academic strengths and interests and remarks that:

"Enrichment theories usually are interest-based; integrate advanced content, processes, and products; include broad interdisciplinary themes; foster effective independent and autonomous learning; provide compacted, individualized and differentiated curriculum and instruction; develop investigative creative problem-solving abilities and creativity; and integrate the tools of the practising professionals in the development of products."

Third, a bona fida enrichment approach in STEAM education aims to increase STEAM skills and attitudes. These skills include cognitive thinking skills (creative, problem-solving, decision-making, critical thinking, and logical thinking), affective skills (interpersonal and intrapersonal), learning skills, research skills, and communication skills (Renzulli, 2016). Regarding the processes or the instructional activities in enrichment strategy, according to Tomlinson (2017, p. 12) the process is a sense-making activity which is a vehicle for learning which includes what students need to know, understand, and be able to do. Therefore, an effective enrichment strategy should be viewed as a sense-making process designed to help a student progress from a current point of understanding to a more complex level of understanding. Learners make sense of ideas and information if the activities are interesting, promote higher-level thinking, and require learners to use knowledge, skills, and understanding (Tomlinson, 2017, p. 12). Process differentiation according to this approach should include (1) the learning and usage of abstract thinking skills, including creative thinking, critical thinking, and problem-solving, (2) the application of abstract thinking skills to complex content, resulting in the production of sophisticated products and, (3)-the integration of basic skills and abstract thinking skills (Hyde et al., 2011). In such a process, learners transfer their knowledge to higher levels of abilities mentioned above and which ends with creative production in authentic settings. In other words, the knowledge transfer process includes experiencing, conceptualising, analysing, and applying. As such, an enrichment strategy in which gifted learners transfer their knowledge in STEAM education should engage those elements and stages.

For making knowledge transfer and creative productivity according to learners' interests and abilities, well-conceived levels of activity should be implemented. These levels should be seen as the breadth of enrichment. Wilson (2018) proposes that such an enrichment process is triggered by external stimulation, internal curiosity, necessity, or combinations of these which result in developing an interest in a topic, problem, or area of study in STEAM fields. This can be achieved by exposure to fields or studies in which students might have interests. In this stage, learners are situated in their interest fields. Such kinds of activities may involve exploration of the field, hands-on activities, and investigative opportunities which allow the learner to situate and discover their interests. Furthermore, an appropriate enrichment strategy involves training and methods instruction teaching them how to integrate advanced content, thinking skills, and investigative and creative problem-solving methodology to self-selected areas of interest, and a process skills component (Davis et al., 2014). Finally, it was expected to engage opportunities to pursue self-selected topics of interest to students and provide them with the opportunities, resources, and encouragement to apply these skills to self-selected problems and areas of interest (Kim, 2016; Renzulli, 2016). Besides, each student needs challenge and success, and addressing learner differences requires a flexible approach to teaching (Tomlinson, 2017).

4. A new approach to gifted STEAM education: "Learning by Design"

Since pedagogy is accounted as a knowledge process where the learner transfers the knowledge according to her interest, skills, and creativity, an effective enrichment pedagogy for gifted learners. Therefore, process as a curriculum element in the enrichment strategy should engage learning activity sequences which are classified according to "what and how" learners can do to know. In this respect, Cope and Kalantzis (2015) suggest an approach in which the learning process is designed for activity types by teachers to implement knowledge processes including 1) experiencing the known and unknown, 2) conceptualising the abstract and theoretical, 3) analysing functions and perspectives, and 4) applying knowledge appropriately and creatively. Such an approach for an enrichment strategy will lead to learning with understanding where gifted learners will (1) grasp the underlying theories, principles, processes, attitudes and beliefs in and across the academic disciplines; (2) they can apply what they learn, (3) can transfer their understanding to familiar and unfamiliar contexts; and (4) integrate many types of knowledge to design and produce in a creative way according to their interests.

The concept of design here is two-fold. First, the teacher is the designer of the process taking into consideration learner differences and learner needs. Second, the gifted learner is the designer who uses her/his knowledge and knowledge transfer through active engagement in learning activities regarding interest, skills, and creativity. In the end, the designed learning process, and learners' design activities support the skills and motivation of the gifted. Cope and Kalantzis (2015, p.38) offer the following activity types (See Figure 1.1), and we advocate these activity types for the enrichment process in gifted STEAM education.

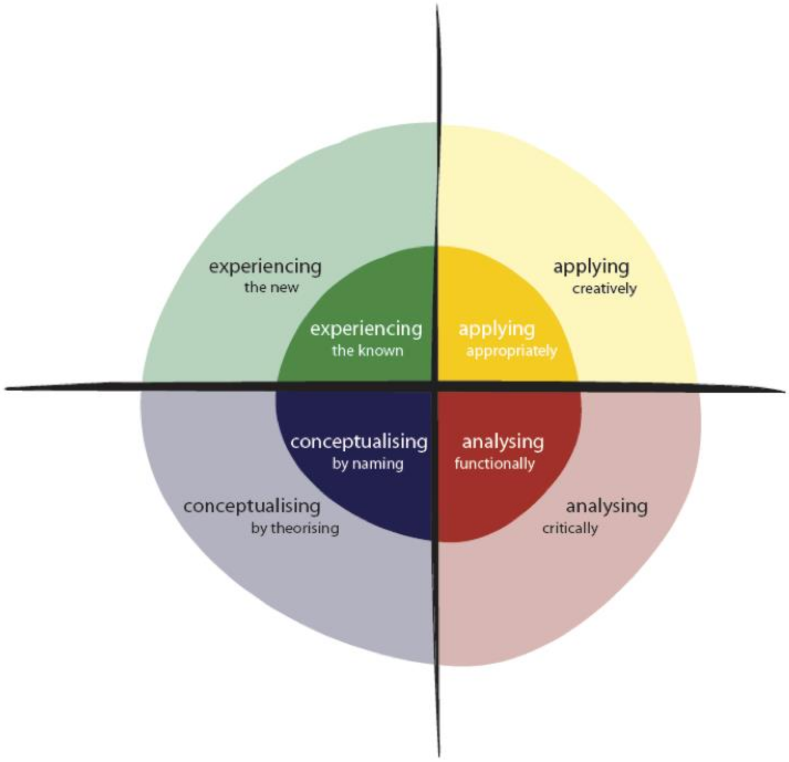

Figure 1.1: Learning by Design Activities

a) Situated practice (Experiencing)

Human cognition is situated and contextual and (Gee, 2004) notes that meanings are grounded in real-world patterns of learners' experiences, actions, and subjective interests. In this type of activity, the learner experiences various known and unknown information, or situations regarding the content field more than the school offers. In the situated practice, learners participate in a knowledge process through which personal experience, concrete engagement, and exposure to evidence, facts and data take place. This participation engages in experiencing the known and unknown. The former refers to "regular returns to student lifeworld experiences, knowledge, and prior experience with metacognitive reflections" and the latter is "Immersion in the range of information sources such as those now available on the web, as well as hands-on activities and immerse experiences" (Cope & Kalantzis, 2015, p. 15). Therefore, in the STEAM class, the gifted learner can explore many known and unknown topics, fields, or interest areas which will also raise interest. Through such experience, the gifted learner will see what is going on in the fields by immersing herself, having resources that can be provided by an expert, or engaging in exploratory activities which are designed to spark his/her interest.

b) Overt instruction (Conceptualising)

In this activity type or phase, the learner conceptualises unknown abstract and theoretical knowledge. Cope and Kalantzis (2015, p. 15) note that “disciplinary knowledge is based on finely tuned distinctions of concept and theory, typical of those developed by expert communities of practice” and remark that in the conceptualisation process, the learners are not merely passive receivers of information from the teachers, it is knowledge process “in which the learners become active conceptualizers, making the tacit explicit and generalising from the particular”.

Here teachers are expected to follow instructional strategies or activities in which learners use their existing knowledge to build new conceptions. Overt instruction activities involve categorising by naming and by theory. In the former, learners make categorizations, classifications, and definitions of concepts. Conceptualising by naming involves drawing distinctions, identifying similarities and differences, and categorising with labels. By these means, learners give abstract names to things and develop concepts. In the latter, learners develop disciplinary schemas and mental models. Such theorising involves explicit, overt, systematic, analytic, and conscious understanding, and uncovers implicit or underlying realities which may not be immediately obvious from the perspective of lifeworld experience. Conceptualization is quite crucial for transforming knowledge into creative learning products since they are vehicles for exploring the nature of the disciplines, for thinking in disciplinary ways, and for improving expertise in the disciplines. When the conceptualization happens, the gifted learner will connect the new knowledge with old knowledge, transfer understanding to new situations, and retrieve previously learned knowledge quickly. In this activity type, teachers are expected to introduce the new knowledge through a learner experience where the gifted learner sees the relation and connection between the old and new knowledge and the conceptualization take place at the highest stake across disciplines.

c) Critical framing (Analysing)

According to Cope and Kalantzis (2015), in-depth and powerful learning engages learners to improve their critical capacity. For the pedagogical context, the term ‘critical’ accounts for analysing and evaluating knowledge. By means of analysis, Cope and Kalantzis add that “learners examine the interrelation of the constituent elements of something, its functioning, and the underlying rationale for a particular piece of knowledge, action, object or represented meaning”. Critical framing activities engage learners to make two kinds of analyses. First, learners analyse functionally in which they examine functions of arguments, explanations, actions, objects, dynamic structures, designs, processes etc. Cope and Kalantzis (2015) note that learners should ask such questions. What does it do? How does it do it? What is its structure, function, relations, and context? What are its causes and what are its effects?

Second, learners analyse critically which encompasses analysis of the aims, and interests of people and the purposes of knowledge or its functioning in the related discipline. In such activities, learners are expected to develop their independent learning skills, and the quality of their personal assignments, projects, and research.

Heilbronner and Renzulli (2016) point out that, through this type of activity, the gifted learner obtains analysed knowledge which develops thinking skills such as "interpreting; extrapolating; recognizing attributes; discriminating between same and different; comparing and contrasting; categorizing; classifying; determining criteria; ranking, prioritizing, and sequencing; seeing relationships; determining cause and effect; pattern finding; and making analogies". These skills are seen as the higher-order thinking skills regarding analysis, synthesis, and evaluation in Bloom's taxonomy. Most of these skills are considered in the context of 21st-century thinking skills. Such activities can be debates, simulations, role-playing, critiquing, and questioning that focus on attitudes, values, conclusions, and why, how, and cause-and-effect are typically the ways in which analysis skills are developed.

d) Transformed practice (Applying)

The final activity type described by Cope and Kalantzis (2015) is the transformed practice through which the learners apply their knowledge and understanding to the diversity of real-world situations regarding their interests and creativity. Heilbronner and Renzulli (2016) propose that learners obtain applied knowledge with which "a major focus on providing opportunities to pursue real problems in investigative and creative ways". In this stage, the learners design their own learning products which engage problem solutions, product designs, artistic designs etc.

Transformed practice enrichment activities include two types of activities. The first is applying appropriately in which the learner puts meanings and knowledge to work effectively in proximate context. Knowledge Process by means of which knowledge is acted upon or realized in a predictable or typical way in a specific context. The second is applying creatively in which learners transfer knowledge to a different context, hybrid knowledge, and express their problems, solutions, new ideas, and creations in a creative way according to their interests and skills. This creative application takes knowledge and capabilities from one setting and adapts them to quite a different setting. Therefore, gifted learners act innovatively and creatively according to their interests, experiences, and aspirations which originate from their natural abilities and talents. In the end, they transfer their newly obtained knowledge into a new setting.

Heilbronner and Renzulli (2016)18 remark that these activities are more advanced levels of problem-solving and the construction of knowledge which require curiosity, creativity, and task commitment. In these activities gifted learners are required to go beyond prescribed problems, and even teacher-assigned problem-based learning activities. Renzulli and Reis (2014) add that in such activities the focus is on "(a) personalization of interest, (b) the use of authentic investigative and creative methodology, (c) problems without predetermined correct answers, and (d) the development of a product that will have an impact on one or more intended audiences". In this respect, students design authentic products at the most individual and creative level in which gifted learners have roles as first-hand investigators, writers, artists, or other types of practising professionals.

5. The use of AR and digital tools for fostering learning experiences of the gifted

VanTassel-Baska (2003) proposes that the curriculum experiences for gifted learners need to be carefully planned, written down, implemented, and evaluated in order to maximize the potential effect. As said earlier, this is possible through the differentiation of curriculum elements which are the environment and the tools used in the learning activities. One way to promote gifted learners' education is the integration of technology into the learning environment and the differentiation of learning tools.

According to the International Society for Technology in Education (ISTE, 2016), technology provides numerous opportunities which involve creativity and innovation, communication and collaboration, research and information fluency, critical thinking, problem-solving, and decision-making, digital citizenship, technology operations and concepts. Learners are viewed as empowered learners, digital citizens, knowledge constructors, innovative designers, computational thinkers, creative communicators, and global communicators. In this respect, Puentedura (2009) explains that digital tools can be used as a means for learning and transforming knowledge towards individualized and creative products. It was also added that if the digital tools are used in an appropriate way during the learning activities, they can make a significant increase in learner engagement and interest. Davis et al. (2014) and Housand (2016) suggest a model in which the teachers of gifted learners use technology in their classroom. If the teachers become aware of the potential and promise of technology for gifted classrooms and if they help their students to use technology meaningfully, learners' creativity, interests, productivity, and responsibility (or task commitment) can be increased. Digital tools also increase the sophistication of the products that gifted and talented students can design. Furthermore, the use of digital tools will make the learning experiences more meaningful and attractive since the children of the era are digital natives.

The use of digital tools and applications will be more valuable in the STEAM class since technology enables more productive tools, design and intersecting interdisciplinary works. Digital tools and applications can be used for acquiring, analysing, and applying knowledge. In other words, especially internet-connected devices and digital tools applications help learners acquire knowledge, apply, and design new products according to their interests and creativity. Augmented reality (AR) tools are among the digital tools which are used in educational practices across many disciplines such as STEAM disciplines. The AR tools allow computer-generated virtual imagery information and knowledge to be overlaid onto a live direct or indirect real-world environment in real-time (Zhou et al., 2008). In a classroom-based approach, the AR tools provide knowledge acquirement, analysis, and application of knowledge. Besides increasing motivation and engagement, digital design tools and applications provide numerous design opportunities where students can creatively produce their own learning products. In this respect, the teachers should benefit from various opportunities provided by digital design and AR tools and digital design tools for differentiating the learning environment and promoting the learning process with high engagement, motivation, and productivity. (More information will be presented in Chapters 5 and 6).

6. GIFTLED: A New Method for Fostering Gifted Learners in STEAM Education

This project proposes a new and innovative enrichment method which aims to foster STEAM education of gifted learners and provide effective resources and tools for teachers of gifted. Considering the gifted learners' differences, abilities, and potentials, the GIFTLED method aims to promote STEAM learning regarding (1) maximum achievement in basic skills, (2) content beyond the prescribed curriculum, (3) exposure to a variety of fields of study in STEAM, (4) student-selected content, (5) high content complexity, (6) experience in creative thinking and problem-solving, (7) development of thinking skills, (8) development of digital literacy skills (9) affective development including intrapersonal and interpersonal, (10) development of productivity, and (10) development of motivation and engagement.

For this aim, firstly, the GIFTLED method adopts the "learning by design" approach as the pedagogical and instructional strategy. It follows and employs the activity types which enable the transformation of knowledge according to gifted learners' skills and potential. In other words, the "learning by design" approach is a strategy for the differentiation of processes in STEAM learning for gifted learners. Secondly, for achieving the above-mentioned aims, the GIFTLED method integrates digital design tools and AR applications. Digital design tools and AR applications are used in the "learning by design" approach in STEAM education. The use of these digital tools is a way to differentiate the learning environment. Teachers will use AR tools in the first three stages of the "learning by design approach". In the fourth stage of the approach, students will use digital design tools (DDTs) for applying the knowledge and design their own creative learning products. The GIFTLED method is visualised in Figure 1.1 below. In the forthcoming parts of the handbook, the teachers will be informed in detail regarding how to use and adapt the GIFTLED method in their STEAM education.

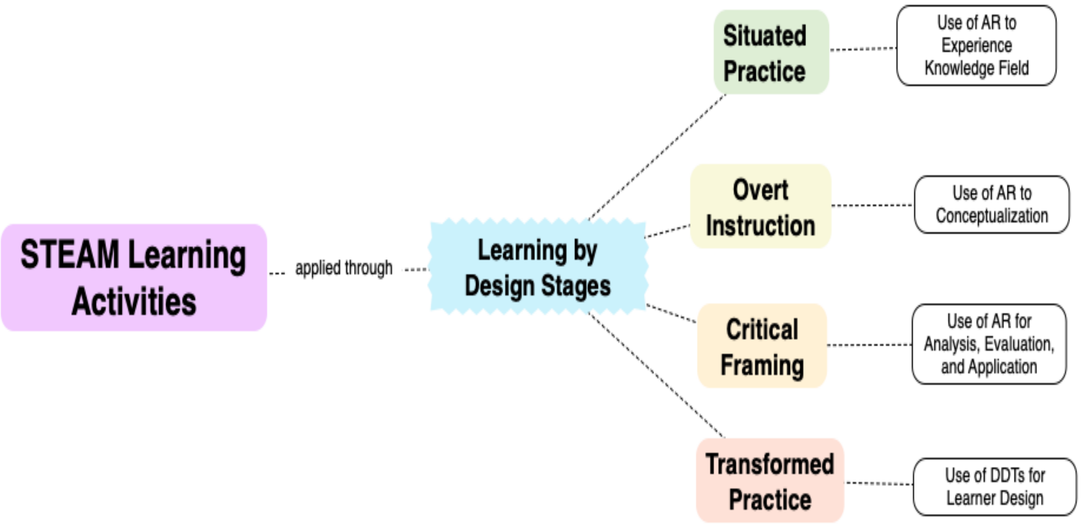

Figure 1.2: Overview of GIFTLED Method as an Enrichment Strategy

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2 Gifted Individuals and Learning Characteristics

Georgia Ropi

1. Who are gifted Individuals: Description of giftedness and gifted individuals

The diverse needs of modern societies necessitate harnessing society's full potential for the benefit of social, technological, and cultural development, which will benefit both people and the environment. As a result, it is critical to fully utilize all available potential. A special role in this regard can be played by gifted individuals, whose abilities are above average and can be especially beneficial to their environment and humanity in general.

The term "gifted" has a nearly 150-year history, but it has remained elusive as it has changed and expanded over time with the addition of new data provided by research (Castellano & Matthews, 2014). Perhaps the most generally accepted definition is that contained in the Javits Gifted and Talented Act (National Society for the Gifted and Talented, 2013):

> "Children and youth with outstanding talent perform or show the potential for performing at remarkably high levels of accomplishment when compared with others their age, experience, or environment. These children and youth exhibit high-performance capability in intellectual, creative, and/or artistic areas, possess an unusual leadership capacity, or excel in specific academic fields. They require services or activities not ordinarily provided in the schools. Outstanding talents are present in children and youth from all cultural groups, across all economic strata, and in all areas of human endeavor." (U.S. Department of Education, 1993, p. 3).

According to the National Association for Gifted Children (as cited in Borders, Woodley, and Moore, 2014), a child must demonstrate exceptional reasoning, learning, or ability in one or more domains, such as math, music, language, or psychosomatic skills, such as painting, dance, and sports, and be in the top 10% relative to his or her peers, a percentage limited to 5% in Illinois Sec 14A-20. According to the United States Department of Education (as cited in Davis, Rimm, and Siegle, 2014), a gifted student's demonstrated abilities should address the following areas: 1. General intellectual ability 2. Specific academic aptitude 3. Creative or productive thinking 4. Leadership ability 5. Visual and performing arts 6. Psychomotor ability. It is also important to note that "exceptional performance" is always judged relative to peers, based on higher performance on ability or achievement tests than their peers (Subotnik, Olszewski-Kubilius, & Worrell, 2011). A rare form of giftedness is "prodigy", which implies gifted individuals with abilities comparable to those of skilled adults in the special domain (Olszewski-Kubilius, Subotnik, & Worrell, 2016).

Sternberg (1995) defines five dimensions of giftedness: excellence (exceptional ability in a field), rarity (ability that is only rarely found in peers), productivity (the ability should be efficient, produce results), demonstrability (the ability should be able to be demonstrated by valid tests), and value (the exceptional ability should be of value to society), which means that giftedness is not a self-existent entity that only affects the individual, but should be applicable to society as well. Renzulli (Renzulli & Reis, 2003) believes that charismatic behavior is a function and interaction of three basic groups of human characteristics: above-average cognitive ability, high task commitment, and a high degree of creativity, which can be applied to any area of human activity. As a result, giftedness could be defined as the early identification and development of gifted individuals' potential for exceptional performance and success in adulthood (Pfeiffer, 2012).

One issue with the definition of giftedness is that it has traditionally been associated with intelligence alone, with certification resulting from IQ tests that place the examinee at a level of intelligence of 130 or higher. It was recognized as early as the mid-1970s that intelligence is only one dimension of giftedness and that IQ tests only capture a limited range of abilities, leaving out important abilities related to academic success or life success (Castellano & Matthews, 2014; Nisbett, 2009; Worrell, 2009). It is also worth noting that there are gifted children with disabilities, commonly referred to as "twice-exceptional children" (Davis et al, 2014).

Giftedness is defined by Worrell and Erwin (2011) as ability without the presence of practice or training: a person is considered gifted if their natural ability is in the top 10% of their age group. From there, giftedness emerges, which describes the application and practice of skills in a specific domain to reach the top 10% of individuals of one's age participating in the same domain. Gagné (2005) emphasizes the distinction between 'giftedness' and 'talent,' stressing the influences of the environment (home, parents, school, companionship, activities, etc.), non-intelligence-related factors such as motivation and character, and education and training, which transform genetic giftedness factors into specific talents in specific areas (e.g., math, science, language, arts, leadership, etc.) Hence Sternberg's (2003) view that gifted individuals are those who can transform the raw materials of their life situations into successful experiences.

Giftedness, according to this viewpoint, is a social construct, which explains why an individual who is considered gifted in one cultural context may not be considered so in another (Pfeiffer, 2012). Similarly, Tannenbaum (1983) regards giftedness as the result of a five-factor interaction: general ability, specific ability, non-cognitive factors, environmental influences, and luck. Heller (2005), too, views giftedness as a combination of genetic and environmental factors. The underrepresentation of students from minority or disadvantaged ethnic groups (such as African Americans or Latinos in the United States) in gifted groups, whereas Asian Americans and European Americans are overrepresented, demonstrates the importance of environmental factors in the development of giftedness and talent (Worrell, Subotnik, Olszewski-Kubilius & Dixson, 2019).

It is interesting to note that giftedness is characterized by an asynchronous development of developed mental and emotional abilities and skills in comparison to the norm for the population as a whole. This asynchrony, in fact, increases as cognitive ability increases, making gifted individuals vulnerable and necessitating appropriate manipulation and counselling by the parental and educational environment in order for the gifted individual to develop properly (Colombus Group, as cited in Borders et al., 2014).

The preceding evidence suggests that giftedness necessitates appropriate educational and social support in order to reach its full potential. This is due to the fact that, while giftedness exists at both academic and non-academic levels, it is most commonly associated with education and school (Worrell et al., 2019). This is why the process of identifying gifted individuals, particularly in schools, is crucial.

2. How gifted individuals are identified: Identification of gifted individuals

Identification is a critical factor in the recognition and exploitation of giftedness, and it is directly related to the student's education, family, and social environment. Without identification, gifted students' talents may never be revealed, and in any case, these students are denied the right to an education that matches their abilities and interests, as well as the opportunity to perform to their full potential (Johnsen, 2017). Identification should be characterized by flexibility, fairness, teacher friendliness, understandability, and time-economy (Davis et al., 2014). Furthermore, one of the primary goals of gifted assessment is to reveal exceptional abilities that may be obscured by poverty, prejudice, diversity, or disabilities in order to properly cultivate them and avoid the risk of ignoring or misinterpreting gifted students, as well as the possibility of their underachievement (Silverman, 2018).

The most commonly used methods for determining giftedness are IQ tests, achievement tests, and assessments of reasoning, creativity, and problem solving (Robinson, 2008). Callahan (2011) adds observations, rating scales, checklists, and standardized tests to this list. There has also been research into nonverbal ability assessments, above-grade-level achievement tests, portfolios, teacher referrals, teacher recommendations, curriculum-based performance tasks, and even multiple measures and matrices (Worrell et al., 2019).

IQ tests, which were and still are used as diagnostic tools based on the belief that intelligence is the key discriminator of giftedness, have traditionally been the most widely used method for measuring giftedness (Brigham & Bakken, 2014). However, current research considers giftedness to be a much broader concept than simply genius (Sternberg, 2018), while the IQ tests contain an element of subjectivity and frequently underestimate the charismatic individual, so they must be interpreted by experts based on qualitative criteria of charisma as well as quantitative performance on them (Silverman, 2018). Furthermore, as Joseph and Ford (2006) point out, IQ tests run the risk of excluding a student who possesses only one of the tested gifted traits because their scores are global. Furthermore, they do not account for the various family and social environments from which students come, which may or may not encourage reading or may be bilingual (Obi et al., 2014). Finally, IQ tests do not assess creativity, which is a learned rather than an innate trait (Guilford, 1968; Weisberg, 1968).

As an alternative to IQ tests for identifying gifted students, multidimensional assessment is proposed, which can diagnose various types of giftedness and talents and can include students from minority or disadvantaged groups (Davis et al., 2014). As a result, Davis et al. (2014) propose nonverbal reasoning tests as an alternative method (which prove to be effective for diagnosing giftedness in students from disadvantaged environments), achievement tests (which indicate specific academic talents), creativity tests (which identify the creative capability), teacher nomination, parental information – according to Davis (2014) parents are the first to diagnose their child's giftedness -, peer nomination (especially for disadvantaged student groups), self-nomination and product and process evaluations. Renzulli's rating scales can be especially useful as they evaluate Intellectual Ability, Creativity, Motivation, and Leadership, while having been enriched with six new scales which include Mathematics, Science, Reading, Technology and Artistic, Musical, Dramatic and Planning characteristics (Davis et al., 2014).

The variety in identification methods or the choice of a combination of methods is also proposed by supporters of the systems view, who recognize in this combination the possibility of diagnosing abilities related to analysis, creativity, wisdom, and task taking, as well as by supporters of the developmental view, who consider giftedness as an evolving process, so they propose different types of assessment depending on the age of the student (Sternberg & Kaufman, 2018). Anyway, for an assessment model to be effective, it must consider non-intellectual personal variables, as well as the examinee's social and cultural environment, in addition to variety (Sternberg & Kaufman, 2018).

As a matter of fact, teachers, as daily observers of school reality, are a reliable source of information and can help with proper identification (Richert, 1992; Mingle, 2012). Gifted students' potential can be enhanced by qualified teachers, coaches, or mentors who provide educational opportunities, encourage and motivate the student, improve skill practice, and support the student cognitively, psychologically, and socially in and out of school (Olszewski-Kubilius et al., 2016). From the point of developmental view, the role of the knowledgeable teacher or experienced coach is critical in the diagnosis of talent, as in areas such as music and sport, but also in some cognitive areas talent is diagnosed or developed at different ages (e.g. boys' soprano voices are diagnosed at an early age, while the adult musical voice develops after adolescence; ability in mathematics is also diagnosed in pre-school age, while an aptitude in social sciences develops after adolescence; sports as gymnastics necessitates distinct flexibility in childhood, whereas strength sports necessitate integrated physical development) (Olszewski-Kubilius et al, 2016). However, teachers' subjective judgment can lead to a hazy picture of giftedness or a focus on the wrong elements (Balchin, 2007). Because their criterion for identifying giftedness is frequently high subject scores, they are more likely to identify students with high scores as gifted while underestimating or dismissing students with high intelligence but lower scores (Kornmann, Zettler, Kammerer, Gerjets, & Trautwein, 2015). Furthermore, a teacher's preference for diligent, well-behaved, and obedient students ("teacher pleasers") may influence their judgment, whereas a more reactive or uncooperative student may be undervalued (Davis et al, 2014; Brigham & Bakken, 2014).

Gender discrimination is another phenomenon associated with the identification of gifted students that reveals teachers' inherent biases (Hernández-Torrano, Prieto, Ferrándiz, Bermejo, & Sáinz, 2013). According to researches of Gagné (1993), Lee (1999), Endepohls-Ulpe and Ruf (2005), and Bianco, Harris, Garrison-Wade, and Leech (2011), teachers are more likely to nominate boys as gifted students in math, science, technology, and engineering, while girls are more likely to be nominated in social-emotional and artistic areas.

The greatest bias or prejudice in identifying gifted students is observed in students from immigrant or disadvantaged populations, as well as students from culturally and linguistically diverse backgrounds, most likely due to inadequate training rather than racial perceptions. (Mingle, 2016). Gifted education has frequently been accused of being elitist (Ford, 2014), because (in the USA) it is mostly about middle and upper class White and Asian students, who are overrepresented in gifted education programs (Borders et al., 2014), while Black or Hispanic students are underrepresented (Scott, 2014). The use of standardized measures and methods of identification based on Euro-American cultural norms (Bonner, 2000; Davis et al, 2014) appears to be a key reason for this distinction, but so do low expectations of learning outcomes from students from disadvantaged social strata (Kurt & Chenault, 2017). As a result, not only the education of gifted individuals, but also the methods and conditions that align with prevailing cultural norms and represent the White race, are largely elitist, resulting in the selection of gifted students widening the gap between privileged and disadvantaged groups (Ford, 2014).

It is worth noting that victims of underrepresentation in gifted identification are also gifted students with disabilities, who frequently go unnoticed because their specificity overshadows their potential talents (Davis et al., 2014).

Alternative and multiple methods of diagnosis, of a dynamic nature, that do not adhere to traditional standardized tests that represent the dominant culture, are required for the representation of students from disadvantaged social groups in programs for gifted students

(Obi et al, 2014), as the abilities and talents of culturally diverse students are more likely to develop in an environment that accepts diversity and enhances their self-esteem and emotional well-being (Bevan-Brown, 2003). Nonverbal ability tests for identification, performance-based assessments, challenging curricula, and methods involving parents and the community can all help in this regard (Obi et al., 2014; Worrell et al., 2019).

Teachers' roles are therefore critical, because children with exceptional abilities frequently go unnoticed, and their abilities are not recognized and exploited not only by teachers, but also by counsellors, psychologists, and paediatricians, who are not trained to recognize the specific cognitive, socio-emotional, and physical characteristics and behaviors of gifted individuals (Wood & Laycraft, 2020). Despite the possibility of partial teacher bias in their assessments, teachers can support more accurate measures when given proper instruction and guidance (Hecht & Greenfield, 2002). As a result, teacher education is required to provide theoretical and practical knowledge about gifted education (Day, 2000), as well as multicultural education, to ensure that the identification of gifted students does not perpetuate existing social inequalities (Obi et al., 2014; Ford, 2014). In Chan and Yuen's (2014) and Demirok and Ozcan's (2015) studies, teachers who had received gifted education training were more likely to encourage creativity and intellectual ability in their students and to identify them as high multi-ability individuals.

To summarize, the most effective identification of gifted students necessitates identification procedures that cover all areas of giftedness rather than just intellectual ability, multiple assessments that account for variations in the student population and students' abilities, and representation of diversity through behavioral methods and flexible behaviors that do not adhere to traditional norms (Johnsen, 2017).

3. Traits of gifted individuals: cognitive, affective, and socio-emotional characteristics of gifted

Myths and preoccupations about gifted children and their education have for decades distorted perceptions of their needs and what they can offer themselves and society, negatively impacting the provision of education that meets their needs (Ambrose & Sternberg, 2016; Dai, 2015; Persson, 2012). Modern research has shown that giftedness is not a given condition and must be nurtured in order to reach its full potential. According to Brigham and Bakken (2014), developing excellence requires 10,000 hours of dedicated effort, which takes about five years under intensive conditions. As a result, it is critical to clarify the characteristics of charismatic individuals so that they can not only be identified more accurately, but also used to benefit themselves and society as a whole.

Although all gifted students share some common characteristics, giftedness does not govern all aspects of expression and behavior similarly. A common feature of gifted children is that they can demonstrate levels of ability normally found only in adults in areas such as mathematics, chess, and music, while performing as expected of a child their age in others (Olszewski-Kubilius et al., 2016). Common consistent characteristics shared by all gifted children include their willingness and desire to work in their areas of interest, competitiveness not only with their peers but also with themselves as they strive to outdo themselves, and fast learning rates of 5:1 when compared to slow learners (Olszewski-Kubilius et al, 2016). They also show greater ability, energy, and intensity in the areas where they are gifted (Wood & Laycraft, 2020). However, their characteristics become clearer when examined by category (cognitive, affective, socio-emotional).

3.1. Cognitive traits

The most basic characteristic of gifted children, according to Davis et al. (2014), is that they have a developmental advantage in language and thinking. These characteristics aid in the development of advanced thinking and comprehension abilities, an expanded vocabulary, and a large store of information on a variety of topics. They think quickly and logically, which, when combined with their natural curiosity, insatiable desire to learn, comprehension of cause and effect relationships, natural proclivity for problem solving, perseverance, dedication, and high motivation, can result in highly advanced learning outcomes.

Language, reading, and rapid learning skills are acquired by gifted individuals at an early age, much earlier than their peers (Wood & Laycraft, 2020). Hollingworth (1942, as cited in Wood & Laycraft, 2020) places reading ability in the preschool years and links it to the strengthening of crystallized intelligence, resulting in the expression of intellectually complex ideas and questions much earlier than peers. The same researcher referred to children with an IQ of 170 as "rapid learners" because they learn four times faster than their peers, allowing them to "skip steps" in learning (Wood & Laycraft, 2020).

Advanced mathematical, musical, and artistic abilities appear very early in gifted individuals in these areas, often concurrently with the acquisition of language and reasoning skills, and children can reason about their particular way of thinking very early for their age (Davis et al., 2014).

Gifted people with artistic tendencies learn to draw at a younger age than their peers, have a strong visual memory, are passionate about developing their talents, are largely instinctive learners, and are creative and original problem solvers (Winner & Martino, 2000, 2003).

Furthermore, gifted students prefer complex and abstract thinking, which is cognitively challenging for them, and as a result, they frequently "overthink," decipher complex meanings, and have a thirst for learning (Wood & Laycraft, 2020), particularly in areas related to their areas of interest (Manning, 2006), and are able to question themselves, reflect, understand, and delve into complex thoughts and concepts related to their environment and themselves (Wood & Laycraft, 2020). It is interesting that, according to Lovecky (1994), simple questions are more difficult for these students than complex questions.

Further particular cognitive characteristics identified by researchers and compiled by Manning (2006) include flexibility and originality of thought, which lead them to find original solutions to complex problems, dedication to their interest-related goals, and the ability to apply knowledge in new areas, all of which indicate that gifted students' learning needs are frequently not met by the conventional curriculum.

Gifted students' advanced cognitive and intellectual abilities frequently lead to high student and academic achievement as well as increased creativity (Endepohls & Ruf, 2005). However, longitudinal survey results from the Malburg Giftedness Project from 2000, highlighted by Ziegler, Stoeger, Harder, and Balestrini (2013), indicated that only 15% of high-achieving students were gifted, while 15% of gifted students were low achievers, casting doubt on the link between school success and giftedness and high intelligence.

3.2.Affective traits

In addition to cognitive abilities, gifted students frequently exhibit highly affective traits; their emotional traits are frequently marked by intensity and extremity, increased curiosity, demandingness, and sensitivity when compared to their peers (Manning, 2006). Steenbergen-Hu (2017) associates charisma with all five types of overexcitability: psychomotor, sensual, cognitive, imaginative, and emotional. This increased sensitivity is often associated with increased energy, fast talk and workaholism, intense expressions of joy, but it can also be associated with fear and depression (Davis et al, 2014). Their feelings are deep and intens. (Manning, 2006). They are often perfectionists with high expectations of themselves and others, and they are distinguished by self-control and the ability to concentrate, which aids them in achieving their objectives (Johnsen, 2021).

Gifted people typically have high self-awareness, especially in terms of academic performance (Johnsen, 2021), self-confidence, and independence. This is understandable given that they receive recognition and praise for their performance from family, school, and friends (Davis et al., 2014). Internal control causes them to attribute any failures to a lack of sufficient commitment to the goal rather than a lack of competence, allowing them to use their mistakes and failures as sources of creative self-improvement, which enhances their innate self-confidence (Davis et al., 2014). Researchers also report a developed ethical code, stable values, a strong sense of justice, and a high level of idealism and empathy (Manning, 2006; Davis et al., 2014).

According to the "harmony hypothesis," parents report low levels of behavioral difficulties, fear of school, and inability to concentrate for gifted children, whereas gifted students appear to have a positive self-image and do not consider themselves prone to depression, which is also confirmed by teachers, who find no signs of maladjustment (Baudson & Preckel, 2016).

However, there are also negative emotional characteristics associated with gifted students, which are reflected in the "disharmony hypothesis," which demonstrates an emotional impact on the gifted child from the residual outdated notion that the gifted person is a case of "mad genius." According to this hypothesis, gifted students are more likely to have social-emotional difficulties and thus develop less harmoniously, possibly due to their unique sensitivities, the intensity with which they experience emotions, and developmental asynchronies in comparison to their peers (Baudson & Preckel, 2016).

According to Rimm (2005), high-ability students are concerned about their acceptance, popularity, and appearance, and they experience alienation, social rejection, and social anxiety as a result of their exceptionality (Kunkel, Chapa, Patterson & Walling, 1995; Neihart, 1999). Furthermore, because of their sensitivity, they may interpret criticism as a personal attack (Borders et al, 2014). Depression, which rarely leads to suicide, and even eating disorders have been reported as negative emotions experienced by gifted people (Neihart, 1999).

In terms of negative school-related emotions, gifted students may express boredom, apathy, or frustration with an indifferent school (Neihart, 1999). Some teachers believe that gifted students exhibit arrogance, insolence, and disobedience, which they interpret as their difficulty integrating into school social life due to "asynchronous development." As a result, they are internally frustrated and have psychological issues such as rejection, antisociality, indifference, and aggression (Cline & Schwarz, 1999). Their often inherent perfectionism, on the other hand, can lead to frustration, feelings of inadequacy, and incompetence as a result of not meeting the high standards they set for themselves (Davis et al, 2014). Despite their superior abilities, when they are required to cover more material as a result of enrolling in a specialized program, the pressure and stress often leads to frustration as they struggle to keep up with this pace of learning (Barton, 2003). As a result of the asynchrony inherent in gifted students, giftedness, while associated with high intelligence and sensitivity, is still associated with problematic situations. Therefore, in order for them to reach their full potential without experiencing disruptive problems, parental and school environment modification is required (Manning, 2006).

3.3.Social-emotional traits

There is a direct relationship between gifted students' affective and social-emotional characteristics, which often overlap. In this section the affective and emotional characteristics that influence the gifted person's social life and behavior will be mainly examined.

In the 'social myths' that persist, charismatic individuals are associated with socially odd behavior, even 'madness,' and charismatics are considered socially dysfunctional; however, recent research shows that the socio-emotional characteristics of charismatic individuals are predominantly positive (Rinn & Majority, 2018), but they may still face social-emotional challenges (Zeidner, 2018). Negative stereotypes are also reflected in the media's portrayal of gifted children, who are frequently portrayed as eccentric, "bookish," absent-minded, and unpopular (Baudson & Preckel, 2016).

To begin with, most research indicates that charismatic individuals have greater emotional power than the general population and are more productive, motivated, conscientious, and less anxious (Freeman, 2017; Kelly & Donaldson, 2016). Furthermore, charisma appears to be associated with popularity at times (Czeschlik & Rost, 1995). It appears that gifted children's higher cognitive abilities and curiosity are associated with acuter emotional awareness and consciousness (Wood & Laycraft, 2020; Piechowski, 1997; Piechowski & Cunningham, 1985), which may be due to the fact that these children observe more things and details in their environment than their peers (Mendaglio, 1995). Acuity, emotional responsiveness and manifestation, calisthenics, and emotional sensitivity in general are other characteristics associated with high sensitivity (Neville, Piechowski, Tolan, 2013). Gifted people also have a superior sense of humor which is associated with their ability to think quickly, confidence, and sociability, and manifests itself in a variety of domains such as art, creative writing, and social interactions. (Davis et al, 2014).

It is also worth noting that charismatic people are sensitive to moral and value issues, as well as distinguishing good from evil, and they have a strong sense of justice, truth, and honesty from a young age, qualities that they value in others, which is why they are less likely to engage in antisocial behavior at school (Davis et al, 2014). They also have strong empathy and sensitivity to others' rights, being able to see a situation from another's point of view and empathise with them (Piaget & Inhelder, as cited in Davis et al., 2014; Wood & Laycraft, 2020). This tendency generates an interest in moral, religious, existential, and philosophical issues (Wood & Laycraft, 2020). As a result, they exhibit strong social sensitivities, particularly on issues of law and reason violations, wars, poverty, lawlessness, violence, and inequality, and they express their feelings on these issues strongly in discussions with elders (Davis et al., 2014; Borders et al., 2014; Silverman, 1994).

In terms of forming and maintaining friendships, there appear to be different approaches to the issue, as differences in the behavior of gifted individuals versus those of average ability may be associated with difficulties in developing positive relationships with peers (Rinn & Majority, 2018), although some researchers believe that there are no differences in social development between gifted and average individuals (López & Sotillo, 2009), and that gifted children appear to have fewer social problems than others (Richards, Encel, & Shute, 2003), as well as that, anyway, gifted children in adolescence do not lack friends (Shore, Chichekian, Gyles, & Walker, 2018). Possible difficulty in forming friendships may be linked to absence of peers who share their interests (Wood & Laycraft, 2020). This is why contemporary research suggests ability grouping for gifted children in order for them to connect with like-minded peers with whom they can fit in (Vogl & Preckel, 2014).

Gifted children also appear to have positive relationships with their parents, especially if the family environment is supportive and warm, which helps them develop healthy interpersonal relationships also with their peers (Olszewski-Kubilius, Lee, & Thomson, 2014).

The "asynchronous development" of gifted individuals, on the other hand, distinguishes them from average people and makes them vulnerable to socio-emotional issues (Rinn & Majority, 2018). Their sensitivity and acute awareness, which make them empathetic and observant, have been described as a "double-edged sword," as they see and feel things that others do not, resulting in feelings of depression and discouragement at times (Wood & Laycraft, 2020). Furthermore, gifted people frequently exhibit overexcitabilities in five domains: intellectual, psychomotor, sensual, imaginative, and emotional (Rinn & Majority, 2018), which affect their socio-emotional behavior.

Perfectionism is frequently associated with charismatic individuals, which is directly related to their high expectations of themselves and their striving for excellence (Stoeber & Otto, 2006), but it is also associated with intense pressure from their environment (family, peers, teachers), as well as from themselves, to perform to their potential (Cross & Cross, 2015; Freeman, 2018). Because they are aware of their high potential, they are frustrated by the possibility of failure and may be driven to procrastination, task avoidance, isolation from peers, and underachievement, adopting self-destructive tendencies (Grobman, 2006). Perfectionism has also been linked to extreme conditions such as anxiety, depression, eating disorders, and even suicide in gifted individuals (Affrunti & Woodruff-Borden, 2014; Kiamanesh, Dyregrov, Haavind, & Dieserud, 2014; Shafran & Mansell, 2001).

When gifted students lack motivation and challenge their intellectual ability at school, their social behaviour at school can be negatively affected, leading to underachievement, boredom, and indifference (Freeman, 2018; Siegle & McCoach, 2001), which can also bring them into conflict with their teachers who are unable to manage their superior intellectual abilities (Freeman, 2018). More broadly, there is a risk of maladaptation of gifted students in the school environment if their specificities are not understood and respected (Neihart et al, 2002, as cited in Wood & Laycraft, 2020).

Hollingworth (1942, as cited in Rinn & Majority, 2018) attributes high gifted children's social potential isolation to their difficulty in finding intellectually equal peers, as this isolation disappears when they are given the opportunity to work or play with their intellectual peers and the child is treated as an equal and valued friend. However, gifted children frequently feel "out of sync" because of their differences, which they are unable to manage, and they tend to hide their giftedness to protect themselves from impending isolation, which negatively affects their self-esteem (Piechowski, 2002; Jackson, 1998; Tolan, Wallace, & Shaughnessy, 2018). Although gifted individuals have a tendency toward introversion (Silverman, 1993), social isolation in this case is caused by the environment's inability to synchronize with them (Neihart et al., 2002) and the informal requirement from them to conform to social norms (Sheldon, 1959).

To summarize, research shows that, with a few exceptions, gifted children do not have more psychopathological problems and vulnerability than their average peers and can develop normally and grow into successful and happy adults. (Worrell et al., 2019). Giftedness does not automatically imply social-emotional difficulties, and gifted students are no less social than their peers of average ability. The danger, instead, lies in the gap between such an individual's developmental needs and their environment's ability to integrate or accept them. This inability to adapt makes gifted students appear "difficult to manage" or "maladaptive" (Baudson & Preckel, 2016). Empirical evidence suggests that social isolation, peer rejection, loneliness, and alienation, which are social-emotional barriers for many gifted children, arise as a result of the social environment's reaction to them rather than as a result of their own abilities (Gross, 2004). Gifted children have emotional needs and, like all children, are entitled to intellectual stimulation, communication with friends who share their interests, opportunities to pursue their interests, and acceptance from their environment (Freeman, 2018), as well as guidance from parents, teachers, and counsellors (Colombus Group, as cited in Rinn & Majority, 2018).

4. Creativity

Any gifted individual's advanced intellectual capacity cannot advance himself or society unless it is transformed into creative productivity, which converts theoretical talent into useful action. Creativity is regarded as a possible indicator of giftedness (Sriraman & Leikin, 2017), though Renzulli (2005) and Runco (2005, as cited in Plucker, Guo, & Makel, 2018) regard it as a necessary but not sufficient component of giftedness. The relationship between charisma and creativity is also reflected in the Triarchic Theory of Intelligence, which is made up of analytical, creative, and practical abilities (Sternberg, 2005), where creativity is regarded as a component of charismatic behavior (Leikin & Pitta, 2013). In fact, intelligence comes before wisdom in Sternberg's (1995) giftdness model, which includes the concepts of wisdom, intelligence, and creativity, intelligence precedes wisdom and creativity precedes intelligence.

The gifted student can also be creative, but this is not necessary, since a minimum IQ of 120 is required for the development of creativity (Davis et al., 2014; Getzels & Jackson, 1962, as cited in Johnsen, 2021). Creativity has been defined psychometrically as "fluency, flexibility, originality, and elaboration" (Guilford, 1950; Torrance, 1974, as cited in Johnsen, 2021), and it is identified in gifted individuals through the methods they use in problem solving (Perkins, 1981; Sternberg, 1988, as cited in Johnsen, 2021).

According to Subotnik et al. (2011), giftedness is first recognized as a potential for superior outcomes. The initial potential develops into an advanced ability in adolescence and becomes an expertise and contribution to a domain in adulthood with the right opportunities and motivation, but also with the individual's study and practice. Creative productivity is the highest and most rare level of giftedness, because through creativity the individual's innate abilities have an impact on society.

Creativity is generally composed of three factors that interact with each other: creative abilities (effectiveness in finding, promoting and implementing solutions characterised by originality and quality, creative imagination and divergent thinking), receptiveness (to experience, intellectual capacity, contact with people and different cultures) and independence (a trait associated with the rejection of conformity and conventionality, as well as the willingness to oppose the group's and external factors' systemic influence) (Karwowski, Jankowska, & Szwajkowski, 2017). According to Johnsen (2021), the most fundamental characteristic of creativity is "divergent thinking," which is associated with the generation of ideas that deviate from the norm and are distinguished by originality.

Individuals who are identified as creative are energetic and highly motivated, regardless of age. They are distinguished by their enthusiasm, hyperactivity, spontaneity, patience, and perseverance, as well as a desire for adventure, industriousness that extends beyond assigned tasks, and a desire for recognition (Davis, 1999). Risk-taking is a characteristic of creativity: the creative person is bold in the face of the new, which is regarded as an intellectual challenge, is not afraid to express himself or herself differently than the norm, has courage, disregards institutionalized boundaries that limit thought and action, is not afraid of criticism and confrontation with others, and is not bothered by failure and even ridicule, as fear is the primary impediment to creative thought and action (Davis, 1999). These characteristics are closely related to charismatic people's openness of mind and proclivity for novelty.

Other characteristics attributed to creative people are deep knowledge, a penchant for complexity, contributing new ideas, methods and products, even in large numbers, fluency of thought, observation and attention to detail, originality in finding solutions and improvisation, challenging traditional methods, ideas and produced work, self-confidence, a propensity for innovation and the different, even the unexplored, and in any case what is intellectually challenging, unconventionality, freedom of expression, consistency and dedication to the work of interest and a sense of creative ability (Johnsen, 2021).

Because creativity is directly related to social contribution, it has been observed that the achievements of gifted students who are creative outperform those of their conventional peers (Davis et al., 2014). As a result, teachers must be able to identify and utilize creatively gifted students. Torrance (1981) outlined the elements that could assist a teacher or parent in identifying a creative student. The creative learner, according to him, prefers to work alone, has a wealth of ideas, thinks of alternatives using the "what if?" method, is fluent in speech, creates and recreates, can manage several ideas at the same time, despises routine and convention, is bored by the obvious and the established, tends to extend beyond the defined boundaries in the tasks assigned to him or her, enjoys talking about his or her discoveries, is inventive in finding ways of acting that deviate from the norm, loves innovation, and is unconcerned about demonstrating his uniqueness.

Harnessing the talents of gifted individuals must therefore extend beyond the boundaries of the school, because, according to Renzulli (as cited in Worrell & Erwin, 2011), school giftedness is a distinction based on performance in tests and academic subjects merely that does not extend beyond the confines of the school, whereas creative productivity produces ideas and work that benefit society as a whole.

5. Special learning needs of the gifted. Learning characteristics of gifted individuals

5.1. Learning characteristics of gifted individuals

The first and perhaps most important identification of gifted individuals occurs at school, where they are given the opportunity to develop, even to discover, their talents. Gifted students exhibit specific learning characteristics that may serve as indicators for designing and implementing educational approaches aimed at better utilizing their talents, as intellectual ability alone is insufficient to develop the talents of gifted students (Pfeiffer, 2012).

According to Cross and Coleman (2005), early forms of giftedness are identified by an extremely rapid rate of learning and high cognitive ability, but interests and skills determine their specific areas of knowledge and skills of interest over time. Griggs and Dunn (1984, as cited in Davis et al, 2014) summarize gifted learners' learning characteristics as follows: They are self-sufficient and motivated more by their own will than by teacher intervention; they prefer flexible and "open" tasks over rigidly defined tasks; they prefer participation and active action in the educational process over passive observation; they learn best in quiet learning environments and on their own or in groups of like-minded gifted learners; they are responsible; and they learn best through visual, auditory, tactile, and kinesthetic educational practices. Endepohls and Ruf (2005) report that teachers recognize in gifted students a thirst for knowledge, an interest in extracurricular objects and subjects, a loss of interest in school when they are not assigned tasks consistent with their abilities and interests, and an ability to work independently.

Another characteristic learning trait of gifted students is their frustration when they realize the gap between their potential and the limits of their education and age within which they can operate, when they regard the tasks assigned to them as unimportant, and the anxiety of potential failure when their ambitions are too high. These characteristics can cause a high achiever to underachieve (Freeman, 2018). Gifted students, on the other hand, tend to have high academic self-esteem in their areas of interest and attribute success to intrinsic factors (their personal abilities) and failure to extrinsic factors (bad luck or an inappropriate strategy) (Clinkenbeard, 2012). In particular, when it comes to distinguishing between endogenous and exogenous learning traits, gifted students are more inclined to endogenous traits, such as being more curious and dedicated to the tasks assigned to them, inclined to reading, thinking, and solitude, than exogenous traits, such as learning outcomes, grades, distinctions, and awards (Cliknenbeard, 2012).

Some negative real-world classroom learning cues that can make teachers aware of the latent presence of gifted students in their classrooms, are following, as summarized by Manning (2006), based on research by Clark (2002), Winebrenner (2001), Smutny, Walker, and Meckstroth (2000):

- Incomplete or sloppy work may reveal a gifted student who is either uninterested in the subject because he or she is well-versed in it, or whose range of interests prevents him or her from concentrating on a subject.
- Hypersensitivity to other people's observations, which may reveal a fear of failure due to gifted people's perfectionism.
- Poor group work performance, which could be due to a fear of being saddled with the full burden of group work or a fear that their ideas will not be properly appreciated.
- Authoritarianism in group work, which may be a sign of an early attempt to apply their leadership skills, or a manifestation of their independence and unconventionality.
- Slow work pace, possibly due to perfectionism.
- Problems with behavior, which may be the result of boredom caused by tasks that are unworthy of their abilities.
- Buffoonery, which may be the result of their innate sense of humour or an attempt to be accepted by their peers, who may judge their differences negatively.
- Emotional outbursts or periods of isolation as a result of their high emotionality.

5.2. Special learning needs of the gifted

Whitmore (1986, p.67, as cited in Reis & McCoach, 2000) concludes that "the problem of gifted students who lack motivation to participate in school or strive to excel academically is, in most cases, a product of a mismatch between the child's motivational characteristics and the opportunities provided in the classroom". It is clear, then, that gifted students have unique learning needs that must be met, as well as unique ways of thinking that must be correlated with learning methods, in order for them to fully develop their potential and achieve their goals (Davis et al., 2014). And this appears to be especially important given the high percentage of gifted students who are driven to underachievement due to unique attitudes, feelings, and learning needs (Betts & Neihart, 1988).

Gifted students prefer learning styles that respond to their unique learning and emotional characteristics, such as motivation, perseverance, confidence, independence, and self-control (Davis et al., 2014). Renzulli and Reis (1997, cited in Davis et al., 2014, p. 39) report the following effective learning styles in gifted students: “lecture (tied with drill and recitation, or “drilland-kill,” according to Renzulli, 1995), discussion, demonstration, small group discussion, peer tutoring, cooperative learning, field trips, learning centers, learning games, electronic learning, simulations/role playing, projects, mentorships (internships, apprenticeships), and independent study”. According to Tannenbaum (1986), education must consider general ability, special abilities related to their talents, external reinforcement, psychological abilities, and the possibility of random factors in order to realize the potential of gifted students.

The most recent programs for gifted students are divided into two categories: a) Acceleration programs, which assume that gifted students have higher rates of information intake and assimilation than their peers, so these programs accelerate these students' learning paths within the given curriculum so that their learning rates match their abilities and potential, so that their learning pace corresponds to their abilities and potential, and gifted students find the intellectual challenge required to pique their interest in the existing curriculum , and b) Enrichment programs, which allow gifted students to delve deeper into traditional subjects than the rest of the class or to be taught subjects that are not typically covered in the traditional curriculum (Worrell et al., 2019). In fact, Kavensky (2013) suggests that gifted students should receive individualized authentic instruction.

Brown and Stambaugh (2014, p. 43-58) mention the following education programs for gifted students:

a) Macro model programs:

- •The Stanley Model of Talent Identification

- •the Renzulli Schoolwide Enrichment Triad Model

b) common program/service delivery models:

- •Resource/Pull-Out Room
- •Cluster Grouping
- •Supplementary programs outside the school day
- •Full-Time Specialized Schools
- •Subject Specific Grouping
- •University-Based Placement Outside the School Day.

The following are examples of various approaches taken by European countries to meet the needs of gifted students.

In England, there is a focus on holistic education, with gifted students included in mainstream classrooms and some extra-curricular opportunities provided (Eyre, 2009).

In Austria, gifted students from the age of 15 can skip classes, opt out of compulsory education, take university courses, and attend university (Weilguny, Resch, Samhaber, & Hartel, 2013).

In Germany, common learning practices for gifted children include early enrollment in primary school, acceleration, skipping classes, taking higher-level courses, collaborating with universities, extracurriculars, competitions, and summer programs (Ziegler, Stoeger, Harder, & Balestrini, 2013).

In Hungary, gifted students are identified as having special educational needs. There are specialized schools for gifted students in mathematics, which has been linked to Hungarian students' success in international competitions and Mathematical Olympiads. (Stockton, 2009). The preferred approach is to assist gifted students (Mönks, Pflüger, & Radboud Universiteit Nijmegen, 2005; Gyarmathy, 2013).

In the Netherlands, gifted students are also considered students with special educational needs in the Netherlands, and they receive individualized education. (Mönks, Pflüger, & Radboud Universiteit Nijmegen, 2005).

In Turkey, programs have been developed to train gifted students in skills such as critical thinking. These programs emphasize learner-centered learning techniques such as problem solving, discussion, brainstorming, and project-based independent or group work. (Dilekli, 2017).

Regardless of the method used, it is critical that gifted students understand the goals of the school and consider how they can identify with their own needs in order to embrace them and enjoy the tasks assigned to them in order to succeed (McCoach & Siegle, 2001). This interdependence between expectations and value takes advantage of Siegle and McCoach's (2005) motivation model, which has four components: goal valuation, self-efficacy, environmental perception, and self-regulation.

Given gifted students' confidence in their abilities, problems may arise if they are placed in a fast-paced classroom while their talent is limited to a specific area (Clinkenbeard, 2012). However, there is always the possibility that the tasks assigned to them will not meet their needs and abilities. For example, if a task is overly difficult, it may cause stress, whereas if it is overly simple, it may cause boredom. It is critical to find the "golden mean" in order to induce a "state of flow" (Csikzentmihalyl, 1991, as cited in Clinkenbeard, 2012), which leads to positive psycho-spiritual outcomes. The three success conditions for motivating gifted learners are as follows: a) matching the difficulty of the tasks assigned to them with their abilities, so that they do not exceed or underestimate them and so that they provide a sufficient challenge; b) projecting the long-term value of these tasks, even if they do not perceive it; and c) allowing students to choose tasks that correspond to the interests they consider important to them (Clinkenbeard, 2012).

An important prerequisite for gifted students to properly evaluate education programs is to guide them so that they can match their high goals with outcomes such as long-term, in-depth, and meaningful learning, conscious effort, and interdependence of learning objects, while providing opportunities for gifted students to exercise their leadership skills can also be a sufficient challenge (Clinkenbeard, 2012). The role of a teacher who values gifted students and shows genuine interest in them has a significant positive socio-emotional impact on them (Clinkenbeard, 2012; Bennett-Rappell & Northcote, 2016), as interaction with peers with similar abilities and interests also has (Clinkenbeard, 2012).

Special reference should be made to underachieving gifted students, who have special educational needs and will benefit most from instruction that is differentiated in content and in pedagogical approach based on their interests, as well as from individualized instruction (Bennett-Rappell & Northcote, 2016). According to Siegle (2012), addressing underachieving gifted students entails instilling self-confidence in them that they can do it, guiding them in setting attainable goals, and emphasizing the significance of their work. In any case, using multiple approaches is necessary for underachieving gifted students as well (Bennett-Rappell & Northcote, 2016).

In conclusion, it should be emphasized that gifted children do not reach their full potential in the absence of specialized support. In the absence of an appropriate curriculum and specialized teachers, socio-emotional difficulties, peer pressure, and parental mismanagement can diminish and leave gifted students' high potential untapped. In the absence of appropriate educational factors, gifted children's potential can remain dormant, and these children do not reach the adult level that they would have reached if they had received appropriate educational and social manipulations (Colangelo & Davis, 2009). Since giftedness has no individual or social benefit in the absence of diagnosis and appropriate utilization, the development of appropriate mechanisms for the identification and quality education of gifted students is an important educational and social asset.

6. Learner differences among gifted individuals. (Ability types, readiness, interest, and learning profile)

The very definition of charisma implies the variety that underpins its various manifestations. According to the United States Department of Education (as cited in Davis et al., 2014), the demonstrated abilities of the gifted student should be related to the following areas: 1. General intellectual ability 2. Specific academic aptitude 3. Creative or productive thinking 4. Leadership ability 5. Visual and performing arts 6. Psychomotor ability. According to the National Association for Gifted Children (as cited in Borders et al., 2014), giftedness can be found in one or more domains, such as mathematics, music, language, or psychosomatic skills like painting, dancing, and sports. It follows that the differences between different types of gifted people extend to their learning profiles. This is why Renzulli (2005) argued that we should look for "charismatic behaviors" rather than charismatic individuals. Furthermore, gifted individuals differ in terms of development, ethnicity, socioeconomic status, gender, and the presence of other specific characteristics other than charisma (Clinkenbeard, 2012).

The following distinction can be made between gifted students based on the domain in which giftedness is manifested (La Porte Independent School District, 2016): a) The visual learner, who remembers what they have seen or read rather than what they have heard, has a vivid figurative imagination, enjoys reading, expresses themselves emotionally through body language, remembers faces but not names, and is sensitive to appearance; b) the auditory learner, who remembers what he has heard, especially music, rather than what he has seen, is a good speaker, remembers names rather than faces, has a kind of "inner voice," is distracted by sounds, and has poor handwriting; and c) the kinesthetic learner, who remembers actions and events, places a high value on touch and movement, seeks physical contact, dislikes reading and may struggle to learn to read, learns through imitation and practice, discusses feelings, has athletic tendencies, enjoys sports, dance, and games, and is impulsive.

There are several models for distinguishing gifted students because gifted students differ in their thinking even when their learning profiles and academic performance are similar (Dai & Feldhusen, 1999). Sternberg's (1986; Sternberg et al., 2001) "Triarchic model" states that gifted people can exhibit one of three types of intelligence: (a) “analytical”, an internal characteristic relating to the ability to acquire and assimilate information and critical faculties; (b) “creative”, relating to the application of analytical ability to unprecedented situations and problems, as well as to innovation; and (c) “practical”, relating to the application of analytical ability to solving everyday problems and achieving personal goals. Sternberg distinguished between "practical" and "wisdom-based" talent (Sternberg, 2020).

Gardner (1983, 1999, as cited in Worrell et al, 2019, p. 554) introduces the "multiple intelligences" model, which categorizes different types of intelligence: “linguistic, logical–mathematical, musical, bodily–kinesthetic, spatial, interpersonal, and intrapersonal, naturalist intelligence, spiritual intelligence, and existentialist”. In the "talent search model," Stanley (1976, as cited in Worrell et al, 2019, p. 555) proposes two basic areas of giftedness: linguistic and verbal ability. The abilities of the gifted student are differentiated in both models based on the type of intelligence.

Renzulli (1978, as cited in Worrell et al, 2019, p. 555) proposed the pioneering "Three-ring model of giftedness", which depicts the three types of giftedness as three overlapping circles: task commitment, creativity, and above-average ability. He also distinguished between "schoolhouse giftedness", which is determined by standardized tests and indicates gifted students who excel in academic subjects and performance, and "creative-productive giftedness", which is determined by significant applicable achievements that have an impact on the general public (Sternberg, 2020).

In the same vein, Sternberg (2020) has distinguished between gifted students who are "transformational" - related to the effort to positively transform the world for the benefit of all - and "transactive" - who work for their personal advancement, have high academic performance, and expect rewards for their giftedness - is related and interesting.

In the same context of transformational and transactive giftedness, Kirton (1976, as cited in Davis et al., 2014) distinguished gifted learners into two groups: a) “innovators”, who have innovative thinking but may appear undisciplined, inefficient, and unwilling to do conventional work for long periods of time, and are related to transformational giftedness; and b) “adaptors”, who are more efficient, conventional, punctual, and committed to work regardless of time, do not challenge hierarchy and authority, and are not always very confident, characteristics that are akin to transactive giftedness. Simonton (1996) used the terms "creative" versus "received" expertise. Sternberg (1997, as cited in Davis et al, 2014) divided gifted people's thinking into two categories: "legislative function" (creation of ideas and rules) and "executive/judicial function" (observance of laws and criticism and evaluation of ideas).

Renzulli and Reis (1997) also have noted differences in the learning environment preferences of gifted students in terms of light, sound, temperature, decoration, locations, food, and time of day. The modes of written or oral expression, props used in class, discussion, dramatization, artistic expression, and service differ accordingly.

Finally, depending on their academic performance, gifted students are classified as "achievers" or "underachievers." Although both groups have high academic self-esteem, their attitudes toward school, teachers, and goals, as well as their motivation and self-regulation, differ (McCoach & Siegle, 2001). Gifted "achievers" have positive attitudes toward school and teachers, value the school's goals, and make a concerted effort to align themselves with those goals (McCoach & Siegle, 2001). Underachievers, on the other hand, have negative attitudes toward school, question teachers' authority and treat them with hostility, and frequently have negative attitudes toward school staff (McCoach & Siegle, 2001; Mandel & Marcus, 1988). It is not so much a lack of knowledge or techniques as it is an inability to recognize that success is a function of disciplined behavior and effort (Borkowski & Thorpe, 1994), motivation, and self-discipline (McCoach & Siegle, 2001).

Finally, it appears that gifted students' learning differences do not seem to be significant factors in their achievement gap and academic progression. Rather, the gifted student's conscious or unconscious effort to achieve goals related to his or her particular abilities seem to make a difference in his or her overall progress and development (Ericsson, Nandagopal, & Roring, 2005).

To conclude, it is clear that a science-based, needs-based education of gifted individuals is required in order for them to realize their potential and develop planning, decision-making, and ethical leadership skills, combining knowledge, intelligence, and creativity, so that they may put their abilities at the service of the complex contemporary needs of the 21st century globalized society (Ambrose & Sternberg, 2016; Sternberg, 2005, 2009, 2013).

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3 How to Teach Gifted Individuals

Indrė Steponavičiūtė-Kupčinskė

1. The instructional strategies to teach gifted learners to address their special learning needs

Gifted learners are those individuals who possess exceptional intellectual abilities, creativity, and talent in various areas (Sternberg, 2005; Reis-Jorge et al., 2021). In this case, they have unique learning needs that require a more challenging and engaging approach to instructions. They require an educational experience that is tailored to their advanced abilities and helps them reach their full potential (Van Tassel-Baska & Stambaugh, 2008). Therefore, teachers must provide instructional strategies that cater to the needs of these learners to ensure their success. Research has shown that instructional strategies for gifted learners should be designed to challenge and stimulate their intellectual abilities while also providing opportunities for creativity, critical thinking, and problem-solving (Gallagher, 1994; Reis et al., 2011). In this chapter, we will explore effective instructional strategies that can be used to teach gifted learners and address their special learning needs. By using evidence-based strategies, teachers can create an enriching and fulfilling learning experience for gifted learners. Through this, we aim to provide insights into the best practices for educators to enhance the learning outcomes of gifted pupils.

Educators can employ a range of plans to meet the educational needs of gifted and talented children, including simple or complex strategies. These strategies can be categorised into three main groups: grouping, acceleration, and enrichment (Davis et al., 2014). Grouping strategies include providing additional study materials to students who finish assignments quickly, compacting the curriculum to allow bright students extra time for learning centres or interest-based projects, and implementing grade-skipping. Acceleration strategies involve offering part-time acceleration to a higher grade for specific subjects. Enrichment strategies encompass cluster grouping, where gifted students receive special services in a single classroom at each grade level, school-wide plans to accommodate gifted students in regular classrooms, district-wide pullout programs where a coordinator teaches gifted students once a week, and options for part-time or full-time special gifted classes at various grade levels. In addition, there are also specialised schools dedicated to the education of gifted students. These strategies, along with others, will be explored in more detail.

2. The teaching strategies foster creativity, increase motivation, content learning, learner differences and individualized learning paths

Gentry and Ferriss (1999) emphasized the importance of considering five interconnected concepts when designing programs or making adjustments for gifted and talented students. Challenge, choice, interest, enjoyment, and personal meaning play a crucial role in motivating students, fostering excellence, and cultivating lifelong learning habits. Educators can enhance the level of challenge by incorporating advanced content and thinking skills into the curriculum and student projects. Providing students with choices in their academic studies and research topics allows them to feel a sense of ownership and increases their motivation to succeed. Students derive enjoyment from tackling demanding tasks that provide a sense of accomplishment, especially when those tasks align with their personal interests. Personal meaning is heightened when students engage in self-selected and self-directed learning experiences, as it allows them to work towards a mutually agreed-upon purpose, which in turn enhances their overall motivation.

2.1. Differentiation

One of the most effective instructional strategies for gifted learners is differentiation. Differentiation in the classroom is an approach that aims to provide tailored learning experiences to meet the diverse needs of students (Tomlinson, 2017). It recognizes that students have different learning styles, interests, and abilities and seeks to provide them with appropriate learning opportunities. When it comes to gifted students, differentiation is particularly important, as these students often require more challenging and complex learning experiences to stay engaged and motivated in the classroom (Roberts & Inman, 2007).

Research has shown that differentiation can be effective in increasing the achievement of gifted learners. For example, a study by VanTassel-Baska et al. (2010) found that differentiated instruction resulted in increased academic achievement for gifted students in science and social studies.

A study by Tomlinson et al. (2003) found that differentiated instruction had a positive effect on the achievement of gifted learners in mathematics. Tomlinson and Jarvis (2009) outlined six premises that underpin differentiation:

1. A moderate challenge promotes learning.
2. Because students possess varying levels of skills and knowledge, the degree of challenge and nature of activities must also differ.
3. Tasks and content that are engaging increase motivation and student involvement.
4. Students have the right to explore and develop their areas of interest.

5. The learning profiles of students are multifaceted and influence their preferred learning styles.

6. Students learn most effectively in a safe, supportive, and inclusive environment.

According to Tomlinson (2001a), there are four misconceptions about differentiation that need to be clarified. Firstly, differentiation should not be confused with the individualized instruction approach of the 1970s, which assumed separate levels of instruction for each student. Instead, differentiation provides multiple pathways for learning, recognizing that students have diverse needs and abilities. Secondly, differentiation is not synonymous with chaotic. It may require increased leadership from the teacher to manage and monitor various activities, when students are given choices and opportunities to learn according to their needs, managing their behaviour becomes less of a challenge. Thirdly, differentiation is not about homogeneous grouping of students. Teachers utilize different grouping options for various purposes when implementing differentiation strategies. Lastly, differentiation is not merely about tailoring the same instruction to all students. It goes beyond superficial approaches such as asking a few higher-order questions or allowing students to select questions to answer. Instead, differentiation involves a more comprehensive and thoughtful approach to meet the unique needs of each student.

Teachers who implement differentiation in their classrooms rely on several key elements, including flexible grouping, clear expectations, and a shared understanding that different students may be doing different things simultaneously (Heacox & Cash, 2020). They begin by identifying worthwhile objectives and selecting strong curricular materials, and then use ongoing assessments to guide instructional decisions while maintaining high expectations for their students. To provide a variety of learning experiences through which students may develop understanding and demonstrate what they have learned, teachers design activities that appeal to students' diverse interests, learning preferences, and readiness levels. This approach ensures that students are challenged at appropriate levels and promotes engagement and motivation (Little et al., in the press).

When it comes to teaching gifted students, the concept of differentiation is closely intertwined with the "learning by design" approach. Pedagogy, as a knowledge process, requires the transfer of knowledge based on the learners' individual interests, skills, and creativity. For effective enrichment pedagogy tailored to gifted learners, the learning process should be designed to engage them in various activity sequences that cater to their abilities and enable meaningful understanding. Cope and Kalantzis (2015) propose an approach where teachers design learning activities based on four knowledge processes: experiencing the known and unknown, conceptualizing the abstract and theoretical, analyzing functions and perspectives, and applying knowledge creatively. By adopting this approach, gifted learners can grasp underlying theories, principles, and processes across disciplines, apply their knowledge, transfer understanding to different contexts, and integrate various types of knowledge to design and produce in a creative manner aligned with their interests. The role of both the teacher and the gifted learner in this process is crucial, as the teacher acts as the designer of the learning process, considering learner differences and needs, while the gifted learner becomes the designer who utilizes their knowledge and actively engages in learning activities. This design-oriented approach in enrichment strategies supports the development of skills and motivation among gifted students in STEAM education.

2.1.1 Principles of effective differentiation

The principles of effective differentiation for gifted students include several key components. One important principle is that differentiation should be flexible and adaptable to individual students' needs. This means that teachers should be willing to modify their teaching strategies and materials to meet the unique needs of each student, rather than trying to fit all students into a one-size-fits-all approach (Tomlinson, 2014).

Another important principle of effective differentiation is that it should be focused on challenging students at their individual level of readiness and ability. This means that teachers should provide opportunities for gifted students to work on more advanced, complex tasks that are appropriate for their level of knowledge and skills. These tasks should be designed to engage students in higher-order thinking and problem-solving rather than simply providing them with more work to do (VanTassel-Baska, 2003).

A third principle of effective differentiation is that it should be supported by ongoing assessment and feedback. Teachers need to regularly assess gifted students' progress and provide them with feedback that is specific, actionable, and focused on growth. This feedback should help students understand their strengths and weaknesses and provide them with guidance on how to improve their skills and knowledge (Reis & Renzulli, 2015).

There are several strategies that teachers can use to implement effective differentiation for gifted students. One strategy is to use curriculum compacting, which involves assessing students' current level of knowledge and skills and then providing them with opportunities to skip over material they have already mastered. This allows students to focus on more challenging material that is appropriate for their level of readiness (Reis et al.,1992).

Another strategy is to use tiered assignments, which involve providing students with different versions of an assignment based on their level of readiness and ability. This allows students to work on tasks that are appropriate for their individual level of knowledge and skills while still working towards the same learning objectives (Tomlinson & Imbeau, 2010).

Finally, teachers can use enrichment activities to provide gifted students with opportunities to explore their interests and passions in greater depth. These activities can take many forms, such as research projects, independent study, and mentorships with experts in their field of interest (VanTassel-Baska, 2003).

2.1.2 Differentiation of content, process, products, environment- tools

The design by learning approach is closely related to the STEAM (Science, Technology, Engineering, Arts, and Mathematics) approach, particularly in terms of how it corresponds to the differentiation of content, process, product, and the learning environment. Teachers have the flexibility to modify these four elements based on the diverse readiness levels, interests, and learning profiles of their students (Kaplan, 2021). In terms of content differentiation, teachers can adapt the curriculum and instructional materials to make them accessible and relevant to students' unique needs and backgrounds. This may involve providing alternative resources, varying the complexity or depth of content, or offering different entry points to the subject matter.

Regarding process differentiation, the design by learning approach encourages teachers to employ a variety of instructional strategies and activities that cater to different learning styles and preferences. This may include assigning different homework tasks, facilitating class discussions that promote critical thinking and collaboration, and incorporating higher-order thinking skills activities to challenge students at varying levels of cognitive ability.

Product differentiation emphasizes how students demonstrate and showcase their learning. It recognizes that students have different strengths and preferences for expressing their understanding. By allowing students to choose from various options, such as presentations, written reports, creative projects, or technological artifacts, the design by learning approach supports individual expression and fosters engagement.

Differentiation in the learning environment focuses on creating an inclusive and supportive classroom atmosphere that respects individual differences and promotes student autonomy. Teachers can organize the physical space, establish class rules, and implement structures that accommodate different levels of student independence and collaboration. This may involve providing flexible seating arrangements, offering choices within assignments, or fostering a culture of respect and open communication.

Overall, the design by learning approach aligns with the principles of STEAM education by recognizing the importance of differentiating content, process, product, and the learning environment to meet the diverse needs of students. By incorporating differentiation strategies within these elements, teachers can create a more inclusive and engaging learning environment that allows students to thrive and reach their full potential (Tomlinson & Jarvis, 2009; Kaplan, 2009).

2.1.2.1 Tiered Instruction

One of the more popular instructional strategies for differentiation is tiering (Tomlinson & Jarvis, 2009). To begin with, any differentiation must involve preassessment of students on the topic to be taught, and it is important not to assume what they know. The tiering strategy involves designing a lesson that is challenging yet accessible and then making it more or less challenging to fit different levels of student readiness (Tomlinson & Jarvis, 2009). In order to achieve this goal, educators need to take into account the task's characteristics that can increase or decrease its level of challenge for diverse learners. Usually, teachers establish three levels based on students' readiness. However, it's crucial to understand that differentiation does not aim to create a separate level for every individual student, but rather to ensure that each level offers engaging and challenging tasks that are respectful to students' abilities (Tomlinson & Jarvis, 2009). Furthermore, each level should align with the instructional objectives set for the lesson, allowing all students to attain a shared outcome through distinct pathways.

Tomlinson (2001a, 2003) developed a graphic equalizer as an instructional strategy for differentiation. The equalizer provides eight dimensions along which a lesson can be differentiated to meet the readiness levels of different students. The terms on the left of the equalizer represent less challenging levels, while those on the right represent higher challenge levels. Depending on the nature of the lesson, different dimensions can be adjusted. The equalizer can be used to place any learning activity, lesson, or assessment task on a continuum for a dimension and then adjusted left or right along the continuum to address the student’s readiness level.

In conclusion, differentiation is a powerful tool for meeting the unique learning needs of gifted students. By using principles of effective differentiation and strategies such as curriculum compacting, tiered assignments, and enrichment activities, teachers can create engaging and challenging learning experiences that will help gifted students reach their full potential.

2.2. Ability Grouping

Wiggins and McTigue (1998) noted, that grouping is most effective when there are curriculum modifications and differentiation (Delisle, 1997; Kaplan, 1986; Kulik & Kulik, 1982;

Renzulli, 1994; Rimm, 2008; Tomlinson, 1995, 1999, 2004; VanTassel-Baska, 1986; Winebrenner, 2001). Rogers (1992) and Kulik (1992) suggest the guidelines for schools.

For the ability grouping; Kulik recommends that (1) schools should resist calls for the wholesale elimination of ability grouping, (2) gifted students, individually or in groups, should be offered acceleration-based options, and (3) benefits are slight from programs that group children by ability, but prescribe common curricular experiences for all ability groups. Rogers also suggests that (1) students who are academically or intellectually gifted should spend the majority of their school day with others of similar ability and interests, (2) when full-time gifted programs are not available, gifted students might be offered cluster-grouping or cross-grade instructional grouping according to their individual proficiencies in school subjects, and (3) mixed-ability cooperative learning plans should be used sparingly for gifted students.

Teachers have the ability to adapt learning activities in order to accommodate the capabilities and learning needs of their students, foster creativity and thinking skills, alleviate boredom and frustration, and address underachievement. This can be achieved through the implementation of differentiation, enrichment, and acceleration strategies. Additionally, it is important to provide opportunities for students to interact with others who have similar abilities for social and academic support. There are three categories of grouping options (Davis et al., 2014):

A. Full-time homogeneous grouping:

- ● Magnet schools,
- ● Special schools for the gifted,
- ● Private schools,
- ● School-within-a-school plans,
- ● Special classes in elementary school.

B. Full-time heterogeneous grouping:

- ● Cluster groups of gifted students placed with regular students,
- ● Individualizing in heterogeneous classes.

C. Part-time or temporary groups:

- ● Pullout programs,
- ● Resource programs,
- ● Part-time special classes,
- ● Enrichment clusters,

- Temporary grouping for reading and math,
- Special interest groups and clubs.

A. Full-Time Homogeneous Grouping

Magnet Schools: Many large cities have embraced the use of magnet high schools to cater not only to gifted and talented students but also to other students seeking specialized training for a specific trade or career. The purpose is to make high school more relevant to students' realistic goals, especially for those who may be at risk of dropping out due to perceiving school as limiting instead of a path to social and economic success. It is crucial to recognize that gifted students, as well as those with low abilities, frequently encounter frustration and dropout. Magnet schools provide tailored training in areas such as arts, math, science, business, or trade skills. Gifted students, in particular, benefit from the autonomy and practical content in a vocational setting associated with career and technical education programs (Gentry et al., 2007).

Special Schools for the Gifted: Gifted students may find special schools designed for their needs to be a good fit. These schools are typically found in medium-sized to large cities and can be either elementary or secondary. The curriculum is based on district guidelines and requirements but also includes specialized enrichment and accelerated training in academic, artistic, scientific, or personal development areas that the school chooses to emphasize (Davis et al., 2014).

Private Schools: Private schools may offer an alternative for an accelerated education, as they tend to have higher achievement levels than public schools.

School-within-a-School: In this kind of school concept, an entire school is organized to provide special classes for gifted and talented students, alongside regular students (Witham, 1991). Gifted students attend advanced and enriched classes for part of the day, and are mixed with other students for non-academic subjects such as physical education, study hall, manual arts, and home economics, as well as sports and social events. This approach allows gifted students to receive specialized education while also having opportunities to interact with students from diverse backgrounds.

Special Classes: There is a growing interest in providing full-time education for gifted and talented children, as part-time programs only offer a partial solution. Special classes designed for gifted and talented students can take different forms. At the elementary level, a special class may be assigned to all gifted students within a particular grade level, age or age range. Apart from covering the standard grade-level objectives, the class also offers various enrichment, personal development, and skill-building experiences (Davis et al., 2014).

B. Full-Time Heterogeneous Grouping

Cluster Groups: Cluster grouping refers to the practice of placing a small group of high-ability students within a regular class, typically consisting of 5 to 10 students per grade, alongside 15 to 20 regular students. The classroom teacher, who has undergone specialized training in gifted education, possesses the skills to modify the curriculum for the gifted students. The curriculum is condensed, allowing these students to bypass material they have already mastered and instead accelerate through new content that they can grasp swiftly. Furthermore, the gifted students, who are grouped together in a cluster, participate in enrichment activities that emphasize advanced and in-depth subject matter, as well as the cultivation of critical thinking abilities like creativity, problem-solving, and research skills (Tomlinson et al., 2002).

Kaplan (1974) listed five crucial elements for designing a cluster group program: (1) establish criteria for student selection, (2) specify the qualifications and selection procedure for teachers, (3) clearly define the responsibilities and activities of teachers, (4) develop differentiated experiences for the cluster of gifted students, (5) plan support services and special resources, such as counselors and computers.

Cluster grouping offers several overlapping advantages, as itemized by Winebrenner (2009):

- ● The teacher of the cluster group is trained to teach gifted students.
- ● Teaching 5 or 10 gifted students, instead of 1 or 2, optimizes the use of teachers' time.
- ● Students interact with intellectual peers, which is both gratifying (having someone to share with) and humbling (learning that others are also smart).
- ● When gifted students are grouped together in one classroom, new academic leaders emerge in the other classroom(s).
- ● Non-clustered classrooms with gifted students elsewhere have a more homogeneous student mix, making teaching easier and improving achievement for all students.
- ● In contrast to a once-a-week pullout program, a cluster program compresses the curriculum and provides challenging learning experiences every day.

Heterogeneous Classes: When there is no possibility to have specific classes or programs for gifted students, teachers in regular classrooms who are aware of giftedness need to come up with creative ways to provide differentiated and enriched learning experiences for their quick-learning and imaginative students. One option is to create learning centers that allow students to explore different areas such as math, art, science, music, crafts, foreign languages, and thinking skills. Cluster grouping can also be used with all students, particularly those who complete their work early or have already mastered the material. It is recommended to use cluster groups for gifted students in the regular classroom.

Winebrenner (2009) suggested using curriculum compacting, which involves pretesting to assess mastery of the material, allowing for individualized learning contracts, and using her Study Guide Method and Resident Expert Planner. These strategies promote deeper and more complex learning and abstract thinking and eliminate the need for waiting.

With Winebrenner's (2009) detailed "Working Conditions" which include the following:

- Stay on task
- Don't interrupt the teacher,
- Use soft voices,
- Never brag about working on different activities,
- Don't bother anyone else,
- Don't call attention to yourself.

Clasen (1982) listed the following alternatives that individual teachers can utilize in schools with minimal involvement in gifted programs:

- Teachers can individually accelerate a student by having them read or work ahead, or by using advanced or supplementary texts and workbooks.
- The curriculum can be modified to allow for greater depth, more complexity, or higher levels of abstraction.
- Enrichment activities can be planned that challenge and build upon the student's special abilities, such as in creative writing, photography, or with computers.
- Students can receive academic and career counseling to help them understand their special capabilities and the training required to achieve their potential.

Treffinger (1982) listed 60 suggestions for teaching gifted students in the regular classroom. Here are some examples:

- Permit students to test out of material they already know (compacting) by using pretests or mastery tests.
- Use individualized learning packets, learning centers, and mini-courses, particularly in the basics.
- Allow time every day for individual or small-group projects.
- Integrate creative thinking into subject areas.
- Assist students in understanding higher-level thinking processes such as analysis, synthesis, and evaluation, and encourage them to plan independent projects around these processes.

- Invite guest speakers to share about their careers or unusual hobbies.
- Implement cross-age and peer tutoring.
- Help students recognize their own strengths, interests, learning strategies, and preferences, and encourage them to be sensitive to those of others.
- Encourage students to explore multiple perspectives on contemporary topics and provide opportunities to analyze and evaluate conflicting ideas and opinions.
- Assist gifted students in setting personal and academic goals.

It is important to note that if schools do not provide differentiated curriculum and learning activities to gifted students in heterogeneous classrooms, it cannot be said that their needs are being met.

C. Part-time and Temporary Groupings

Pullout Programs: The pullout program is a traditional approach often used in the education of gifted and talented students (Vaughn et al., 1991). In this model, elementary students are periodically withdrawn from their regular classes, typically once or twice a week, for sessions lasting 2 to 3 hours. During these sessions, they engage in specialized enrichment activities led by a district teacher or coordinator with expertise in gifted and talented education. The coordinator often oversees pullout classes at different schools within the district, utilizing a designated space known as a "resource room" that provides unique reading materials and equipment. Similar to other specialized classes and cluster groupings, the pullout activities are designed to promote the acquisition of knowledge and skills, while also fostering creativity, thinking skills, communication abilities, and the development of students' self-concept.

Resource Programs and Resource Rooms: The terms "resource program" and "resource room" are often used interchangeably. This is because pullout programs typically involve sending students to a designated resource room for specialized instruction. Therefore, pullout programs may also be referred to as resource programs or resource-room programs. Currently, a resource program refers to a pullout program implemented at the district level, where gifted students are transported to dedicated resource rooms or enrichment centers, staffed by specialized teachers, for one or two weekly sessions (Hong et al., 2006).

Part-Time Special Classes: In the section on "Full-Time Homogeneous Grouping," special classes were discussed, and it was mentioned that they can also be offered as a part-time or temporary option. For instance, in elementary schools, gifted and talented students may be assigned to self-contained classes for 50% to 70% of the school day. In these classes, they may engage in differentiated experiences such as independent projects, accelerated subjects, and small-group enrichment activities, all designed to foster creative and other high-level thinking skills.

Enrichment Clusters: As previously mentioned, a cluster group, consisting of 5-10 gifted students per grade level, is formed within a single classroom where a teacher with specialized training in gifted education provides instruction. While enrichment clusters differ in that they bring together students with shared interests, regardless of gifted identification (Reis et al., 1998; Renzulli, 1994), from various grade levels. These clusters may focus on activities such as painting, writing, archaeology, languages, or creating a school newspaper (Reis et al., 1998). During designated times these students gather with an expert in the field, which could be a teacher, parent, or community member, for a duration of approximately 6-12 weeks. Enrichment clusters delve deeply into the chosen subject matter, offering students the opportunity to not only learn for example Spanish, but also gain insights into Spain and other cultures.

The preparation of lesson plans in advance is not done. Instead, three questions serve as a guide: (1) What are the activities of people with an interest in this area? (2) What are the necessary knowledge, materials, and resources? (3) How can the product or service have an effect on a targeted audience? The idea is that creators in the real world develop products for an audience, not solely for themselves.

Reis et al. (1998) emphasized the following four principles of enrichment teaching and learning:

- Acknowledge the uniqueness of each student.
- Enhance learning by ensuring that students find enjoyment in their activities.
- Ensure that learning is more meaningful by having students solve real problems while acquiring content and processing knowledge.
- The primary aim is to promote knowledge and thinking skills by allowing students to apply what they have learned and construct their own meaning.

D. Temporary Grouping

Both within-class grouping and cross-grade grouping are methods that adapt teaching to match student achievement or ability, as noted by Kulik (2003). Although such grouping typically accounts only for differences in reading and math ability or achievement, a study conducted by Tieso (2002) found that students who received math instruction in different achievement groups within the same class or attended a different class for appropriate instruction (i.e., Joplin plan, cross-grade grouping) demonstrated higher levels of achievement than control students who received traditional whole-class instruction. The students enjoyed both grouping plans, with a preference for cross-grade (Joplin plan) grouping.

E. Special Interest Groups

Gifted and talented-conscious teachers at any level can take on the responsibility of organizing enriching activities for interested students by leading special interest groups and clubs that are available in most schools. The teacher-leader has the responsibility to organize various enriching activities for interested students, including meetings, competitions, research projects, field trips, and meetings with community experts. Additionally, the teacher-leader can offer career information and guidance. One can also arrange minicourses taught by either teachers or community experts that cover special interest areas. Grouping gifted students can be done in various ways, as research has shown to be effective (Kulik, 1992; Rogers, 1991, 2002). While placing gifted students together without changing their learning experience has a small positive effect on their learning, the real effectiveness of grouping lies in what occurs within the groups. By grouping gifted students and modifying the curriculum to match their current understanding and pace of learning, achievement gains of a full year greater than what would typically occur can be achieved (Rogers, 1991, 2002).

2.3. Acceleration, Enrichment, and Counselling

Incorporating suggestions from Davis (1998), Davis and Rimm (2004), Feldhusen, Hansen, and Kennedy (1989), Ganapole (1989), Kaplan (1974), Pyryt (2003), Renzulli (2003), Smith (1990), VanTassel-Baska (2003), and Winebrenner (2001), a curriculum for gifted includes (1) maximum achievement in basic skills; (2) content beyond the prescribed curriculum; (3) exposure to a variety of fields of study; (4) student-selected content; (5) high content complexity; (6) experience in creative thinking and problem solving; (7) development of thinking skills; (8) development of computer skills; (9) affective development; (10) development of motivation.

A. Acceleration

Acceleration is an instructional strategy that has been found to be effective for gifted learners (Stenbergen-Hu & Moon, 2011). Acceleration involves allowing students to move through the curriculum at a faster pace or access advanced content that is beyond their grade level (Kulik, 2004). This strategy is based on the premise that gifted students can handle more challenging work and need to be challenged to reach their potential. Research has shown that acceleration can be an effective strategy for meeting the academic needs of gifted learners. For example, Colangelo and colleagues (2004) found that acceleration resulted in increased academic achievement and higher levels of motivation among gifted learners. Additionally, Kulik and Kulik (1984) found that acceleration had a positive effect on the achievement of gifted learners in mathematics and science. Moreover, Bernstein et al. (2021) indicated that contrary to concerns about acceleration, it was found that acceleration did not negatively affect gifted students socially and emotionally. There are 13 types of acceleration explained below.

Early Admission to Kindergarten or First Grade: Feldhusen (1992) proposes that early admission to kindergarten or the first grade accommodates the high energy, enthusiasm, curiosity, and imagination of gifted children, as well as their intellectual needs to investigate, observe, and examine.

Grade-skipping: Grade-skipping, which involves advancing precocious elementary school students by one or more grades, is a traditional method of acceleration. Parents, teachers, psychologists, or counsellors may initiate grade-skipping when they observe that the child is one or two years ahead of the rest of the class, bored with school, and impatient with their peers (Feldhusen, 1992). This acceleration strategy does not require special materials, facilities, or gifted/talented programs, making it cost-effective for moving gifted or talented children through the school system ahead of schedule. Double promotion usually occurs in the lowest elementary grades but may also take place in advanced grades.

Subject-skipping and acceleration: Subject-skipping is a form of partial acceleration and is sometimes referred to as "full acceleration". This approach involves studying specific subjects or taking classes with students in higher grades. It is particularly effective in sequential subjects like reading, math, and languages but can be applied to other subjects as well. Subject-skipping is most suitable for students with special skills and talents in a single area. It can begin in elementary school and continue through high school. Implementing subject-skipping within a school usually does not require extra costs but heavily relies on the flexibility of teachers and administrators.

Southern and Jones (2004) suggest that students can accomplish other kinds of subject acceleration by taking summer school, attending after-school or Saturday classes, or receiving mentoring or tutoring. If elementary schools have not provided advanced math classes, students can take these alternative accelerated classes to join the honor sections of their high school.

Early admission to middle or senior high school: Brody and Stanley (1991) suggest that skipping grades 5, 6, 8, or 9 may be the best option for some students just before middle or high school, despite this acceleration alternative not being popular.

Credit by examination: Gifted students can be encouraged to accept advanced challenges in middle or high school through a cost-free mechanism known as credit by examination. For instance, if a talented student in mathematics or language feels that they have already learned the content of a semester course through home study or foreign travel, they should be permitted to "test out" of the course and, if they can demonstrate mastery, receive academic credit (Reis &McCoach, 2000). Allowing credit by examination not only prevents repetition and boredom but also promotes academic growth among gifted students.

College courses in high school: Dual enrollment programs provide an opportunity for academically talented and motivated high school students to take college-level courses while still in high school (Barnhart & Jake, 2019). By participating in such programs, students can attend classes on a college campus, being excused from their high school for a portion of the day. The credits earned from these courses can then be applied towards their college admission requirements or transferred to another college. It is crucial for the selected courses to also fulfill the high school graduation requirements, ensuring that students do not have to bear the additional workload of duplicative coursework.

Advanced placement: The College Board sponsors the Advanced Placement (AP) program, which offers high school students' college-level courses and examinations. Instructors who follow an AP course description typically teach the courses, which often take the form of honors classes.

Distance learning: Major universities have been offering distance learning courses, also known as independent study or correspondence courses, for a long time. With the expansion of computer-based courses, distance learning has now gone beyond college courses and presents valuable opportunities for talented students living in rural areas, small cities, or small towns who wish to take more advanced courses than what their schools offer. Duke University's Talent Identification Program, the Center for Talent Development at Northwestern University, the Education Program for Gifted Youth at Stanford University, and the Renzulli Learning System online program are leaders in providing distance learning to gifted students.

Telescoped programs: Telescoping refers to collapsing multiple academic years' work into fewer years. For instance, in middle school, if there are enough talented young mathematicians, a 3-year math and algebra sequence may be taught in 2 years at an accelerated pace. This method can be applied to other subjects as well, such as condensing 3 years of middle school science into 2 years. In high school, the counselor can assist the energetic and capable student in cutting down on "study hall" classes and scheduling 4 years of high school requirements into a more compact and busy 3 years. If 3 years is not possible, a 3.5-year program would still enable a capable student to begin college a semester early, assuming district policies permit such acceleration.

Early admission to college: Educators often allow gifted and talented students in high school, and sometimes even middle school, to enroll in college at an earlier stage on a full-time basis. This can be accomplished through various approaches. In some cases, students accelerate their progress by fulfilling high school requirements ahead of schedule through customized plans. Alternatively, if not all high school courses have been completed, students may earn their high school diploma after successfully finishing substitute college courses. Flexibility in high school requirements is sometimes granted, with certain course requirements waived, allowing capable students to enter college full time without meeting all the typical graduation criteria (Brody & Stanley, 1991; Brody, Muratori, & Stanley, 2004;

Colangelo et al., 2004; Gregory & March, 1985; Karnes & Chauvin, 1982; Olszewski-Kubilius, 1995).

Residential high schools: States are initiating residential high schools in math, science, and technology in response to the need for mathematicians, engineers, and scientists, as well as the troubling results of the National Assessment of Educational Programs. Gifted high school students can attend live-in schools. Residential high schools operate on the philosophy that regular high schools cannot provide a sufficient number of advanced courses or a diverse enough curriculum to meet the needs of gifted students, who may complete all the math courses offered by their school within one or two years. Therefore, residential programs are appropriate for students who can master content at a much faster rate than others and engage in complex processes at high levels of abstraction (Kolloff, 2003, 2005).

International baccalaureate programs: The International Baccalaureate (IB) programs expose students to worldwide international concerns and provide excellent advanced coursework, including foreign languages.

Talent search programs: The Talent Search programs, originally initiated as Julian Stanley's Study of Mathematically Precocious Youth (SMPY) at Johns Hopkins University in 1971, have been highly successful in facilitating the acceleration of academically talented secondary students into college-level coursework (Stanley, 1979, 1991; Benbow & Lubinski, 1997). The primary objective of SMPY was to identify seventh-grade students displaying exceptional mathematical abilities and provide them with specialized opportunities, supplementary resources, and accelerated pathways to advance their proficiency in mathematics and related disciplines like physics and computer science (Stanley, 1991). Selection for participation in these programs involves assessing the Scholastic Aptitude Test (SAT) mathematics scores of seventh and some eighth-grade students through an annual mathematics Talent Search.

B. Enrichment

Enrichment is another instructional strategy that has been found to be effective for gifted learners. Enrichment involves providing additional learning opportunities that go beyond the standard curriculum (Davis et al., 2014). Enrichment activities can include independent projects, research, field trips, and extracurricular activities. Research has shown that enrichment can be an effective strategy for stimulating and engaging gifted learners. For example, Renzulli and colleagues (1994) found that enrichment programs resulted in increased academic achievement and higher levels of creativity among gifted learners. Additionally, Gubbins and colleagues (2007) found that enrichment activities had a positive effect on the motivation and engagement of gifted learners.

Many different enrichment theories have been proposed, developed, and studied in the field of gifted education and enrichment during the last few decades. Enrichment pedagogy encompasses a variety of strategies aimed at enhancing student effort, enjoyment, and performance and promoting advanced-level learning, critical and creative thinking, and problem solving across all subject areas. The theories and practices related to enrichment in the field of gifted education can be broadly categorized into two types. The first category involves enrichment experiences tailored to the interests and talents of individual students, as recommended in the Schoolwide Enrichment Model (SEM) (Renzulli & Reis, 2014). The second category includes theories in which enrichment is integrated into the curriculum through teacher-selected opportunities and appropriate content (Robinson et al., 2007).

Enrichment pedagogy plays a foundational role in the Enrichment Triad Model of the Schoolwide Enrichment Model (SEM). This model encompasses two broad categories of general enrichment, referred to as Types I and II, which are recommended for all students. Additionally, a third category, Type III, is specifically designed to meet the needs of students who demonstrate academic talents, advanced abilities, interests, and task commitment. Type I Enrichment aims to expose young learners to exploratory experiences that introduce them to new interests and potential areas of exploration. Type II Enrichment consists of training activities spanning six distinct domains, namely Cognitive Thinking Skills, Character Development Skills, Learning How-To-Learn Skills, Utilizing Advanced Research and Reference Skills, Developing Written, Oral, and Communication Skills, and Mastering Meta-Cognitive Technology Skills. Type III Enrichment involves individual and small group investigations focused on authentic problems, providing a context where the most innovative and creative instances of talent development can be observed (Reis & Renzulli, 2015). Table 1 provides a comprehensive overview of the strategies associated with enrichment pedagogy, along with corresponding sections that illustrate the practical implementation of these pedagogical approaches in both classroom settings and dedicated enrichment programs.

Independent and Small Group Projects: These enrichment activities include, for instance, students passionate about the arts involving extensive hours of drawing, painting, animation, and illustration. Individual students or small groups can also conduct research and develop original solutions to real-world problems without preexisting answers

Enrichment Pedagogy Strategy	Description
Strength-based Learning Opportunities	Using knowledge of students' academic strengths, learning preferences, interests, and talents to systematically create learning opportunities focusing on talent development opportunities to develop their talents, gifts, interests, and strengths

Critical/Creative Thinking and Problem Solving	Providing opportunities to use critical and creative thinking and problem solving (ability to interpret information critically and make a judgement, and using open-ended thinking resulting in multiple ideas and solutions)
Identification and Development of Interests (such as using Interest Development Centers)	Purposeful methods used to identify and develop student interests in class, such as using interest assessment instruments and interest development centers in the classroom.
Independent and Small Group Projects, Studies, and Explorations (Opportunities for Creative Prod	Enable the development of creative-productive gifted behaviors that enable students to work on problems and areas of study that have personal relevance to them. Work on these studies can often be used for solving problems and making a difference in society, either by individual or groups of students.
Open-ended and Choice Assignments and Other Choice Enrichment	Provide open-ended and choice in assignments, including homework and class assignments. Additionally, offering choices for enrichment learning, such as in enrichment clusters selected by students, in which the production of a product or service occurs.
Differentiated Instruction (Curriculum Compacting) Targeted to Student Needs	Make instructional and curricular modifications and differentiated instruction to ensure that instruction and content are more challenging and advanced, as needed.
Integrating Depth and Complexity	Infuse the curriculum with depth and promoting in students a desire for complexities beyond the requirements of the standard curriculum to stimulate student inquiry or questioning and/or student responses
Embracing Affective Differences and Support for Social Emotional Needs and Development	Use pedagogy that addresses the multifaceted characteristics of diverse groups of students, also focusing on their social and emotional needs, and ways of supporting their social and affective growth through academic engagement and strength-based pedagogy

Table 1. Enrichment Pedagogy Strategies (Reis & Renzulli, 2021)

Interest Centers: To integrate enrichment pedagogy into the classroom, teachers can use an interest centre as a method to spark students' curiosity within or across disciplines. This approach involves organizing a variety of resources, such as fiction, nonfiction, picture books, websites, and virtual tours, in a space that invites students to pursue interdisciplinary or content-specific enrichment. These centres offer a wide range of resources, including video clips featuring knowledgeable speakers, exposure to internet sites, and a diverse collection of books spanning various difficulty levels and disciplines. For instance, a biology-themed interest center can incorporate an assortment of materials like fiction and non-fiction books, magazines, journals, charts, posters, diagrams of body organs, measurement tools such as a measuring tape and a timer, X-rays of bones, writing and art supplies, a computer with internet access, and a model of human skin. By engaging in activities such as reading, hands-on interactions, watching films, and listening to blogs, students have the opportunity to deepen their understanding of biology (National Association for Gifted Children, 2010).

Enrichment Clusters: Enrichment clusters are a crucial part of the Schoolwide Enrichment Model, where groups of students with common interests are placed together during designated time blocks to work with an adult mentor who has advanced knowledge in that area (Renzulli, Gentry, Reis, 2013). These clusters are often not graded and can include students of varying ages. Research has shown that enrichment clusters can benefit all students, as they allow them to pursue and develop their interests. These clusters are offered to the entire student population and can include a wide range of subjects such as arts, drama, history, creative writing, music, science, inventions, archeology, and others. All teachers, including those of music, art, and physical education, are involved in facilitating the clusters, with their involvement based on their own interests and expertise. Students have a choice in the products or services they complete in enrichment clusters, guided by teachers or adult volunteers with advanced knowledge of the area.

The Schoolwide Enrichment Model in Reading (SEM-R): The SEM-R approach is an enrichment strategy that incorporates constructivist theories developed by Renzulli (1976) and Renzulli and Reis (2014), along with Kaplan's (2020) depth and complexity approach to gifted education content and teaching methods. This approach aims to provide a variety of structured enrichment experiences for all students while offering advanced learning opportunities to those who have high levels of achievement and interest. In the SEM-R approach, educators strive to establish interdisciplinary connections in literature, encompassing both fiction and non-fiction works across different subject areas. By adopting an interest-based reading approach, students are exposed to the interconnectedness of literature and are encouraged to explore books that align with their interests, both within and outside their usual areas of focus. The SEM-R approach underscores the importance of matching students with self-selected reading materials that slightly surpass their current reading levels, ensuring that the texts are both challenging and captivating.

The SEM-R approach aims to achieve several goals. First, it aims to promote a love of reading by providing students with access to high-interest, self-selected books that they can read both in school and at home. Second, it aims to foster independence and self-regulation in reading by allowing students to choose their own books and providing personalized reading instruction. Finally, the SEM-R approach seeks to improve reading fluency and comprehension for all students. Numerous studies conducted over the course of almost a decade have shown that the SEM-R approach has been successful in helping teachers implement enrichment pedagogy to improve reading achievement and encourage talented readers to engage with more challenging and enjoyable materials for longer periods of time. Randomized studies suggest that the SEM-R approach is particularly effective for diverse groups of talented students (Reis et al., 2008).

C. Curriculum Compacting

The strategy of compacting is a form of differentiation that allows for the documentation of compacted content areas and substitution with alternative work. Compacting may involve accelerating regular curriculum material for students who can complete it more quickly or accelerating content for advanced projects or added depth or complexity. Curriculum compacting, as an effective pedagogical strategy, integrates several other approaches, including leveraging students' curricular strengths and interests while fostering depth and complexity. It further encourages active engagement in and completion of Type III enrichment studies, facilitating the cultivation of advanced thinking and problem-solving skills. By providing necessary effective support for advanced work and substituting mundane tasks with more stimulating alternatives, curriculum compacting mitigates the risk of underachievement and offers social and emotional assistance to advanced students. Extensively researched and widely implemented, curriculum compacting is a differentiated instructional method typically accessible to all eligible above-average students (Reis & Renzulli, 1992). This approach empowers teachers to modify the standard curriculum by removing previously mastered content and replacing it with more captivating, challenging, and intellectually stimulating activities. This, in turn, enables students to focus on talent development pursuits such as advanced projects or independent/small group Type III investigations (Reis & Renzulli, 2014; Renzulli & Reis, 1997).

Integrating Depth and Content into Student Learning: Integrating depth and complexity into student learning enables them to better comprehend the material, develop an appreciation for it, and engage in critical thinking. This approach is particularly beneficial for academically talented and high-potential learners as it promotes their active involvement. Gifted students, specifically, can benefit from focusing on depth to acquire a profound understanding of a specific subject area, while emphasising complexity helps them gain insights into the interconnections among different disciplines. According to Kaplan's (2020) research, a deeper understanding is fostered when students explore content using various icons, such as details, patterns, rules, trends, unanswered questions, ethics, and big ideas. Additionally, Kaplan's study reveals that a more complex understanding of disciplines is achieved when students delve into how fields have evolved over time, consider diverse perspectives, and examine the interconnectedness of different disciplines. To support these discussions, Kaplan has developed icons as educational tools and prompts for teachers to employ.

Conclusion

As briefly stated in the first chapter, the GIFTLED method engages "the learning by design" and AR and Digital Design Tools for better engagement of gifted learners in STEAM education. Therefore, the GIFTLED method offers instructional strategies to meet the special learning needs of gifted learners in STEAM education to foster their creativity, increase their motivation, enable deeper content learning, and address learners' diversities through individualized learning paths.

In this respect, the GIFTLED Method should be seen as an enrichment strategy that involves differentiation over curriculum elements in the STEAM classroom. This differentiation mainly includes process differentiation, product differentiation, and learning environment differentiation. The process differentiation is implemented through the use of the "learning by design" approach explained in Chapter 1. As stated, the approach offers experience in the content/field, having explicit knowledge and conception of the topic which offers deeper knowledge, using the obtained knowledge to evaluate various instances, and using the knowledge to create something new. In this respect, the differentiated process enables experiencing, conception, challenge/critical thinking, and design/creativity. The differentiated learning environment firstly engages the use of AR technologies that offer increased engagement and learning experience for better implementation of the first three stages of learning by design approach. Second, the differentiated learning environment engages the use of Digital Design Tools through which gifted learners will be able to design new products and develop new solution proposals in the STEAM fields. Finally, the GIFTLED Method involves differentiated learning products which are designed by learners in digital forms and include vast resources for design and creativity.

GIFTLED Method as an enrichment and differentiation strategy offers easy-to-use instructional activities that should be used in general classrooms or other enrichment programs. Furthermore, instructional activities offered by GIFTLED Method should be applied as groups or individual work.

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4 STEAM and STEAM Education

Yianna Spanou

1. What is STEAM and STEAM education?

STEAM (Science, Technology, Engineering, Arts, and Mathematics) is a comprehensive approach to education that integrates the aforementioned subjects into a cohesive, interdisciplinary curriculum. It aims to prepare students for success in the 21st century by developing their critical thinking, problem-solving, creativity, and collaboration skills.

The term STEM, which unites related topics and is used in formal education all over the world, has already gained widespread recognition. STEAM is a recent evolution of STEM. STEAM is a teaching approach that encourages interdisciplinary learning, particularly for science and art topics together. The STEAM approach has recently come up for discussion in the area of education. Different people have different ideas about what precisely STEAM means. We can find a viewpoint that considers A in STEAM to be the school topic of ART. Another perspective uses ART to refer to all kinds of art and craft, and the broadest of them all uses ART to refer to the arts, which includes all humanities. (Piila et al., 2021).

The common characteristic of the two fields (STEM & STEAM) is integration and more precisely, the multidisciplinary approach that both adopt to deliver learners with inquiry-based lessons that are created on project work and missions. Adding 'Arts' in STE(A)M promotes the combination of creative thinking and applied arts while dealing with real-world situations. An example of STE(A)M would be architecture, which includes technology, mathematics, engineering, and science, as well as arts to create good-looking structures and buildings (IN2STEAM Online Courses, https://in2steam.eu/course/course/view.php?id=2).

Ryu et al. (2021) in their book they mentioned that the STEAM pedagogy is founded on the idea that by fostering students' capacity for creativity and innovation while they attempt to solve real-life problems or create and make science-related products, students' knowledge and skills in STEM subjects can be further enhanced through the arts.

2. STEAM (Science, Technology, Engineering, Arts, and Mathematics) Education for Gifted: STEAM as a differentiated learning path for the Gifted

The integration of STEAM education can be particularly beneficial for gifted students, as it provides opportunities for them to explore their interests and talents in multiple areas simultaneously. STEAM programs can challenge these students to think beyond traditional academic boundaries and to apply their skills and knowledge to real-world problems (Bertrand & Namukasa, 2022).

Gifted students acquire knowledge more quickly than their peers do; as a result, they require enrichment and a variety of programming choices. It is thought that teachers of gifted pupils could improve their students' critical thinking if they improved their own (Tüzün, & Tüysüz, 2018).

Moreover, STEAM programs often offer enrichment opportunities such as research projects, mentorship, and competitions, which can provide gifted students with additional challenges and recognition for their accomplishments. Overall, the integration of STEAM education can help gifted students reach their full potential and prepare them for success in a rapidly changing world (SIG, 2019).

Wilson (2018b) in his article highlighted that there hasn't been a lot of systematic research on how STEAM instruction or arts integration can help gifted students advance toward academic objectives like achievement, attitudes, or school engagement. However, numerous authors have provided explanations of approaches and plans for further integrating the arts for gifted students through reviews of past work and specialized teaching manuals. Alternative approaches to including the arts in gifted classes include discussion-based techniques like Paideia Seminar.

There are several ways in which STEAM education and activities can be used as learning paths to support gifted students. Firstly, by encouraging exploration and creativity. STEAM education can provide a platform for gifted students to explore their interests and creativity. They can use their skills and knowledge in multiple disciplines to find innovative solutions to complex problems. Secondly, by providing challenging and engaging learning experiences. STEAM activities can be designed to challenge and engage gifted students. They can participate in projects that require higher-level thinking skills, such as critical thinking, problem-solving, and decision-making (Bertrand, & Namukasa, 2020).

Moving forward, fostering collaboration and teamwork could be a good activity to support gifted students. STEAM education emphasizes collaboration and teamwork, which can be especially beneficial for gifted students who may work well with others. Gifted students can collaborate with peers to develop and implement innovative solutions to problems. A thematic review of gifted education and STEM suggests that the development of gifted and talented students is to provide educational programs that are a better match to students' learning paces and levels of achievement (Ulger, & Çepni, 2020).

Also, by offering specialized programs. Some schools offer specialized STEAM programs for gifted students. These programs may provide advanced coursework, research opportunities, and mentorship from professionals in the field. On the same page, specialized classes can be created to provide rigorous and challenging material to our most capable learners so to help them achieve STEM excellence (Danielian et al., 2018).

Lastly, by providing access to cutting-edge technology and resources. STEAM education provides access to cutting-edge technology and resources that can enhance the learning experience for gifted students. They can use tools like 3D printers, coding software, and virtual reality to explore their interests and develop their skills (Best 3D Printers for Schools & STEM Education 2023).

STEAM activities are related to enrichment strategies in many ways. To start with, STEAM activities can boost students' engagement, motivation, and interest in learning by providing them with authentic, real-world, and problem-based challenges that require them to use their creativity, critical thinking, collaboration, and communication skills (Gieras, 2022). Secondly, STEAM activities can enhance students' academic achievement and performance by exposing them to rigorous and challenging material that integrates science, technology, engineering, art, and mathematics concepts and skills according to Ulger & Cepni (2020). Thirdly, STEAM can foster students' talent development and career readiness by nurturing their potential and interest in STEM fields and providing them with opportunities to explore various STEM careers and role models (Staff, 2019). Moving forward, STEAM activities can promote students' cultural awareness and diversity by allowing them to learn about different artistic traditions and expressions from around the world and how they relate to STEM concepts and phenomena (PCS Edventures, 2023). Lastly, STEAM can promote gifted students' social and emotional development by providing them with a supportive and collaborative learning environment that values their diversity and uniqueness. STEAM can also help them develop their self-confidence, self-regulation, and resilience by encouraging them to take risks, learn from failures, and celebrate successes (Reis et al., 2021).

Overall, STEAM education and activities can provide gifted students with opportunities to explore their interests, develop their skills, and reach their full potential. By providing engaging, challenging, and collaborative learning experiences, STEAM education can help gifted students prepare for success in a rapidly changing world.

3. Differentiation Learning by design for STEAM education

The Learning by Design method is an inquiry-based learning approach that integrates Science, Technology, Engineering, Arts, and Mathematics (STEAM) education. It emphasizes the importance of design thinking and problem-solving skills in STEAM education (Li et al., 2019b). The method involves students in designing and creating solutions to real-world problems (Quigley et al., 2020b). It is an effective way to engage students in STEAM subjects and develop their creativity and critical thinking skills (Chung et al., 2020).

3.1. LbyD activities with STEAM use

The Learning by Design activities are four (4) and they are divided into the below areas:

a) Situated practice (experiencing)
b) Overt instruction (conceptualising)
c) Critical framing (analysing)
d) Transformed Practice (applying)

To begin with, the situated practice (experiencing) is a term that mentions the process of learning through participation in authentic activities and contexts that are relevant and meaningful to the learners. Situated practice (experiencing) is connected with STEAM education in several ways. First, it can enhance STEAM education by providing students with opportunities to apply their knowledge and skills of science, technology, engineering, art, and mathematics to real-world problems and situations that require creativity, innovation, and collaboration (Lugthart & van Dartel, 2021). Second, it can support STEAM education by engaging students in simulating professional practice and developing their identity and agency as STEAM practitioners. For example, students can simulate media design studios, engineering firms, or art galleries and take on various roles and responsibilities within these contexts (Lugthart & van Dartel, 2021). Third, it can complement STEAM education by fostering students' social and emotional learning and well-being. For example, students can learn how to communicate effectively, work cooperatively, cope with challenges, and reflect on their learning experiences within situated practice (experiencing) environments (Liao et al., 2019).

Moving to the 2nd activity, overt instruction (conceptualising) refers to the procedure of learning through explicit and direct teaching of concepts, principles, and skills that are relevant and meaningful to the learners. Overt instruction is connected with STEAM education in several ways. First, it can enhance STEAM education by providing students with clear and structured guidance and feedback on their learning of science, technology, engineering, art, and mathematics concepts and skills. Overt instruction can also help students develop their metacognitive and self-regulatory skills by making them aware of their learning goals, strategies, and progress (Holbrook et al., 2020). Second, it can support STEAM education by engaging students in active and interactive learning activities that involve inquiry, exploration, experimentation, and reflection. Overt instruction can also scaffold students' learning by providing them with appropriate levels of challenge and support based on their prior knowledge, abilities, and interests (Bertrand & Namukasa, 2022). Third, it can complement STEAM education by fostering students' conceptual understanding and transfer of learning across different disciplines and contexts. Overt instruction can also help students make connections between their learning experiences and real-world applications and implications of STEAM concepts and skills (Khine & Areepattamannil, 2019).

The 3rd activity, critical framing (analysing) discusses the process of learning through critical reflection and evaluation of one's own and others' perspectives, assumptions, and actions in relation to the learning context and the broader social and ethical implications. Critical framing is connected with STEAM education in several ways. First, it can enhance STEAM education by providing students with opportunities to develop their critical thinking, reasoning, and argumentation skills in relation to science, technology, engineering, art, and mathematics concepts and skills. Critical framing can also help students develop their metacognitive and self-regulatory skills by making them aware of their own and others' strengths, weaknesses, biases, and values (Colucci-Gray et al., 2019). Second, it can support STEAM education by engaging students in dialogic and collaborative learning activities that involve questioning, challenging, and debating different viewpoints and evidence from multiple sources and disciplines. Critical framing can also scaffold students' learning by providing them with appropriate levels of challenge and support based on their prior knowledge, abilities, and interests (Holbrook et al., 2020). Third, it can complement STEAM education by fostering students' social and ethical awareness and responsibility in relation to the impact and consequences of STEAM concepts and skills on themselves, others, and the environment. Critical framing can also help students make connections between their learning experiences and real-world issues and dilemmas that require creativity, innovation, and collaboration (Mejias et al., 2021).

The last activity is the transformed practice (applying and designing). Is a term that refers to the method of learning through applying one's knowledge, skills, and attitudes to new and authentic situations that require creativity, innovation, and collaboration (Perales & Aróstegui, 2021). Transformed practice is connected with STEAM education in several ways. First, it can enhance STEAM education by providing students with opportunities to demonstrate their mastery and integration of science, technology, engineering, art, and mathematics concepts and skills in meaningful and relevant contexts (Perignat & Katz-Buonincontro, 2019). Transformed practice can also help students develop their problem-solving, decision-making, and project-management skills by involving them in complex and open-ended challenges (Perignat & Katz-Buonincontro, 2019). Second, it can support STEAM education by engaging students in authentic and collaborative learning activities that involve creating, designing, producing, and presenting original products or solutions that address real-world needs or issues (Perales & Aróstegui, 2021). Transformed practice can also scaffold students' learning by providing them with appropriate levels of challenge and support based on their prior knowledge, abilities, and interests (Perignat & Katz-Buonincontro, 2019). Third, it can complement STEAM education by fostering students' personal and social development and responsibility in relation to the impact and consequences of their products or solutions on themselves, others, and the environment (Perales & Aróstegui, 2021). Transformed practice can also help students make connections between their learning experiences and their future aspirations and opportunities in STEAM fields and careers (Perignat & Katz-Buonincontro, 2019).

STEAM education is an interdisciplinary approach that integrates science, technology, engineering, art, and mathematics in meaningful and relevant contexts. To foster students' multiliteracies and creative capacities in STEAM education, teachers can use a pedagogical framework that consists of four elements: Situated practice, Overt instruction, Critical framing, and Transformed practice (Kalantzis & Cope, 2005; New London Group, 1996). Situated practice involves immersing students in authentic and collaborative learning experiences that draw on their prior knowledge, interests, and cultural backgrounds. Overt instruction involves providing students with explicit guidance and scaffolding on the concepts, skills, and strategies involved in STEAM disciplines. Critical framing involves engaging students in analyzing and evaluating the social, cultural, and ethical implications of their STEAM products or solutions. Transformed practice involves enabling students to apply their learning to new situations and contexts, and to create original and innovative outcomes that address real-world problems or needs. By integrating these four elements in STEAM education, teachers can help students develop their critical thinking, problem-solving, communication, collaboration, and creativity skills in a holistic and integrated way.

Thinking skills such as creative thinking, problem-solving, cooperation, and communication skills will make students to surpass in this changing world. Digital literacies such as coding and life skills such as risk-taking and leadership are important too. Children can learn these skills in a variety of effective methods, including STEAM learning and design thinking pedagogies. With a focus on practical uses, STEAM Learning integrates Science, Technology, Engineering, the Arts, and Mathematics (Ezyschooling). Some other various skills of gifted learners that are fostered by STEAM are the creativity, meaning that STEAM education encourages students to think outside the box and use different ways of thinking and skills to solve problems. It also allows students to express themselves through various art forms and media (Staff, 2019). The confidence, where STEAM education helps students develop their communication and presentation skills by engaging them in artistic processes such as design and design thinking. It also boosts their self-esteem by giving them opportunities to showcase their talents and achievements (Staff, 2019). Another one is the problem-solving already mentioned above, which STEAM education challenges students to apply their knowledge and understanding of science, technology, engineering, art, and mathematics to real-world situations and issues. It also teaches them how to use the design thinking process, which involves empathizing, defining, ideating, prototyping, testing, and iterating (Ulger & Cepni, 2020). The collaboration is a significant skill that gifted learners adopt using STEAM education, which promotes teamwork and cooperation among students by engaging them in group projects and activities that require diverse perspectives and skills. It also fosters a sense of community and belonging among students who share similar interests and passions (Staff, 2019). Finally, STEAM education nurtures the potential and interest of gifted students in STEM fields by providing them with rigorous and challenging material, specialized classes and programs, mentorship and guidance, and exposure to STEM careers and role models (Ulger & Cepni, 2020).

According to Bertrand, & Namukasa, (2020), STEAM programs help students learn character-building skills that are transferable to other real-life contexts such as post-secondary education and the workforce. A study by O'Grady-Jones, & Grant, (2023b) found that game design-based learning can have cognitive and motivational impacts on middle school children. Another study revealed that STEAM-based activities can have positive effects on gifted students' STEAM attitudes, cooperative working skills, and career choices (Konkus, & Topsakal, 2022).

Yakman (2008) in her paper stated that STEAM It is a transdisciplinary method of education that tasks young brains with improving the world. Modern education is interactive, linked, and dynamic. The use of commonplace technology in virtual projects is integrated into STEAM teaching and learning. Design thinking (DT) is a design-led method for solving practical issues that is based on human-centeredness as well as imaginative, all-encompassing, and multidisciplinary thinking. STEAM is anticipated to have a significant role in catalyzing innovation, discoveries, and knowledge gains. According to Culén and Gasparini (2019), these assumptions are in line with DT.

Learning by Design can be integrated into STEAM education in several ways, such as using design thinking as a framework to guide STEAM activities and projects that involve science, technology, engineering, art, and mathematics. For example, students can use design thinking to create a solar oven, a musical instrument, a video game, or a wearable device that incorporates STEAM concepts and skills (Henriksen et al., 2019). Also, according to Li et al. (2019) using design thinking as a way of developing students' creativity, confidence, problem-solving, collaboration, and STEM talent development skills that are essential for STEAM education. For example, students can learn how to generate multiple ideas, communicate their thoughts effectively, apply their knowledge to new situations, work with others from different backgrounds and perspectives, and nurture their potential and interest in STEM fields. Lastly, using design thinking as a way of connecting STEAM disciplines and making them more relevant and meaningful for students. For instance, students can learn how art and design can enhance their understanding and appreciation of science and mathematics concepts and phenomena, such as symmetry, patterns, shapes, colors, sound, light, etc. (Staff, 2019).

4. Challenging gifted learners in STEAM

There are many programs and approaches designed to support the learning of gifted and talented students in STEAM subjects. Offering opportunity for advanced programs beginning in elementary school is one method to challenge these learners. Currently, most gifted children spend the majority of their time in regular classrooms without access to challenging coursework or teachers knowledgeable about the special learning needs of our most highly able learners.

There are also books that offer an overview of programs designed to support the learning of gifted and talented students in STEAM subjects, both to allow them to meet their potential and to encourage them to proceed towards careers in STEAM areas (Taber et al., 2017). The Summer Institute for the Gifted (SIG), which provides gifted students ages 5–17 with a broad and comprehensive selection of STEAM courses, is another option to push the learners who are gifted. The development of talented individuals' talent and intellectual rigor through STEAM education (SIG, 2019). A quality STEAM education program, according to studies, is collaborative, inventive, student-centered, engaging, and applies real-world applications. However, it can be challenging to integrate STEAM into existing teaching practice (STEAM Stars Project, 2022). Taber et al., (2017) mentioned that there are also books that offer an overview of programs designed to support the learning of gifted and talented students in STEM subjects, both to allow them to meet their potential and to encourage them to proceed towards careers in STEM areas.

Finally, the below strategies are align with the National Association for Gifted Children (NAGC - https://giftedandtalentedresourcesdirectory.com/) and the International Technology and Engineering Educators Association (ITEEA - https://www.iteea.org/STEMCenter.aspx) standards for gifted education and STEM education.

- Provide opportunities for independent research: Gifted learners may be interested in exploring topics beyond what is covered in the classroom. Encourage them to conduct independent research on a topic of their interest and provide resources to support their learning.
- Offer advanced coursework: Gifted learners can benefit from advanced coursework in STEM subjects, such as math, physics, and computer science. Offer honors, AP, or IB courses to challenge and engage them.
- Create opportunities for hands-on learning: Provide gifted learners with opportunities to apply their knowledge in practical and real-world situations. For example, they could participate in a science fair, robotics competition, or coding challenge.
- Encourage interdisciplinary learning: STEAM education is inherently interdisciplinary, and gifted learners can benefit from exploring connections between different subjects. Encourage them to explore topics that integrate STEM and the arts, such as designing video games, building sculptures using math principles, or exploring the science of music.
- Provide mentorship and internships: Gifted learners can benefit from interacting with professionals in STEM fields. Connect them with mentors or provide opportunities for internships or job shadowing in STEM-related industries.

5. Innovative Hands-On Learning Practices in STEAM for gifted through LbyD approach

First of all, it is essential to describe what hands-on learning practices are. Wu et al., (2023) describe Hands-On Learning Practices are activities that need to be difficult, interesting, and rich. Projects could contain issues with several possible solutions, for instance. Ideally, a tie-in to a real-world scenario would be most enriching to students since they can see how their learning correlates with their daily lives. Forbes contributors (2021) discuss how hands-on learning offers time and space to think through each action, as well as support from teachers who can provide real-time feedback.

Regarding hands-on practises in STEAM education, Belbase et al., (2021b) explains how STEAM education may empower students to use their imagination and analytical skills to the design of novel goods, the resolution of challenging issues, and the discovery of fresh approaches to the pursuit of sustainable economic growth that place humans at their core. The Ministry of Education of New Zealand suggests using art to make STEAM learning more hands-on by designing technologies and prototypes for 3D printing in Tinkercad, doing graphic design around your prototype, designing apps for solving problems, drawing up design plans to reinforce your team's project vision, and doing projects that explore connections between art, science, and maths.

Some other innovative learning practices in STEAM for gifted learners through the LBD approach are the following. According to Bell, (2010) an innovative learning practise is the authentic problem-based learning, where gifted learners can be challenged by authentic, real-world problems that require the integration of STEM and arts knowledge and skills to design and develop creative solutions. This can involve tasks such as designing a sustainable building, creating a digital game, or developing a prototype for a new product. These tasks can be designed to challenge gifted learners to think critically, apply their knowledge, and collaborate with others.

Bell, (2010) and Kolodner et al., (2004) are highlighting the Project-based learning innovative practise. More specifically, they highpoint that Project-based learning (PBL) is a powerful tool for gifted learners as it enables them to explore complex topics in depth and develop a deep understanding of the subject matter. Projects can be designed to incorporate STEM and arts knowledge and skills, such as designing a bridge or creating a digital animation. The LBD approach can provide gifted learners with opportunities to work collaboratively, experiment, and learn through trial and error.

Another innovative approach is the Inquiry-based learning. According to Kolodner et al., (2004) Inquiry-based learning (IBL) is an approach that emphasizes questioning, exploring, and discovering new knowledge. The LBD approach can be used to engage gifted learners in

IBL activities by providing them with opportunities to investigate and explore problems, develop hypotheses, and conduct experiments. This approach can help gifted learners to develop critical thinking skills, creativity, and a deep understanding of STEM and arts concepts.

Culen & Gasparini, (2019) mention two innovative practises in STEAM education for gifted learners. The first is Design thinking is a problem-solving approach that emphasizes empathy, ideation, prototyping, and testing. The LBD approach can incorporate design thinking into STEAM education to engage gifted learners in the design process. Gifted learners can be challenged to identify problems, develop solutions, and create prototypes that address real-world issues. The second one is Multidisciplinary learning. The LbyD approach can be used to integrate STEM and arts education to provide gifted learners with a multidisciplinary learning experience. This can involve creating projects that incorporate multiple subjects, such as designing a video game that requires knowledge of mathematics, programming, and visual design. This approach can help gifted learners to develop a broad range of knowledge and skills, and to make connections between different subjects.

6. STEAM Activity based on LbyD approach: Designing a Solar Oven

In this activity, students will use the Learning by Design approach to create a solar oven that can cook food using only the energy from the sun. They will learn about the science of solar energy, heat transfer, and insulation, as well as the engineering design cycle and the principles of sustainability.

Learning Objectives:

- Students will be able to explain how solar energy can be converted into thermal energy and used for cooking.
- Students will be able to identify and apply the steps of the Learning by Design approach: experiencing, conceptualizing, analyzing, and applying.
- Students will be able to evaluate their design based on criteria and constraints such as cost, efficiency, safety, and environmental impact.

Materials:

- Cardboard boxes of various sizes
- Aluminum foil
- Plastic wrap
- Black construction paper
- Tape
- Scissors

- Thermometers
- Marshmallows
- Graham crackers
- Chocolate bars
- Paper plates
- Napkins

Procedure:

1. Introduce the activity by asking students what they know about solar energy and how it can be used for cooking. Explain that solar ovens are devices that use the sun's rays to heat up food or water. Show some examples of solar ovens from different parts of the world and discuss their advantages and disadvantages.

2. Divide the students into groups of 3 or 4 and give each group a cardboard box, aluminum foil, plastic wrap, black construction paper, tape, scissors, and a thermometer. Tell them that they will use these materials to design and build their own solar oven that can cook a s'more (a sandwich of marshmallow and chocolate between two graham crackers).

3. Guide the students through the Learning by Design approach as follows:

- Experiencing: Ask the students to explore the materials and experiment with different ways of using them to capture, reflect, and retain heat from the sun. Have them observe how different shapes, sizes, colors, and arrangements affect the temperature inside their boxes. Have them also try to cook a s'more using their initial designs and see how long it takes to melt.
- Conceptualizing: Ask the students to explain their observations and findings using scientific concepts and vocabulary. Have them discuss how solar energy is converted into thermal energy and how heat transfer and insulation work. Have them also compare their designs with the examples of solar ovens they saw earlier and identify similarities and differences.
- Analyzing: Ask the students to evaluate their designs based on criteria and constraints such as cost, efficiency, safety, and environmental impact. Have them consider how they can improve their designs by using less materials, increasing the temperature, reducing the cooking time, or minimizing waste. Have them also research other examples of solar ovens online or in books and see how they can learn from them.
- Applying: Ask the students to modify their designs based on their analysis and feedback from their peers. Have them build a new prototype of their solar oven using the materials provided or any other materials they can find. Have them test their new design by measuring the temperature inside their oven every 5 minutes

using a thermometer and recording it on a chart or graph. Have them also place a s'more inside their oven and observe how long it takes to melt.

Have each group present their final solar oven design to the class and explain how it works, how it meets the criteria and constraints, and what they learned from the process. Have them also share their s'mores with the class and enjoy!

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5 What is Augment Reality? The Use of AR Applications in Learning Activities

Darlene Schrembi

Augmented Reality: An Introduction

The aim of this chapter is to introduce readers to Mixed reality, focusing especially on Augmented Reality (hereinafter referred to as AR). This chapter will explain what AR is and how it can be used in STEAM disciplines. This chapter will also investigate the use of AR as a learning tool and design tool. After this, AR will be explored through its use in STEAM and STEAM disciplines and its value in fostering creativity and producing problem-solving scenarios. Finally, the AR tool which will be used in the GIFTLED, ZAPPAR, will be introduced to the readers to familiarize themselves with this application as it will be applied in a tool created through the GIFTLED project.

Mixed Reality

Nowadays, through technological developments, various ‘realities’ exist. AR should be distinguished from Virtual Reality (hereinafter referred to as VR). VR is a technology that creates a fully digital environment in which humans can interact in (Berryman, 2012). AR allows humans to combine reality and digital information (Berryman, 2012). Thus, the main difference between AR and VR is that AR combines the real and digital world while VR allows humans to interact in a fully digital scenario. Between AR and VR, there is another virtual world, called Augmented Virtuality. This allows people to control with real world objects in a virtual world. In the GIFTLED project, AR will be utilized, thus gifted students will be able to see virtual objects overlaid in the real-world environment. The figure below shows the distinction between different realities.

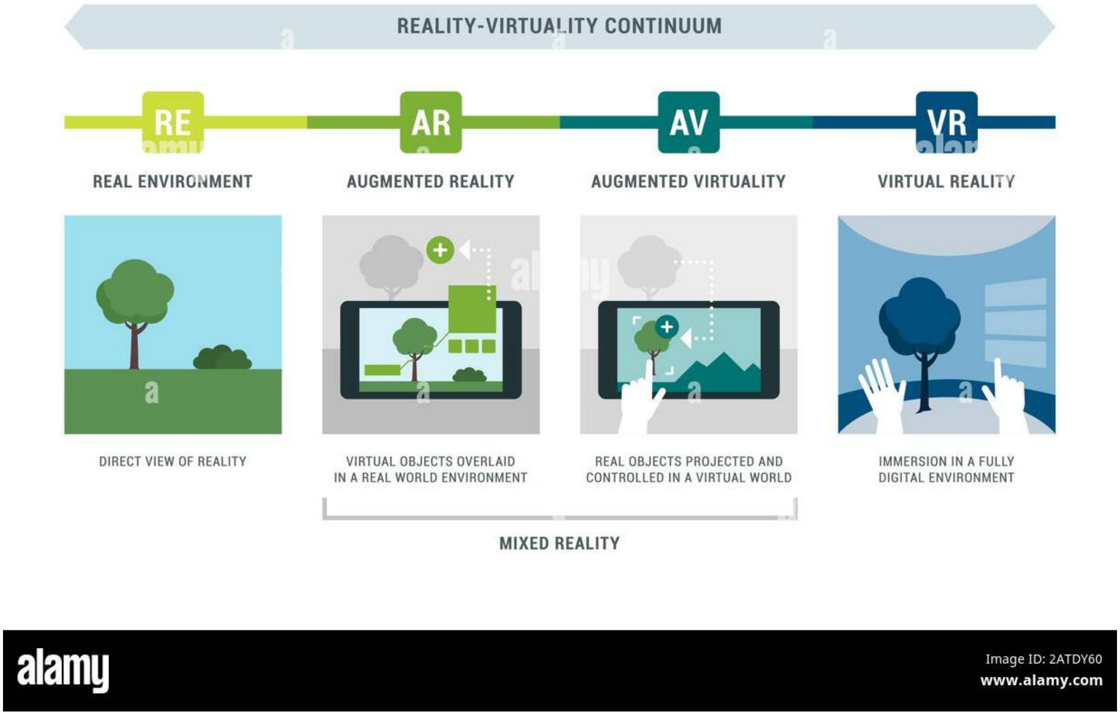

Figure 5.1. Figure showing different types of realities (Source: Alamy, 2023)

1. What is Augmented Reality?

As explained in the previous section, AR is a technology that combines digital information with our real world and allows us to interact with it (Berryman, 2012). AR is a technology that overlays digital information or objects onto the real world, creating a mixed reality experience that blends virtual and physical environments. This is done to enhance user experience (Berryman, 2012). Simply put, AR is an interactive medium which humans engage with (Craig, 2013). Humans engage with AR as it appeals to our senses (such as vision and sound) (Craig, 2013). Augmented reality can be applied in various areas, such as but not limited to education, medicine, fashion, museums, marketing, and entertainment (Berryman, 2012; Craig, 2013). This technology has the potential to revolutionize the way we learn, work, and interact with the world around us. In particular, AR has many applications in STEAM disciplines (science, technology, engineering, arts, and mathematics), where it can be used to enhance learning and understanding of complex concepts.

Figure 5.2. Man wearing smart glasses (Source: Unsplash, 2023)

2. Origin of Augmented Reality and use its Today

AR was first developed by the United States Air Force in the early 1990s (Boudreau, 2021). The first use AR consisted of bulky headsets, but today has developed into applications on mobile phones and grown in popularity (Boudreau, 2021). An example of the use of AR is in games. In 2016, Pokémon GO became a popular game which uses AR around the world (Boudreau, 2021). This game consists of 'catching' Pokémon's. This application uses AR as you can see the Pokémon's in our real world while playing. Furthermore, another mobile application which uses AR is Snapchat. Snapchat offers lenses which are engaging and interactive to users. Dodoo and Youn (2021) carried out a study to enhance our understand consumers' motivations to use Snapchat. Their research found that consumers use Snapchat and it's AR features for entertainment, aesthetics, uniqueness, curiosity, brand fan, and social interaction.

Figure 5.3. Pokémon GO application (Source: Unsplash, 2023)

Apart from the use in mobile applications like Snapchat and Pokémon GO, AR can make learning more engaging and interactive, which can help learners to stay motivated and interested in the subject matter. This is particularly important in STEAM disciplines, which can be complex and challenging to learn. This helps students to engage with the topic at hand in a more interactive way, rather than the traditional classroom setting.

3. Augmented Reality in STEAM and STEAM disciplines

2.1.Science

AR can be used to bring complex scientific concepts to life, making them more engaging and accessible to learners (Papagiannis, 2017). For example, AR can be used to create interactive 3D models of scientific phenomena, such as the solar system, the human body, or chemical reactions. Learners can explore these models in real-time, zooming in and out, and rotating them to gain a deeper understanding of the concepts (Wu et al, 2013)

AR can also be used to simulate scientific experiments, providing learners with a safe and cost way to conduct experiments without the need for expensive equipment. For example, AR can be used to simulate chemical reactions, allowing learners to observe the changes in real-time and understand the underlying principles. Scientific topics can be experiences through AR in all of the first three stages of the learning by design approach, i.e., experiencing, conceptualizing and analysing.

2.2.Technology

AR can be used to enhance the learning experience in technology disciplines, such as computer science, information technology, and engineering. For example, AR can be used to create interactive tutorials that guide learners through complex programming concepts, such as data structures, algorithms, and object-oriented programming.

AR can also be used to simulate engineering designs, allowing learners to visualize and test different design concepts in a virtual environment. This can help learners to identify potential design flaws and optimize their designs before prototyping and testing in the real world (Krokos et al, 2013). Through AR, gifted students can experience technology in a more hands-on approach. This will also allow them to understand better how and technology works.

2.3.Engineering

AR can be used to enhance the learning experience in engineering disciplines, such as mechanical, civil, and electrical engineering. For example, AR can be used to create interactive 3D models of engineering designs, such as buildings, bridges, and machines. Learners can explore these models in real-time, zooming in and out, and rotating them to gain a deeper understanding of the concepts (De Jong et al, 2013)

AR can also be used to simulate engineering designs, allowing learners to visualize and test different design concepts in a virtual environment. This can help learners to identify potential design flaws and optimize their designs before prototyping and testing in the real world (De Jong et al, 2013). Here AR can also be applied for students to learn about engineering in the learning by design approach, as AR helps students in observing, understanding and testing engineering mechanisms.

2.4. Arts

AR can be used to enhance the learning experience in arts disciplines, such as graphic design, animation, and film. For example, AR can be used to create interactive 3D models of art installations, allowing learners to explore the installations in real-time and from different perspectives.

AR can also be used to create immersive storytelling experiences, where learners can interact with virtual characters and objects to explore different narratives. This can be particularly useful in teaching storytelling techniques, such as plot development, character development, and dialogue. AR can be used for students to experience different artistic fields and build further knowledge in art disciplines. Furthermore, gifted students can criticize art through the use of AR.

2.5. Maths

AR can be used to enhance the learning experience in mathematics disciplines, such as geometry, algebra, and calculus. For example, AR can be used to create interactive 3D models of geometric shapes, allowing learners to explore the properties of these shapes in real-time (Liarokapis et al, 2014).

AR can also be used to visualize mathematical concepts, such as functions, equations, and graphs, in a more intuitive way (Liarokapis et al, 2014). For example, learners can use AR to overlay graphs onto real-world objects, such as buildings or landscapes, to better understand the relationship between the graph and the real world. Mathematical disciplines can be experienced through AR, to help students in visualizations and building knowledge.

3. Use of AR to Foster Creativity

AR can be used in a variety of ways to foster creativity, as it allows users to interact with virtual objects and environments in new and innovative ways. AR can help to inspire and unleash creativity in a variety of contexts. Some ways in which AR fosters creativity include enabling design and visualization, interactive storytelling, virtual art creation, experiential learning, and innovative marketing and advertising.

AR can be used to create 3D models of products and to visualize how they would look and function in the real world. This can help designers to iterate on their designs and to test different configurations before creating physical prototypes (Gauthier et al, 2018; Sönmez & Akın, 2019) This is useful in subjects and disciplines that involve the design and testing process. For example, this can be used in engineering, as it allows students to interact and visualize with the product they want to create.

Another example of the use of AR is when it is used to create interactive and immersive stories, allowing users to become part of the narrative and to engage with the story in new ways. For example, AR can be used to bring characters and environments to life, creating a more engaging and memorable storytelling experience (Hillier et al, 2018; Shirazi & Schmidt, 2019). AR can also be used to create virtual art pieces that are interactive and responsive to the environment. This allows artists to explore new mediums and to push the boundaries of what is possible with traditional art forms (Bell et al, 2018; Doering & Großmann, 2019). AR can be useful to different art disciplines and gives the opportunity to use new mediums in art. (Doering & Großmann, 2019).

AR can be used to create virtual environments that allow users to learn by doing, thus it boosts experimental learning. This can help to foster creativity by allowing users to explore and experiment with different concepts in a safe and controlled environment (Sjölie & Sjölie, 2019; Fidan & Kursun, 2019). This can be mainly applied in the scientific and engineering fields, where certain tests can be of danger to students, but the use of AR in such cases does not pose the dangers in the real settings (Fidan & Kursun, 2019).

AR can also be used to enhance marketing and advertising campaigns, allowing users to engage with products and services in new and innovative ways. This can help to capture users' attention and to create memorable experiences that foster creativity (Molinillo et al, 2020; Han & Stoel, 2018).

4. Use of AR in problem-solutions scenarios

AR can be a powerful tool for producing problem solutions, by allowing users to visualize and interact with data and information in new and innovative ways. This is very helpful in STEAM education as it gives the opportunity to students to learn in a more interactive manner. AR can be used in different problem-solution scenarios, such as but not limited to enhancing data visualization, enabling remote collaboration, supporting maintenance and repair, enhancing training and education, and enabling spatial computing, AR can help users to solve problems more efficiently and effectively.

AR can be used to create visual representations of data that are more interactive and engaging than traditional charts and graphs. This can help users to better understand complex data sets and to identify patterns and trends that might not be immediately apparent in a 2D representation (Tang & Owen, 2017; Lee et al, 2020). Thus, AR can help to enhance data visualization to help learners comprehend material in a more visual way. This can be particularly helpful in science and mathematics.

AR enables and enhances remote collaboration in teams. This is because AR can be used to create virtual meeting spaces that allow teams to collaborate and solve problems in real-time, even if they are located in different parts of the world. This can help to reduce travel costs and to increase efficiency by allowing teams to work together more effectively (Raento et al, 2009; Xu et al, 2019).

AR can be used to provide real-time information and guidance to technicians and maintenance workers, allowing them to quickly identify and solve problems in the field. For example, AR can be used to overlay instructions and diagrams onto equipment, making it easier for workers to perform repairs and maintenance tasks (Lei & Wu 2019; Bujak et al., 2021). This is efficient for engineers and engineering students, as this AR helps them solve problems in a more visual and guided manner.

AR can be used to create interactive and immersive training and educational programs that allow users to practice problem-solving skills in a safe and controlled environment. This can help to prepare users for real-world problem-solving scenarios and to build confidence and competence in their problem-solving abilities (Wang et al, 2017; Sadi et al 2020). This training and education can be applied in different fields, such as engineering, science laboratories, construction. These settings can be dangerous, especially for students who are still learning the discipline. Thus, by using AR, they can immerse themselves and learn through the scenario created by the AR (Wang et al, 2017; Sadi et al 2020).

AR has various advantageous elements. Teachers and students can use AR for its interactive and problem-solving qualities. Creating an AR simulation was appealing for students. This was noticed especially among behavioural and academically challenging students (Dunleavy et al, 2009). However, while the use of AR provided a different classroom scenario with added value, it also presented new management, technological and cognitive challenges to teaching and learning (Dunleavy et al, 2009).

Zappar

In the GIFTLED project, Zappar will be the AR used in the Project Results. ZAPPAR was founded in 2011 at the University of Cambridge (Zappar, n.d). It is one of the leading AR companies and has delivered over 1000 AR projects. It offers a combination of software and hardware solutions as well as a creative studio. Its services include consultancy to help businesses to develop full AR strategies. Furthermore, Zappar provides the needed hardware and tools to its customers to use AR. It provides products and services catered for the needs of varied cases, aims and contexts. Some of the sectors which Zappar caters for retail, marketing, learning & development, events, tours, and attractions, among others.

5. Using AR in the Learning by Design Approach

As you have read in Chapter One, the Learning by Design Approach consists of four steps. Learning by design is a pedagogical approach which transforms learning environments for students (Kalantzis & Cope, 2014). Learning by design is assisted by digital technologies, including AR. Learning by design using AR creates a more effective way of learning in the changing world (Kalantzis & Cope, 2014). In the GIFTLED method, AR will be applied for the first three steps, while the Digital Design Tools will be applied for the fourth step. In this section, we will focus on how AR can be applied in the first three steps of the Learning by Design Approach.

1) Situated practice (Experiencing)

As explained in Chapter 1, in a situated practice, learners participate in a knowledge process through which personal experience, concrete engagement, and exposure to evidence, facts and data take place. Here, participants engage in known and unknown experiences. With the use of AR, gifted learners will learn about STEAM subjects using more than just the traditional learning methods thanks to this technology. AR can augment textbooks or learning materials, turning static images into interactive elements. Students can scan specific images with AR-enabled devices to access additional information, 3D models, videos, or interactive quizzes related to the content. Teachers can use AR to enhance their lectures by presenting visual aids, interactive diagrams, or real-life examples that reinforce the conceptual understanding of the topic. Furthermore, AR games can be designed to align with educational objectives. By incorporating game elements into instruction, students may become more motivated to participate actively and persistently. AR can be used in any of the

STEAM disciplines. For example, when learning about science, learners can use AR to learn about bones, organs, and other topics. That means that diagrams seen in pictures can now be visualized through AR. These will spark more interest in the learners as they can utilize such tools which make visualizations in the real world. This makes it much easier for learners to learn STEAM disciplines.

2) Overt instruction (Conceptualising)

Here, learners conceptualise unknown abstract and theoretical knowledge. The role of the teachers here is to conduct activities to help learners use their existing knowledge and build new conceptions. There are various ways to achieve conceptualisation. AR can be a valuable tool to engage students and facilitate conceptualisation. AR can be used to create interactive simulations of real-world scenarios, environments, or processes. Students can explore and interact with these virtual elements, enabling them to gain practical experience and develop problem-solving skills in a safe and controlled setting. Here, the learner would be gaining more knowledge on a concept, thus achieving conceptualising. Furthermore, AR can be used to visualize abstract or complex concepts that are difficult to understand through traditional means. For example, it could represent complex scientific models, historical events, or mathematical structures, allowing students to grasp the ideas more intuitively.

3) Critical framing (Analysing)

In order to properly conduct critical framing, learners should ask questions about the element they are analysing, such as its function, how it operates and similar questions. Furthermore, they should ask about the aim of the element at hand. At this stage of the Learning by Design Approach, learners should develop independent learning skills which they apply in projects, assignments etc… For example, AR can present three-dimensional models of abstract concepts, allowing students to view and interact with them from different angles. For example, in physics, students can visualize complex structures or atomic models in 3D, providing a more tangible understanding of abstract principles. in chemistry, students can observe molecular reactions in real-time, making it easier to grasp the changes and interactions between elements.

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6 Digital Design Tools & Applications

Begoña González & Uxue Arregui

Design tools are software applications or programs that help individuals create and manage all kinds of content (Kumar & Puranik, 2020): visuals, graphics, text, audio, etc. They include a wide range of software tools, from graphic editors like Canva, to user interface design tools like SketchUp, and even to coding tools like Code. These tools enable individuals to create, edit, and manipulate various design elements, such as shapes, lines, colours, graphics, and typography.

Digital design tools also provide features such as layering, grouping, and alignment to enable individuals to manage complex designs easily (Kumar & Puranik, 2020). Additionally, design tools often come with pre-designed templates, icons, and other assets that the users can use as a starting point to speed up their workflow and creations.

In addition, design tools and applications offer several functional benefits that can be beneficial in educational fields. It's important to note that the functional benefits can vary depending on the specific tools used and the context of their application, but the general benefits are the following:

- Differentiated learning: Design tools allow gifted learners to explore complex concepts and advanced topics at their own pace, providing opportunities for differentiated learning experiences.
- Depth and complexity: Design tools encourage gifted students to delve into deep, complex problems and challenges, nurturing their ability to think critically and consider multiple perspectives.
- Autonomous learning: Design tools empower gifted learners to take ownership of their learning, providing them with the tools and resources to pursue self-directed projects and explore their interests.
- Enrichment and extension: Design tools offer opportunities for enrichment and extension of the curriculum, allowing gifted students to delve into advanced topics beyond the regular classroom content.
- Creative expression: Design tools provide gifted students with a platform to express their creativity and unique perspectives, allowing them to showcase their talents and ideas through design projects.

In general, the digital design tools and applications play a crucial role in the design process, enabling individuals to create stunning visual content for a wide range of applications, including the personal, academic, and professional field (Kumar & Puranik, 2020). Therefore, they have become very attractive and interesting for the educational sector and can be used to improve the comprehension and attractiveness of lessons in schools and many other types of education (Blikstein & Worsley, 2016).

Lastly, with regard to the use of digital design tools within the framework of GIFTLED, these tools will be utilised in the fourth pedagogical phase within the model proposed by the project (see chapter 1 of this handbook). In this phase, learners will be able to translate their knowledge and understanding of the real-world situations into practice by designing their own learning products or materials in a practical, creative and visual way. Furthermore, this approach proposed by the GIFTLED model will allow learners to engage in problem solving, product design, artistic design and many other activities.

1. Possible contributions of design tools in STEAM learning activities

Design tools can make significant contributions to STEAM (science, technology, engineering, arts, and mathematics) learning activities in a variety of ways (Blikstein & Worsley, 2016; Bull et al., 2008; Dorst, 2011; Edelson et al., 1999). Here are some of the possible contributions of design tools in STEAM learning activities:

In fact, teachers can use these tools to teach the content of various STEAM-related subjects. This can make the content more deeply understood by the students and make them feel more interested in the subject. Therefore, these digital design tools can contribute to STEAM learning activities in the following several ways:

- Encouraging Creativity: Design tools help students to unleash their creativity and express their ideas through visual and graphic design. They provide an opportunity for students to think beyond traditional forms of learning and explore innovative solutions to problems. This allows students to explore new ways of thinking and develop innovative solutions to problems (Peppler & Kafai, 2009).
- Enhancing Visual Communication: Design tools enable students to communicate complex ideas visually. They can create infographics, data visualizations, and interactive designs that help to simplify and explain complex concepts.
- Encouraging experimentation: Design tools can provide students with hands-on learning experiences, which can help them develop practical skills and deepen their understanding of STEAM subjects (Blikstein & Worsley, 2016).
- Facilitating Collaborative Learning: Design tools are often cloud-based, which means students can collaborate on projects in real-time. This fosters teamwork, communication, and problem-solving skills. This can lead to deeper learning and better outcomes (Bull et al., 2008).

- Developing Technical Skills: Design tools require technical skills such as understanding design principles, colour theory, typography, and layout. Students can develop these skills through the use of design tools, which can be applied in other STEAM activities.
- Integrating Art and Design with STEM: Design tools allow students to apply art and design principles to STEM activities. They can design prototypes, develop user interfaces, and create visualizations that bring STEM concepts to life.
- Promoting critical thinking: Design tools can help students develop critical thinking skills by encouraging them to analyse problems, evaluate different solutions, and make informed decisions (Edelson et al., 1999).

In conclusion, design tools and applications provide a dynamic and engaging learning experience that promotes critical thinking, problem-solving, and creativity in STEAM education. In addition, these digital design tools are accessible and easy to use for the overall individuals as they are free and not difficult to use.

2. How can design tools increase the interest and creativity of gifted learners

The GIFTLED pedagogical method proposes to use differentiation strategies (see chapter 3 of this handbook) in providing effective instruction and education. This approach can be promoted by the digital design tools that are proposed in this chapter, as each tool can address the diverse needs of all gifted learners. In fact, these digital design tools allow each student to learn in their own way, as they can generate their own content that they find interesting and effective in their learning process.

These tools will enable to engage gifted students in a more active way by designing activities that are more appropriate to their level of readiness and learning preferences. In fact, the digital design tools allow to challenge students on an individual level according to their readiness and ability as well as to analyse the progress of each student and give feedback. Therefore, these tools allow to enhance the differentiation strategies that the GIFTLED method intends to use.

In addition, keeping the differentiation strategies in mind, design tools can be an effective tool for increasing the interest and creativity of gifted learners by providing them with a platform to express their ideas and engage in project-based learning (Naghshpour et al., 2018). Here are some ways in which design tools can be particularly effective in enhancing the differentiated learning experience of gifted learners:

- Providing a Creative Outlet: Design tools offer a wide range of design options that can help gifted learners to explore their creativity. The flexibility of design tools allows gifted learners to create their own unique designs, which can be particularly appealing to those with an artistic or design-oriented mindset (Bekdemir & Kocak, 2017).

- Encouraging Self-Directed Learning: Design tools enable gifted learners to work independently and take control of their own learning (Fiedler et al., 2017. They can experiment with different design options, adjust settings, and explore new features without the need for constant supervision.
- Offering Project-Based Learning: Design tools can facilitate project-based learning, where gifted learners can apply their skills and knowledge to real-world problems (Yoon & Scharber, 2016). By working on meaningful projects, they can develop their critical thinking and problem-solving skills while engaging in a challenging and stimulating learning experience.
- Providing Opportunities for Collaboration: Design tools are often cloud-based, which means that gifted learners can collaborate with others in real-time (Lee & Cho, 2021). This can foster a sense of community and encourage social interaction, which can be particularly important for gifted learners who may feel isolated or disconnected from their peers.
- Providing Instant Feedback: Design tools offer instant feedback, which can be particularly helpful for gifted learners who crave immediate feedback and validation (Lohr & Friesen, 2020). The ability to see the results of their work immediately can be motivating and inspiring for gifted learners.

Therefore, design tools can be a powerful tool for increasing the interest and creativity of gifted learners by providing them with a platform to explore their interests, develop their skills, and engage in challenging and meaningful learning experiences.

3. Digital Design Tools

This section will present the digital design tools and applications that are proposed within the pedagogical framework of GIFTLED as useful tools to promote STEAM education for gifted students. For this purpose, in this section two digital design tools will be proposed that are relevant within each STEAM discipline: 2 in science, 2 in technology, 2 in engineering, 2 in art and 2 in mathematics. For each digital design tool presented, you will find a brief explanation of what it is, what each platform allows to do and how they can enhance STEAM education in the corresponding discipline for gifted students.

3.1. Science-related Digital Design Tools

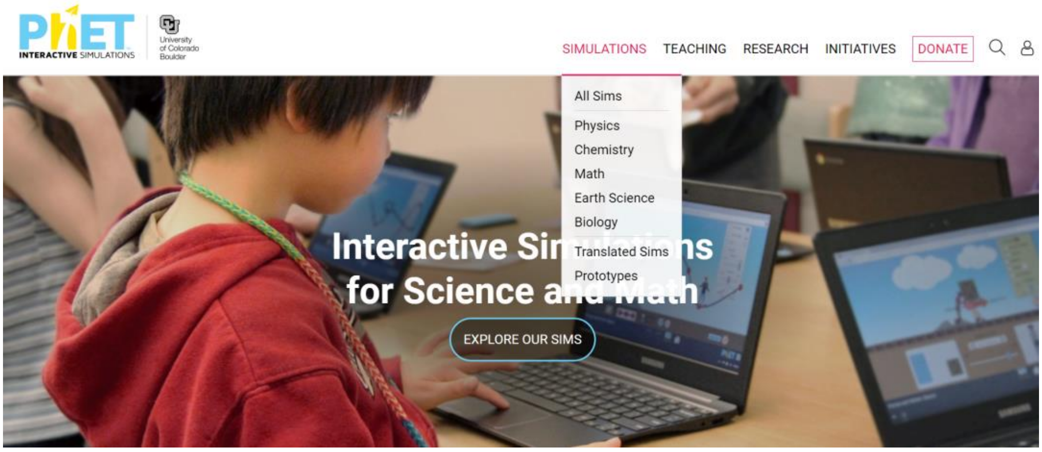
PHET

PhET, short for Physics Education Technology, is a suite of interactive simulations developed by the University of Colorado Boulder. These simulations are designed to help students learn and explore various scientific terms, primarily in the fields of physics, chemistry, biology, earth science, and math. PhET simulations are free to use and are widely used by teachers, students, and educators around the world.

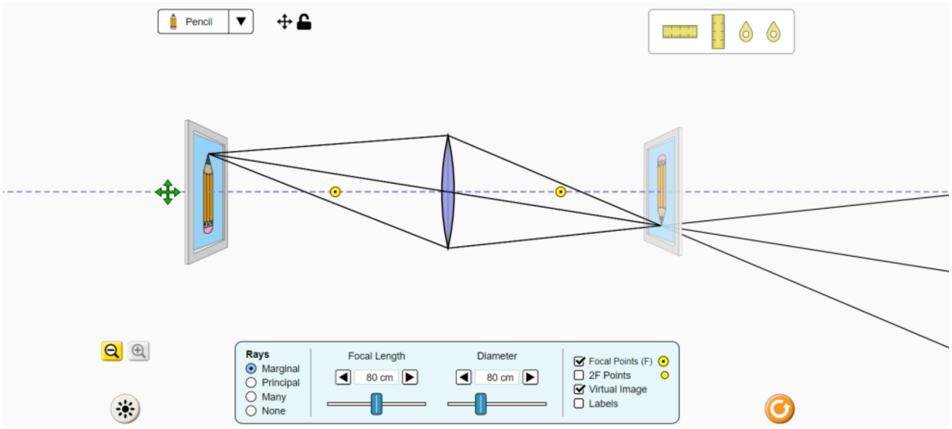
The PhET simulations provide an interactive and visual representation of scientific concepts, allowing students to manipulate variables, conduct experiments, and observe the outcomes in a virtual environment. The goal of PhET is to enhance science education by providing students with an engaging and interactive way to learn scientific concepts. In fact, the simulations cover a wide range of topics, including mechanics, waves, electricity, magnetism, quantum mechanics, thermodynamics, molecular interactions, natural selection, and more.

Here's a step-by-step guide on how to use PhET:

1. Access the PhET website: Visit the official PhET website at https://phet.colorado.edu/. This website provides free access to all the interactive simulations.
2. Choose a simulation: Browse through the list of available simulations or use the search bar to find a specific topic you want to explore. PhET offers a wide range of simulations covering subjects such as physics, chemistry, biology, math, and more.



3. Launch the simulation: Click on the simulation you want to use, and it will open in a new window or tab. Make sure you have a compatible web browser and the necessary plugins installed, as specified on the PhET website.
4. Interact with the simulation: Once the simulation is loaded, you can start interacting with it. Depending on the simulation, you may have control over variables, sliders, buttons, or other tools. Play around with these controls to observe the effects and behavior of the system you are exploring.



5. Learn and experiment: As you interact with the simulation, observe the changes in real-time and try different scenarios. Take note of the patterns, relationships, and scientific principles that become apparent. PhET simulations often provide accompanying instructions, questions, or suggested activities to guide your learning. Make use of these resources to deepen your understanding of the concept being demonstrated.

Remember, PhET simulations are interactive and dynamic tools that promote active learning and engagement. The simulations can be used in teaching, by adapting the steps based on the specific needs and abilities of the gifted learners. It's essential to encourage exploration, inquiry, and critical thinking, and foster a collaborative and supportive learning environment.

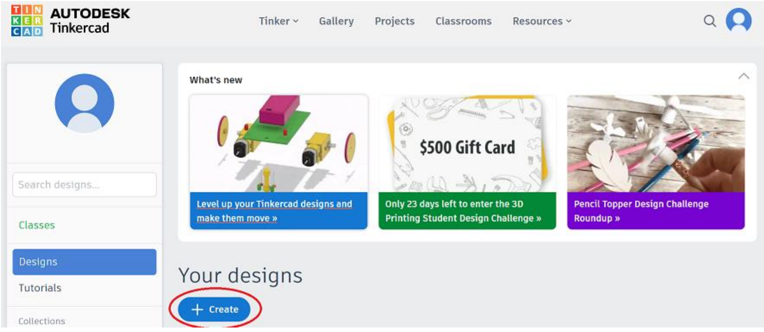
Link: https://phet.colorado.edu/

TINKERCARD

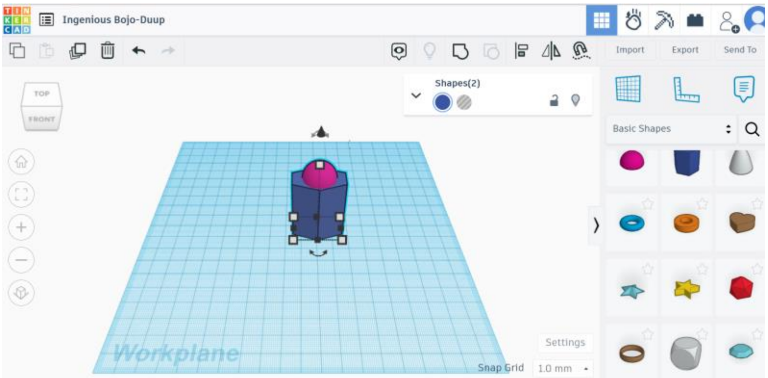
Tinkercad is an online 3D design and modeling tool that can be used to create digital designs for 3D printing, laser cutting, or CNC milling (Dudley, 2022). It is a free, web-based tool that can be accessed through a web browser and does not require any software installation. Tinkercad is very user-friendly, making it an excellent tool for teachers and learners who are just starting with 3D modeling. With its online platform, it is accessible from anywhere with an internet connection, making it an ideal tool for students, hobbyists and professionals.

Here are some steps that teachers can follow to start using Tinkercard for STEAM education of gifted individuals:

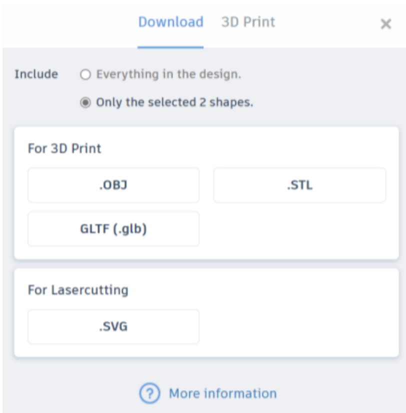
1. When teachers first log in to Tinkercad, they will see the main dashboard where they can access already existing designs or start a new one. To create a new design, click on the "Create New Design" button.



2. Tinkercad has a wide variety of shapes and objects that you can use to create your design, which can be accessed through the "Shape Generator" tab. Teachers can also import designs that you have created in other software or found online, and modify them in Tinkercad.
3. When creating or editing a design, teachers can group and ungroup elements as well as adjusting the size, position, and rotation of objects by dragging them with the mouse or by entering specific values in the object properties menu.



4. Once finished creating a design, teachers can export it as an STL file, which can be used for 3D printing or other manufacturing processes. Then, teachers can share the created designs with others, for instance with their gifted learners, by publishing them on the Tinkercad community or by sending them a link.



This browser-based 3D modeling platform that can be used to introduce gifted individuals to a variety of STEAM concepts. Here are some ways in which teachers can use Tinkercad for STEAM education of gifted individuals:

- Introducing 3D Design: Tinkercad allows gifted learners to create and manipulate 3D objects, which can help them understand spatial reasoning, geometry, and physics concepts. Learners can experiment with shapes, sizes, and angles, and gain a deeper understanding of how 3D models work.
- Project-Based Learning: Tinkercad provides gifted learners with the opportunity to engage in project-based learning, where they can apply their skills and knowledge to real-world problems. This can help learners develop critical thinking and problem-solving skills while engaging in a challenging and stimulating learning experience (Duran et al., 2018).
- Collaboration: Tinkercad is a cloud-based platform that enables gifted learners to collaborate with others in real-time. This can foster a sense of community and encourage social interaction, which can be particularly important for gifted learners who may feel isolated or disconnected from their peers (Kaufman, 2018).
- Programming and Electronics: Tinkercad also offers circuits and coding modules that allow gifted learners to design, simulate, and prototype circuits and code. This can help them learn about electronics and programming concepts and apply them in their designs (Duran et al., 2018).

We can conclude that in general Tinkercad is a great tool for STEAM education of gifted learners, as it offers a flexible, engaging, and accessible way to introduce and explore various STEAM concepts.

Link: https://www.tinkercad.com/

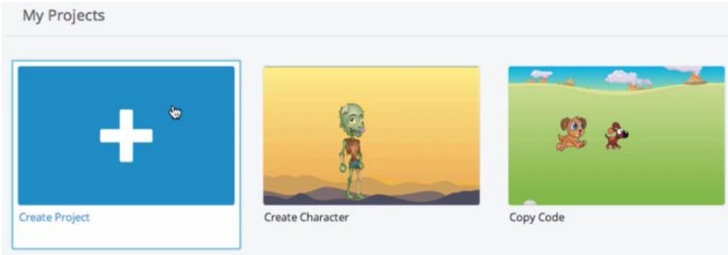
3.2. Technology-related Digital Design Tools

TYNKER

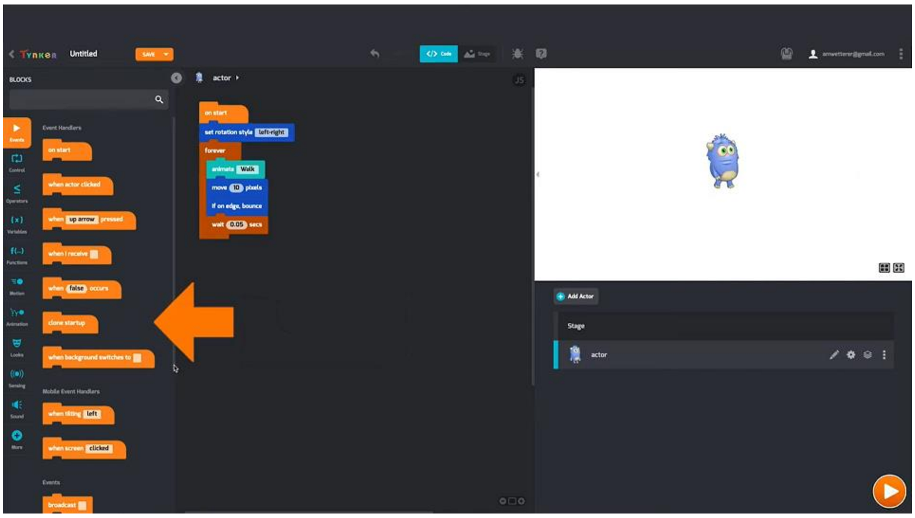
Tynker is an online platform that provides coding courses for children, which are designed to introduce programming concepts and teach coding skills in an interactive and engaging way. It offers game-based activities and projects for teachers to teach coding concepts, project-based learning, collaboration tools, and STEAM integration into its courses. Tynker makes coding education fun and engaging and offers an accessible and flexible way to learn coding skills and explore various STEAM concepts ("Why Tynker," n.d.).

This platform has a user-friendly interface that is designed to be easy to use, even for beginners. Therefore, even teachers with low digital skills can use Tynker to promote STEAM education among their gifted individuals. In order to do so, teachers can follow these steps:

1. After logging in to Tynker the main dashboard will be displayed, which provides access to all of the tool's features and functionalities. From here, teachers can choose to start a new project or access existing projects.



2. Using Tynker's visual coding system. This system uses drag-and-drop code blocks to make it easy for learners to create programs and projects. Therefore, students can choose from a range of code blocks to create their programs, and can connect them together to create complex logic and functionality. The visual coding system makes it easy even for beginners to learn programming concepts and get started with coding.
3. Use the platform's several assets and characters to create games, animations, and other projects. These assets include sprites, backgrounds, and sounds that users can use to create their own unique projects. Tynker also includes a range of pre-built projects and templates that users can use as a starting point for their own projects.



4. Both teachers and students will be able to share their projects with others on the Tynker community, where they can get feedback and collaborate with other users. Tynker also includes tools for publishing projects to the web, making it easy for teachers and gifted students to share their projects in the classroom.

Therefore, in general Tynker is a user-friendly tool that is designed to teach how to code in a fun and engaging way. With its visual coding system, range of assets and characters, and collaborative features, this platform is an excellent tool for teachers to show gifted individuals how to code or create their own digital projects.

In addition, according to Kidspot (2022), Tynker is a platform that provides coding courses for children, designed to introduce programming concepts and teach coding skills in an interactive and engaging way. Here are some ways in which Tynker can be used for STEAM education of gifted individuals:

- Coding education: Tynker is a visual programming language that is designed to teach kids how to code. The tool has a range of coding lessons and challenges that teach coding concepts such as loops, variables, and conditionals.
- Game development: Tynker has a range of game development tools that allow users to create their own games. The tool includes a visual coding system that allows users to drag and drop code blocks to create their games.
- Robotics: Tynker can be used to program a range of robotics systems, including drones, robots, and IoT devices. The tool has pre-built code modules that can be used to control these systems, making it easy for users to get started.
- App development: Tynker has an app development feature that allows users to create their own apps. The tool includes a visual coding system that allows users to drag and drop code blocks to create their apps.
- Creative projects: Tynker can be used for a range of creative projects, such as creating animations and interactive stories. The tool has a range of assets and characters that can be used to create these projects, making it easy for users to get started.

Overall, Tynker is a great tool for STEAM education of gifted learners, as it offers a flexible, engaging, and accessible way to learn coding skills and explore various STEAM concepts.

Link: https://www.tynker.com/

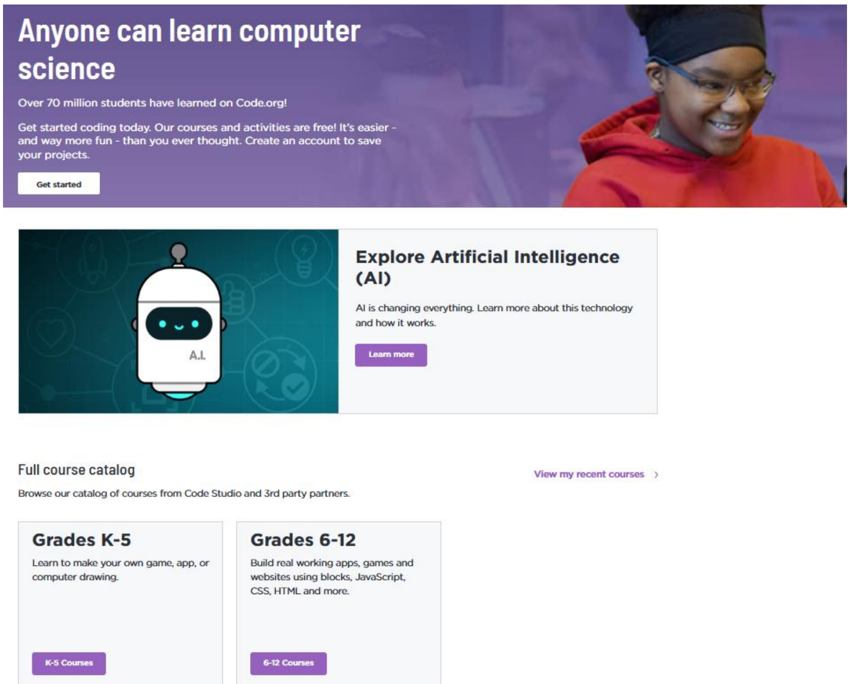
CODE

Code.org provides a wide range of resources for both students and teachers, including courses, coding activities, and lesson plans. The courses offered by Code.org cover a variety of topics, from basic coding concepts to more advanced programming languages. These courses are designed to be engaging and interactive, using puzzles, games, and other activities to teach coding skills. In addition, this platform also offers professional development opportunities for teachers to learn how to teach computer science effectively (Code.org, 2022).

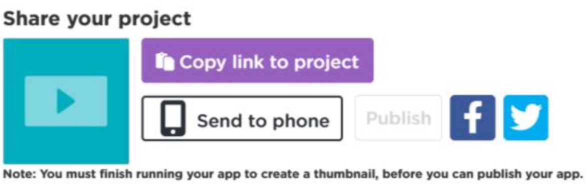
Another key aspect of Code.org's work is its emphasis on diversity and inclusion in computer science education. The organization aims to increase participation by underrepresented groups, including women and minorities, by creating resources and tools that are accessible and engaging for all students (Code.org, 2022). Code.org has also partnered with schools, districts, and other organizations to help expand access to computer science education in underserved communities.

Therefore, Code.org is a valuable resource for educators looking to teach computer science effectively through its clean and user-friendly interface that is designed to be easy to navigate. In fact, teachers can use this platform by following the next steps (Code.org, 2022):

1. After logging in, the main dashboard will be displayed, which provides access to all of the tool's features and resources, including coding lessons, activities, and tutorials. Teachers and students can easily find what they need using the main menu, which includes options for courses, tools, and resources.
2. Use Code.org's comprehensive coding curriculum. The tool offers a range of courses that teach users how to code using visual programming languages like Blockly, JavaScript, and Python. Each course includes a series of lessons and activities that build on one another to teach users coding concepts such as loops, variables, and functions.



3. Use other resources and tools to support learning and exploration. These include a range of coding challenges and puzzles, as well as resources for teachers and educators. Teachers can use the platform's tips for getting started and ideas on how to support their students' learning.
4. Code.org includes a range of features for users to share their work and collaborate with others. Thus, teachers and students can share their projects on the Code.org community or publishing projects to the web, making it easy for users to share their projects and get feedback.



Therefore, Code.org is a comprehensive tool that is designed to teach coding to users of all ages and skill levels, even gifted learners. With its coding curriculum, resources, and collaborative features, Code.org is an excellent tool for teachers to promote STEAM education among gifted individuals. In fact, here are some of the uses for teachers to promote STEAM through Code.org:

- Learn and teach how to code: Code.org is primarily designed as an educational tool for teachers to learn how to code. Thus, it's an excellent platform for beginners to learn the basics of coding, as well as for more experienced teachers to explore new programming languages and concepts. Code.org is also a valuable tool for teachers and educators who want to incorporate coding into their classrooms. The tool includes resources and lesson plans that can be used to teach coding to students of all ages, and its visual programming languages and drag-and-drop interface make it easy for students to learn.
- Explore coding concepts: In addition to its educational uses, Code.org can also be used as a tool for exploring coding concepts and experimenting with programming. Its range of coding challenges, puzzles, and projects can be used to develop skills and knowledge in areas such as logic, problem-solving, and creativity.
- Support diversity in tech: Code.org is committed to promoting diversity in the tech industry and increasing access to coding education for underrepresented groups like gifted individuals. The tool includes resources aimed at promoting diversity and equity in tech, and encourages users to get involved in efforts to support diversity and inclusion in the field.

Code.org is a valuable resource for anyone interested in learning how to code, as well as for educators looking to teach computer science effectively. Through its courses, activities, and partnerships, Code.org is helping to create a more diverse and inclusive field of computer science.

Link: https://code.org/

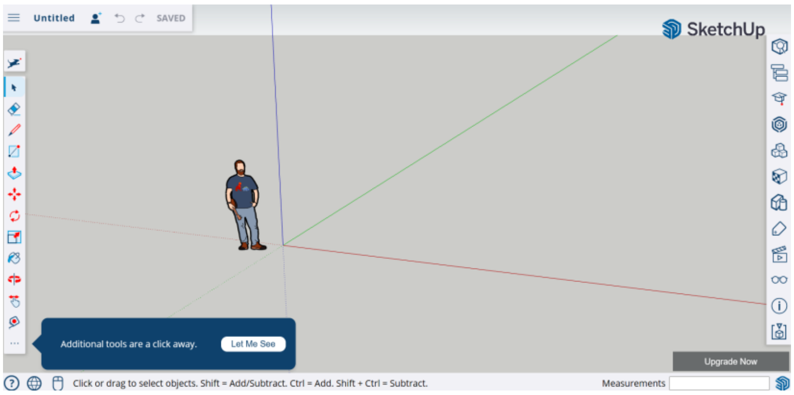
3.3. Engineering-related Digital Design Tools

SKETCHUP

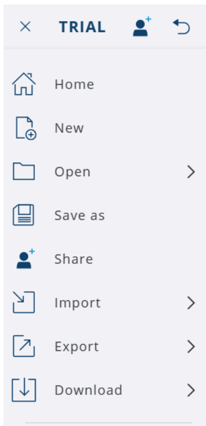
SketchUp is a 3D modelling software used for creating, viewing, and modifying 3D designs. It is a powerful tool used by architects, interior designers, and engineers to create precise and detailed models of buildings, furniture, and other structures (SketchUp, n.d.). The software is user-friendly, making it easy for anyone to learn how to use it, regardless of their level of experience in 3D modelling.

The interface of SketchUp is intuitive and easy to navigate. The main screen provides access to all of the tool's features and resources, including its toolbar, menu, and component library. The toolbar includes a range of tools for creating, editing, and modifying 3D models, while the component library includes a range of pre-made 3D models that can be added to designs (SketchUp, n.d.). The menu includes options for file management, editing, and customization. In addition, the following are the steps that teachers can follow to use SketchUp:

1. Download and install the software in order to launch it.
2. Start creating 3D models by selecting the appropriate tools from the toolbar and using them to create designs. Teachers can also import existing 3D models into their design from the component library or other sources.
3. While creating a design, several editing tools can be used to modify and refine it. The software includes a range of editing tools that allow users to manipulate individual components, adjust lighting and shadows, and apply textures and materials to models. Users can also add annotations and dimensions to their design to provide additional information and context.



4. Once the 3D mode is completed, users can save it and export it in a range of file formats, including PDF, DWG, and 3DS. Teachers and students can also share their design with others by uploading it to the SketchUp 3D Warehouse or sharing it on social media.



In general, SketchUp is a powerful tool that is widely used in the architecture and design industries to create 3D models and designs, but teachers can also use it to promote STEAM education among their gifted students. Teachers can use SketchUp to promote STEAM education among gifted students in several ways:

- Design Challenges: Teachers can create design challenges that involve using SketchUp to design 3D models related to science, technology, engineering, art, or math. For example, students can design a sustainable building, a roller coaster, a bridge, or a piece of furniture. These challenges can encourage students to think creatively, problem-solve, and apply their knowledge in a real-world context.
- Collaboration: SketchUp allows multiple users to work on the same project simultaneously, which can facilitate collaboration among gifted students. Teachers can assign group projects that require students to work together to design a 3D model. This can help students develop teamwork and communication skills, as well as expose them to different perspectives and approaches to problem-solving.
- Exploration: SketchUp can be used to explore various STEAM concepts in a visual and interactive way. For example, students can use SketchUp to design and explore the anatomy of a human heart, the solar system, or a complex machine. This can help students understand complex concepts more easily and foster their curiosity and interest in STEAM subjects.
- Cross-Curricular Integration: Teachers can integrate SketchUp into various subjects, such as math, science, art, or social studies. For example, students can use SketchUp to design a 3D model of a historical building or to create a mathematically accurate model of a geometric shape. This can help students see how STEAM subjects are interconnected and apply their knowledge in a cross-disciplinary way.

SketchUp is a powerful tool that can be used by teachers to promote STEAM education among their gifted students through design challenges, collaboration, exploration, and cross-curricular integration.

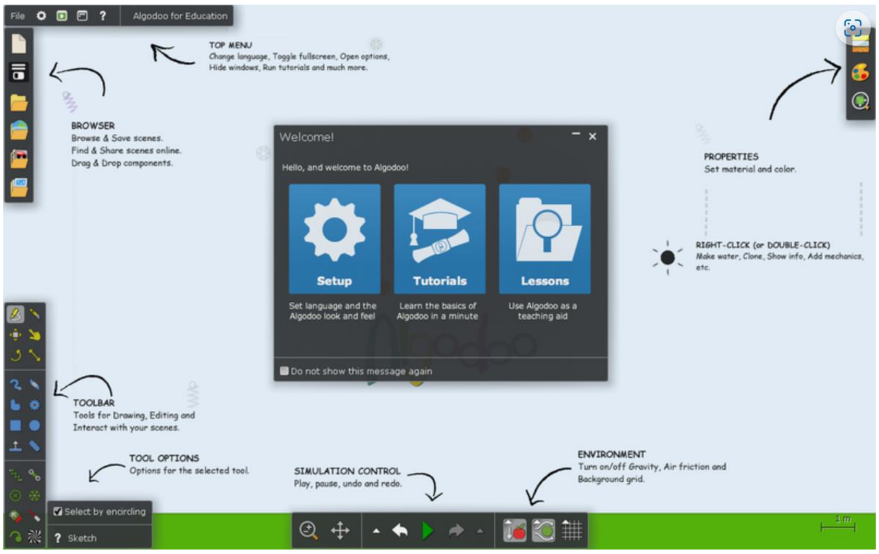
Link: https://www.sketchup.com/

ALGODOO

Algodoo is a physics simulation software that allows users to create and interact with virtual 2D scenes. It can be used for educational purposes, such as teaching physics concepts, as well as for entertainment purposes, such as creating games and animations (Algodoo, n.d.). Algodoo features a user-friendly interface that allows users to easily create and manipulate objects in a virtual environment.

The Algodoo interface is split into several areas. The main area is the scene view, where users can see their virtual 2D environment (Algodoo, n.d.). This area contains tools for creating and manipulating objects, such as circles, rectangles, and gears. The right-hand side of the screen contains the toolbar, which contains a range of tools for creating and manipulating objects. The toolbar includes tools for selecting, dragging, and rotating objects, as well as tools for creating springs, hinges, and other connections. In addition, teachers can start using Algodoo by following these steps:

1. Download and install the software.
2. Start creating 2D scenes by selecting the appropriate tools from the toolbar and using them to create objects. Teachers and students can also import existing 2D objects into their scene from other sources.



3. As users create a scene, they can use the editing tools to modify and refine it. The software includes a range of editing tools that allow users to manipulate individual objects, adjust properties such as mass and friction, and apply textures and colours to objects. Users can also create interactions between objects by using tools to connect them with springs, hinges, and other types of connections.
4. Once the 2D scene has been created, you can save it and export it in a range of file formats, including PDF, PNG, and SVG. Users can also share their scene with others by uploading it to the Algodoo community or sharing it on social media.

Algodoo is widely used in education to teach physics concepts to students. Teachers can use the software to create interactive simulations that allow students to explore and understand complex physics principles, such as gravity, friction, and velocity (Algodoo, n.d.). However, it can also be used to promote STEAM education among gifted students in several ways:

- Game design: Algodoo can be used to design games that incorporate physics-based mechanics. For example, students can design a game that involves launching objects, navigating mazes, or solving puzzles using physics principles. This can help students apply their knowledge of physics in a creative and engaging way (Roberts et al. 2018).

- Engineering challenges: Algodoo can be used to create engineering challenges that require students to design and build virtual machines or structures. For example, students can design a bridge that can withstand a certain amount of weight or a car that can navigate a rough terrain. These challenges can help students develop their engineering skills and encourage them to think critically about design and construction.
- Art and design: Algodoo can also be used to create visual and interactive art projects. For example, students can use Algodoo to design a virtual machine or create a digital animation. These projects can help students develop their creativity and imagination, as well as expose them to new forms of art and media (Pandey et al., 2021).
- Cross-curricular integration: Teachers can integrate Algodoo into various subjects, such as math, science, art, or social studies. For example, students can use it to simulate the behavior of waves, to model the solar system, or to create a virtual city. This can help students see how STEAM subjects are interconnected and apply their knowledge in a cross-disciplinary way.

In general, Algodoo is a powerful tool that allows students to explore and experiment with STEAM concepts in a virtual and interactive way. By using Algodoo in their classrooms, teachers can engage and challenge gifted students and foster their curiosity and passion for STEAM subjects.

Link: http://www.algodoo.com/

3.4. Art-related Digital Design Tools

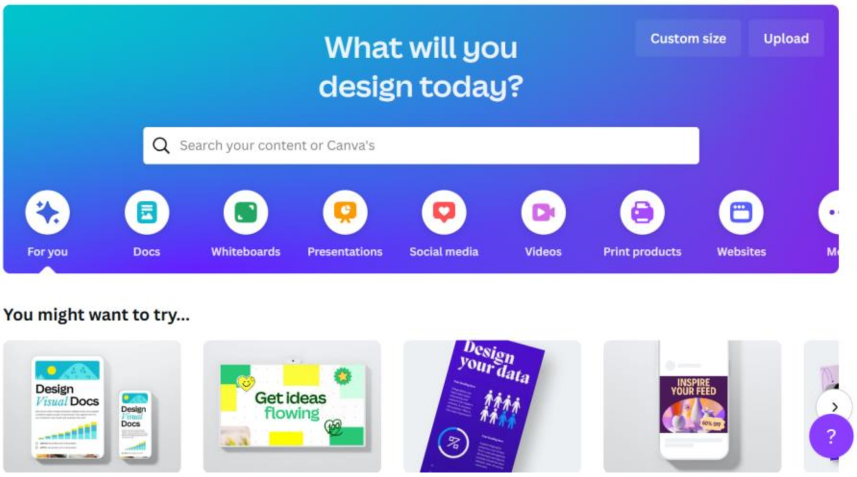
CANVA

Canva is a web-based design platform that allows users to create a variety of digital and print materials, such as graphics, posters, flyers, presentations, social media posts, and more. Canva provides a user-friendly interface that allows users to select from a wide range of templates, graphics, fonts, and images to create professional-looking designs (Canva, n.d.).

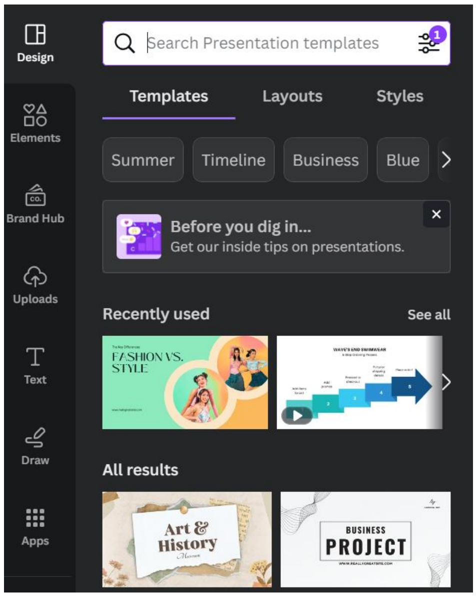
In fact, this popular graphic design tool that allows users to create a wide range of designs and with its easy-to-use drag-and-drop interface, even beginners can create professional-looking designs in just a few minutes (Canva, n.d.). Canva is used by individuals, small businesses, non-profits, and even teachers and educational institutions to create visual content for a variety of purposes. In the case of teachers, they can start using this tool by following the next steps:

1. Get started with Canva by signing up for a free account on the Canva website.

2. Once logged in, users can choose from a wide range of templates or start with a blank canvas to create their own design. Teachers and students can access its extensive library of design elements, including images, illustrations, and fonts.



3. Add elements to a design, by using the toolbar on the left-hand side of the screen. The toolbar includes a range of options for adding elements to your design, such as text, images, shapes, and charts. Users can also search for specific elements using the search bar at the top of the screen.



4. Customize elements in a design by clicking on them and using the editing tools that appear. Canva's editing tools are easy to use and allow to resize and reposition elements, adjust colours and fonts, and add effects such as filters and drop shadows.
5. Once a design is finished, users can download it in a range of file formats, including PDF, PNG, and JPG. This way both teachers and students can share their design directly from Canva by generating a shareable link or embedding it in a website or social media post.

Overall, Canva is a versatile and user-friendly tool that can be used for a wide range of design projects. With its extensive library of design elements, templates, and editing tools, it's easy to create professional-looking designs in just a few minutes. In fact, teachers can use Canva to promote STEAM education among gifted students in several ways (Pappas, 2019):

- Visual Communication: Canva allows students to create visual communication materials such as posters, infographics, and presentations. By designing these materials, students can develop their creative and visual thinking skills. They can also learn about the principles of design, such as colour theory, typography, and composition, which are important for communication and visual arts.
- Digital Art: Canva can be used as a digital art platform for creating illustrations, logos, and other graphics. Students can experiment with different digital tools and techniques to create their own unique designs. They can also learn about digital art software and the process of creating digital art.
- Science Projects: Canva can be used to create science projects, such as diagrams, charts, and graphs. Students can use Canva to design and present their findings in a visually appealing way. This can help students understand complex scientific concepts and communicate their ideas effectively.
- Website Design: Canva can be used to design websites, which can help students develop their coding and web development skills. They can use Canva to create website layouts, graphics, and other design elements. This can also help students understand the principles of user experience design and the importance of visual design in website development.
- Digital Storytelling: Canva can be used as a digital storytelling platform. Students can use Canva to create multimedia stories that incorporate graphics, animations, and other visual elements. This can help students develop their narrative skills and learn about the importance of visual storytelling.

In conclusion, Canva is a powerful tool that can help teachers engage gifted students and promote STEAM education in a creative and interactive way. By using Canva in their classrooms, teachers can help students develop their skills and interests in STEAM subjects.

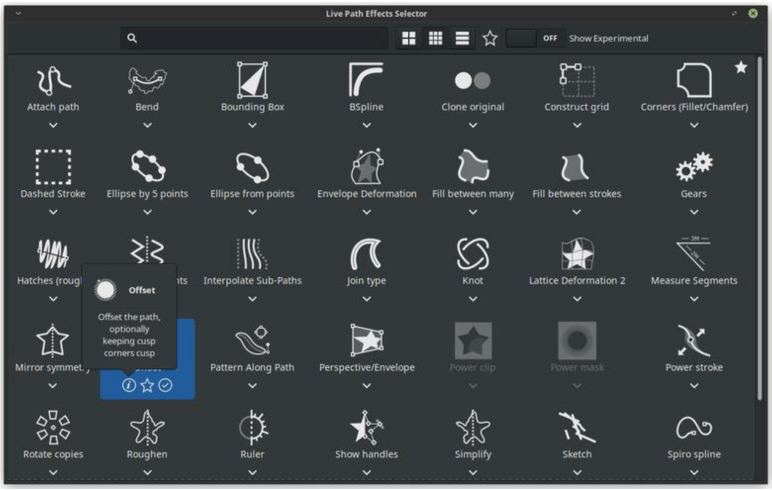
Link: https://www.canva.com/

INKSCAPE

Inkscape is a free and open-source vector graphics editor that allows users to create and edit vector graphics such as illustrations, diagrams, line arts, charts, and logos (Inkscape, n.d.). It is available for Windows, macOS, and Linux. The software has a simple and user-friendly interface that allows users to create stunning designs without any prior experience in graphic design. Therefore, it is highly used by designers, artists and illustrators to create a wide range of graphics, including logos, icons, illustrations, diagrams and more.

The interface of Inkscape is divided into several sections, including a toolbox, a document window, a menu bar, and a status bar. The toolbox contains various tools such as selection, text, pen, shapes, and gradients, that can be used to create and modify vector objects. The document window is where users can create their designs and apply various effects and filters. The menu bar contains various menus such as File, Edit, View, Object, Path, and Extensions that offer a wide range of features and options.

1. To use Inkscape, start by opening the software and creating a new document.
2. Select the tool to be used from the toolbox and start creating a design. Users can draw shapes, lines, curves, and text using the available tools. Once a design has been created, teachers and students can modify it using various options such as fill colour, stroke colour, gradient, and opacity. Users can also add effects and filters such as blur, drop shadow, and emboss to enhance the design.



3. Inkscape supports various file formats to download the designs such as SVG, PNG, PDF, and EPS, which makes it easy to share your designs with others. To export a design, simply select the File menu and choose the Export option. Users can then choose the file format and the location where they want to save the design.

Thus, Inkscape is a versatile tool that can be used for a wide range of graphic design tasks. Its extensive features and capabilities make it a popular choice among designers, artists, illustrators and even teachers in the educational field. Here are some ways teachers can use Inkscape to promote STEAM education for gifted students:

- Illustration and Graphic Design: Inkscape can be used to teach students about vector graphics and the principles of graphic design. Students can use Inkscape to create logos, posters, and other graphics using tools such as the pen tool and text tool. By learning these skills, students can develop a better understanding of design principles and how to communicate visually.
- 3D Design: Inkscape can be used in conjunction with other software such as Blender to create 3D models. Students can use Inkscape to create 2D vector drawings that can

then be imported into Blender and extruded to create 3D models. This can help students develop spatial reasoning and visualization skills.

- STEM Diagrams: Inkscape can be used to create diagrams and illustrations that are commonly used in STEM subjects. For example, teachers can use Inkscape to create diagrams of chemical compounds, electrical circuits, and biological processes. By creating these diagrams, students can develop a deeper understanding of the subject matter and improve their ability to communicate visually.
- Animation: Inkscape can be used to create simple animations using vector graphics. Students can use Inkscape to create a series of drawings that can be combined into an animation. Inkscape has basic animation capabilities that allow users to create simple animations such as moving objects and changing colours. This can help students develop their animation skills and learn about the principles of motion and timing.

Inkscape can be used to teach a wide range of STEAM subjects. By incorporating Inkscape into their curriculum, teachers can help students develop their creativity, critical thinking, and technical skills.

Link: https://inkscape.org/

3.5. Mathematic-related Digital Design Tools

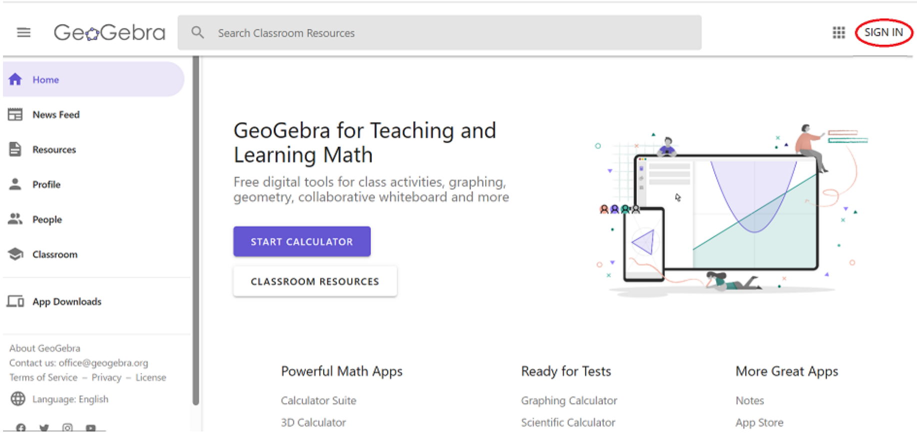
GEOGEBRA

GeoGebra is a dynamic mathematics software that allows users to explore, visualize, and analyse mathematical concepts in 2D and 3D. Its interface is user-friendly and consists of several windows that can be rearranged and customized to suit the user's needs. The software includes a wide range of tools for algebra, geometry, statistics, calculus, and graphing (Geogebra, n.d.). GeoGebra is widely used by teachers, students, mathematicians, and researchers for learning, teaching, and exploring mathematical concepts and phenomena.

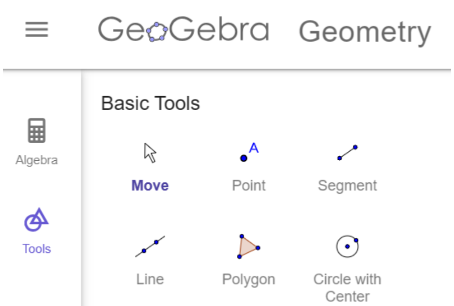
One of the most powerful features of GeoGebra is its ability to create dynamic objects and animations. Users can create objects that depend on other objects, and then manipulate them to see how they change in real-time (Geogebra, n.d.). For instance, users can create a circle that is tangent to two other circles, and then drag one of the circles to see how the tangent circle moves accordingly. Moreover, it also includes a spreadsheet view where users can enter data and perform calculations. This can be used for creating tables, computing statistical measures, and fitting curves to data (Geogebra, n.d.). This way, users can switch between the graphics and spreadsheet views by clicking on the corresponding tabs at the bottom.

For teachers to get started or master the features of this software, it provides numerous resources and tutorials. These resources include online courses, video tutorials, and a community forum where users can ask questions and share their work. Overall, GeoGebra is a powerful tool for mathematics education and research, and its intuitive interface and dynamic features make it accessible to users of all levels. However, in order to use this software, teachers can start by following these steps (Geogebra, n.d.):

1. Open Geogebra by visiting the Geogebra website (www.geogebra.org) or by downloading the Geogebra software to a device. Once Geogebra is open, the main interface with several icons and menus will be displayed.



2. Create a new project by clicking on the "New" button. Users will be prompted to choose the type of project they want to create, such as a geometry, algebra, 3D, or probability project.
3. Depending on the project teachers and students are working on, they will be able to create various geometric objects, such as points, lines, circles, and polygons, as well as algebraic objects, such as functions and equations. To add an object, select the corresponding icon from the left-hand side menu and click on the workspace to add the object.



4. Once an object has been added, users can edit it by clicking on the object and using the available tools in the right-hand side menu. This way, users can change the object's properties, such as colour, size, and label, or modify its shape, position, or orientation.

5. When users are done creating a project, they can save it by clicking on the "Save" button. Geogebra allows to save a project in various formats, such as Geogebra files (.ggb), images (.png, .jpg), and documents (.pdf, .html). Users can also export your project to other software, such as LaTeX, Wolfram Alpha, and GeoGebraTube.

Moreover, GeoGebra is a versatile tool that can be used in a wide range of fields, from education to research, engineering, and art. Its user-friendly interface and features make it accessible to teachers of all levels, and its open-source nature allows for continuous development and improvement. When it comes to using it in education, among the STEAM fields it is mainly suitable for mathematics, as it allows users to create and manipulate geometric constructions, algebraic equations, and data representations. Here are some ways teachers can use GeoGebra to promote STEAM education for gifted students (Geogebra, n.d.):

- Geometry: GeoGebra can be used to teach geometry to students. Teachers can create geometric constructions and shapes using GeoGebra and use them to explain various concepts such as angles, parallel lines, and triangles. Students can also use GeoGebra to explore and discover these concepts on their own. For example, teachers can give students a task to create a geometric shape with specific dimensions, and students can use GeoGebra to construct the shape and discover its properties.
- Algebra: GeoGebra can be used to teach algebra to students. Teachers can create algebraic equations and functions using GeoGebra and use them to explain various concepts such as linear and quadratic functions. Students can also use GeoGebra to explore and discover these concepts on their own. For example, teachers can give students a task to create a graph of a function and students can use GeoGebra to plot the points and discover the properties of the function.
- Data Representation: GeoGebra can be used to teach data representation to students. Teachers can use GeoGebra to create charts, graphs, and other visual representations of data. Students can also use GeoGebra to create their own visual representations of data, such as bar charts and scatter plots. By using GeoGebra, students can develop their data analysis skills and learn how to communicate data visually.

- Statistics: GeoGebra includes tools for data analysis and statistics, which can be used for analysing and visualizing data sets. The software provides tools for creating histograms, box plots, scatter plots, and other statistical graphics.
- Art: GeoGebra can be used for creating geometric art and designs, as it provides tools for creating complex shapes and patterns. Artists and designers can use the software to create intricate designs and explore mathematical patterns and symmetries.
- STEM Applications: GeoGebra can be used in various STEM applications such as physics, engineering, and computer science. For instance, teachers can use GeoGebra to create simulations of physical phenomena such as pendulum motion and projectile motion. Students can also use GeoGebra to create their own simulations and models of physical phenomena, which can help them develop their understanding of these concepts.

In conclusion, GeoGebra is a versatile tool that can be used to teach a wide range of STEAM subjects. By incorporating this tool into their curriculum, teachers can help students develop their creativity, critical thinking, and technical skills.

Link: https://www.geogebra.org/

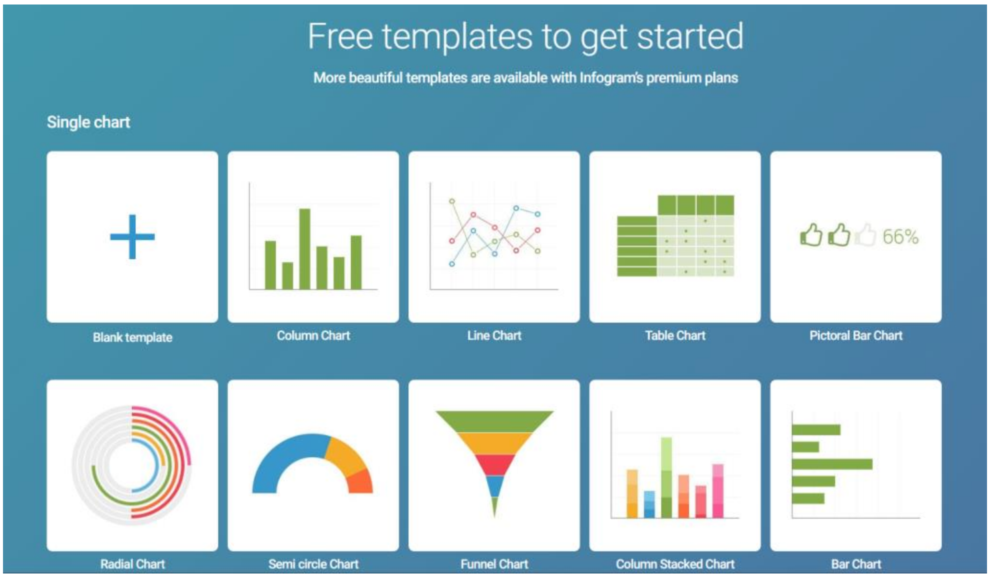
INFOGRAM

Infogram is a web-based data visualization and infographics tool that allows users to create and share interactive charts, maps, graphs, and other visual representations of data (Infogram, n.d.). It offers a user-friendly drag-and-drop interface, a wide range of customization options, and a variety of templates to help users create compelling and engaging visual content (Martinez, 2017). Infogram is often used by businesses, journalists, non-profits, and even teachers and educators to communicate complex data in a more accessible and engaging way.

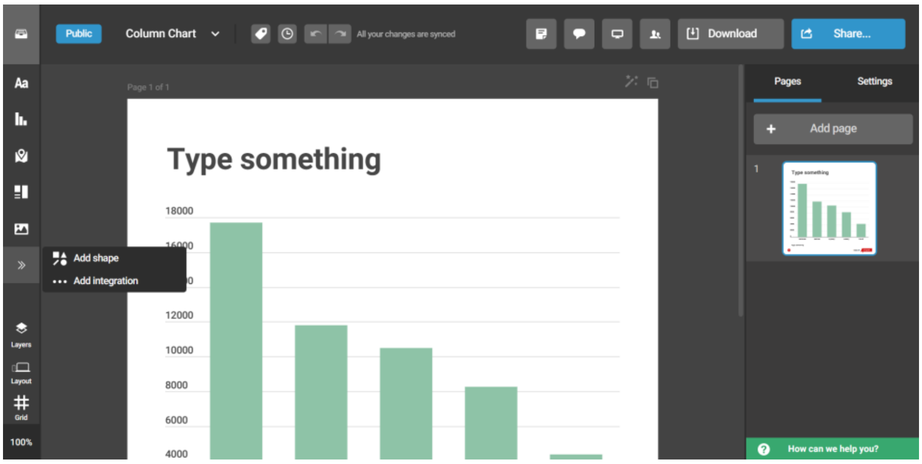
The tool is very user-friendly and has an intuitive drag-and-drop interface, which makes it easy for anyone to use and create stunning visualizations, even if they have no design experience. Its intuitive interface and extensive library of templates and design elements make it easy to use, and its spreadsheet editor and data import feature make it easy to add and edit data. Users can customize their visualizations with different charts, colours, fonts, and graphics to make them more engaging, and they can share them online using different channels. Therefore, Infogram is a powerful and user-friendly tool for anyone looking to create compelling data visualizations.

1. To start using Infogram, users must first create a new project by selecting a template or starting from scratch. Infogram offers a wide variety of templates for different types

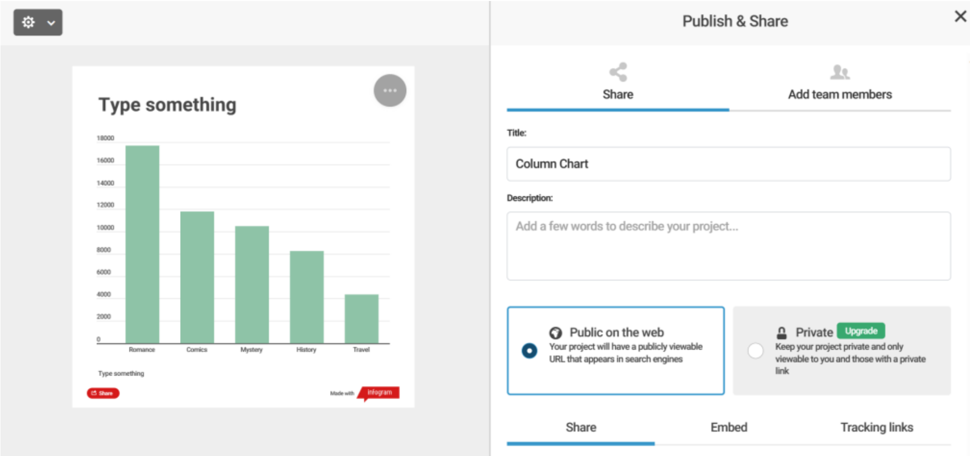
of visualizations, such as charts, maps, and diagrams. Users can start by selecting the type of visualization they want to create and choose a template that suits their needs.



2. After selecting a template or creating a new project, it's time to add data. Users can import data from Excel or Google Sheets, or enter it manually. Infogram's interface is designed to be intuitive and user-friendly, so adding data is straightforward.
3. Customize the visualization by using the different options that Infogram offers to make the visualization how the user wants. The data can be formatted and edited directly in Infogram, and users can add text, images, and other design elements to their visualization to make it more engaging. The tool offers a wide range of chart types, including bar charts, line charts, pie charts, and more, and users can customize charts with different colours, fonts, and graphics.



4. Once the visualization is complete, users can share it online by embedding it on a website or sharing it on social media. Infogram also provides analytics to track the performance of the visualization, including the number of views, shares, and interactions. This information can help used optimize the visualizations and improve the outreach efforts made.



Infogram is great because it offers a user-friendly platform that allows anyone to create professional-looking visualizations, including charts, maps, infographics, and reports, without any prior design or coding experience. With Infogram, users can quickly and easily turn data into engaging and interactive visual content that can be easily shared on social media, websites, or presentations. Moreover, it offers a vast library of templates, icons, and images that can be used to create custom designs, and it integrates with other tools, such as Excel, Google Sheets, and Salesforce, to streamline data import and management (Infogram, n.d.).

Therefore, Infogram is a powerful tool that can help businesses, journalists, and even educators communicate their ideas and data effectively and efficiently. In fact, this tool can be highly used in educational settings to improve the understanding of students and encouraging a bigger engagement as well as involving students in learning activities. Teachers can use this data visualization tool to promote STEAM education for gifted students in several ways:

- Create visualizations: Create interactive and engaging visualizations of data related to science, technology, engineering, arts, and mathematics. For example, students could use Infogram to create charts, graphs, and maps that visualize data on climate change, renewable energy, or scientific discoveries.
- Teach students about data analysis and statistics: Teachers can provide students with a data set related to a STEAM topic and ask them to use Infogram to create a visualization that highlights trends or patterns in the data. This can help students develop skills in data analysis and interpretation, which are important for STEAM careers.
- Sharing information and promoting STEAM projects and events: Teachers can create visually appealing posters, flyers, or infographics that showcase, for example, upcoming STEAM projects and events at school or in the community. This can help generate interest and excitement among students and parents.
- Support cross-curricular projects: Infogram can be used to create visualizations that combine data from different STEAM fields, such as a map that visualizes the

distribution of renewable energy sources around the world or a graph that shows the correlation between music and math.

- Creating reports: Infogram can be used to create reports that summarize complex information and data in a clear and concise way. Users can add text, images, and other design elements to their reports to make them more engaging and visually appealing.

By incorporating Infogram into their curriculum, teachers can provide gifted students with a fun and engaging way to learn about STEAM concepts and develop important skills in data analysis, visualization and interpretation.

Link: https://infogram.com/

4. Additional resources

In conclusion, the tools that have been are all powerful and relevant tools that can be used for a variety of purposes. In fact, in this chapter of the handbook, two digital design tools have been presented for each of the fields that compose STEAM. Each of these tools has its own unique features and strengths, but they all share a common goal: to make learning and creating easier and more accessible. Whether you're a student or teacher, these tools can help you improve your education, bring your ideas to life and make a positive impact on the world around you.

If you want to learn more about these digital tools and learn how to use them in detail, you can visit the tutorials below:

- PhET tutorials: https://phet.colorado.edu/es/teaching-resources/tipsForUsingPhet
- Tinkercad tutorials: https://www.tinkercad.com/learn/
- Tynker tutorials: https://www.tynker.com/support/videos
- Code.org tutorials: https://code.org/learn
- SketchUp tutorials: https://www.sketchup.com/learn/videos
- Algodoo tutorials: http://www.algodoo.com/edu/video-tutorials/
- Canva tutorials: https://designschool.canva.com/tutorials/
- Inkscape tutorials: https://inkscape.org/learn/tutorials/
- GeoGebra tutorials: https://www.geogebra.org/m/tutorials
- Infogram tutorials: https://infogram.com/blog/tutorials/

These resources offer step-by-step guides, images, and videos to help you get started with each tool and learn how to use its various features and functionalities.

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7 The GIFTLED Curriculum

Aneta Poniszewska-Maranda

This chapter presents the introduction to the GIFTLED Curriculum to present the innovative GIFTLED method in practice and implementation at schools. The GIFTLED method is the product of this project. This part of the handbook explain in general "how the special educational needs of gifted learners in STEAM education can be addressed through the "Learning by Design (LbyD)" with the use of AR (Augmented Reality) applications and digital design tools".

1. Introduction

According to the project application, the final action in WP2 is to develop a GiftLed Curriculum through the use of previous results, such as teacher/trainer's handbook, Toolkit Introduction Videos (TIVs), augmented reality case studies brochure and adding new resources.

A curriculum will be developed and designed to demonstrate how the GIFTLED method can be used in STEAM disciplines for inclusion and education of gifted/talented individuals. The curriculum should include content, process and product parts. The seven topics will be selected from STEAM disciplines, such as science, technology, engineering, art and mathematics, and the content (objectives & topic), process (educational method – learning by design) and product (creative learning products) will be demonstrated. The curriculum will be developed through the use of previously developed products. These products will be used by actual users (teachers and learners) as piloting and through "remote brunches" their ideas and comments will be taken. After the completion of five "remote brunches" the curriculum design will be done.

Within this aim, partners will plan and brainstorm the parts, content, and specific exercises within the curriculum. Each partner will contribute one part of the curriculum and A.2.4 leader (AHE) will collect and make one publication in English.

The curriculum shows on how to use GiftLed method in "Learning by Design (LbyD)" method in gifted/talented STEAM education to meet the special educational needs of gifted/talented education and their talent development. The GIFTLED Method is a method which encovers the use of LbyD approach in STEAM education. The AR tools and digital design tools will be used as a tool to perform GIFTLED method in gifted STEAM education. Curriculum involves content (including objectives), process, and product dimensions of the use of digital and augmented reality toolkit through “learning by design” in STEAM education.

2. The Curriculum for Gifted in STEAM

The **STEAM disciplines**, such as science, technology, engineering, art and mathematics, are currently the important components of education process both in primary and secondary schools in each partner countries as well as in all EU countries and also world countries. The different technologies that are developing currently very quickly are based on these disciplines. Especially, the IT and ICT technologies that are present in our public and private life every day are joined with STEAM disciplines.

The **GIFTED curriculum** is based on Learning by Design method which is a project-based and inquiry-based learning approach that integrates Science, Technology, Engineering, Arts, and Mathematics education with the use of design thinking and problem-solving skills, and also creativity potentials in STEAM education process. It has to fulfil the standards for gifted education and STEAM education that are as follows:

- provide opportunities for independent research,
- offer advanced coursework,
- create opportunities for hands-on learning,
- encourage interdisciplinary learning,
- provide opportunities for design and problem solving,
- provide mentorship and internships.

Learning outcomes of **GIFTED curriculum** that the pupils will achieve upon the completion of the whole learning program based on GIFTLED method are the following:

LO1: maximum achievement in basic skills

LO2: content beyond the prescribed curriculum

LO3: exposure to a variety of fields of study in STEAM

LO4: learner-selected content

LO5: high content complexity

LO6: experience in creative thinking and problem-solving

LO7: development of thinking skills

LO8: development of digital literacy skills

LO9: affective development including intrapersonal and interpersonal

LO10: development of productivity and development of motivation and engagement

Moreover, the **Industry 4.0** that is currently present in our world and also the Industry 5.0 that is very close and will be present in very near future are based on IT/ICT technologies and STEAM disciplines.

Industry 4.0 or fourth industrial revolution represents the set of terms that describe social, industrial and technological changes brought about by the digital transformation of industry. Industry 4.0 is defined as a modern industry, supported by automation and information technology, new sub-production technologies (3D printing, VR, collaborative robots), IT / communication solutions (Cloud Computing, Big Data, Internet of Things) and enterprise management in the era of new industrial revolution.

The application of Industry 4.0 are as follows: (1) Internet of Things, (2) Data analytics and healthcare optimization, (3) IT integration and creation of cyber-physical systems (CPS), (4) Cybersecurity, (5) Artificial intelligence, (6) Additive printing (3D printing), (7) Digital and digitization of production, (8) Cloud computing, (9) Big Data, (10) Virtual and augmented reality, (11) Collaborative robots, (12) Mobile robots, (13) RFID, (14) Mobile interfaces, (15) Blockchain, (16) Geolocation.

It was obvious that we could join the STEAM disciplines with Industry 4.0 technologies and field to introduce them in our GIFTLED method in education of gifted/talented individuals, so in the GIFTLED Curriculum. It is proposed to explore the following application fields of Industry 4.0 and join them with STEAM disciplines:

1. Smart cities – digital infrastructure.
2. Smart cities – renewable energy for heat and power.
3. Smart cities – big data management.
4. Smart transport – bike using and sharing.
5. Smart transport – electric vehicles.
6. Smart buildings – reducing energy consumption.
7. Smart buildings – water recycling.

Moreover, these topics are also green topics and give the possibility our gifted/talented individuals to investigate the green, environment-friendly and sustainable solutions and projects.

The proposed topics should be realized in the set of seven modules creating the whole learning program oriented on the STEAM disciplines and Industry 4.0 technologies, such as Internet of Things, Cybersecurity, Additive printing (3D printing), Cloud computing, Big Data, Virtual and augmented reality.

Internet of Things: communication with distributed sensors, devices and other network elements, implementation of technical and healthcare solutions based on Internet technologies.

Cybersecurity: implementation of security measures to minimize external and internal cyber threats; strategy including an appropriate methodology for designing industry/public/learning/healthcare systems.

Additive printing (3D printing): possibilities of rapid prototyping of elements and production of parts with unusual shapes and functions; low and medium-volume production of plastics, resins and metals.

Cloud computing: distributed computing structures enabling remote data storage and processing; resource virtualization and the ability to easily scale systems; concerns related to data security and cybercrime.

Big Data: analysis of large and diverse data sets using advanced analytics and artificial intelligence algorithms.

Virtual and augmented reality: supporting engineers and technicians during design and service works thanks to the use of goggles or other virtual and augmented reality devices; virtual training reducing the costs of introducing new employees.

It is also possible to identify the **practical learning outcomes** that the pupils will achieve upon the completion of the tasks/activities/projects defied in the learning program as follows:

LO-P1: Understand the concept of smart city and recognise the role of STEAM in developing smart city solutions.

LO-P2: Investigate the contribution of STEAM and Industry 4.0 in renewable energy to power smart cities.

LO-P3: Consider how data is captured, stored, analysed and managed in smart city.

LO-P4: Explore the technologies enabling the development of smart transport in the cities.

LO-P5: Identify the role of electric vehicles in smart cities.

LO-P6: Examine the resource efficiency within smart building.

LO-P7: Explore the possibilities of saving water.

3. Content, process, product, and environment/tool components of the GIFTLED curriculum

Title: GIFTLED Learning Program

Level: Primary/secondary school pupils aged 10-18

Primary mode of delivery: Face-to-face

Suggested duration: 4 hours face-to-face contact per week (2 x 2 meetings per week) – over a 7 week period (28 hours in total)

Aim: The principle aim of the GIFTLED curricular learning program is to stimulate interest and competences of gifted/talented individuals in STEAM (Science, Technology, Engineering, Art and Maths) subjects with the use of Learning by Design method. It is based on project-based learning, design thinking and problem-solving skills. This purpose will be archived by introducing the concepts that have real-life applications within the context of Industry 4.0 and smart cities.

Basic resources: AR applications, Digital Design Tools (DDTs toolkit).

Content: The curriculum is designed to be delivered as 7 face-to-face modules for gifted/talented individuals:

Module I. Smart cities – digital infrastructure

Module II. Smart cities – renewable energy for heat and power

Module III. Smart cities – big data management

Module IV. Smart transport – bike using and sharing

Module V. Smart transport – electric vehicles

Module VI. Smart buildings – reducing energy consumption

Module VII. Smart buildings – water recycling

Each module should be defined in GIFTLED curriculum according to table 7.1.

Learning outcomes	Description of module content	Methods and resources for module learning	STEAM disciplines and STEAM tools to use	AR application to use	Assessment criteria	Timetable and duration
…….	…….					

…….	…….					

Table 7.1 Structure template for definition of modules in GIFTLED curriculum

The process proposed by the GIFLED curriculum is based on the Learning by Design approach. The realization of modules listed above have to be done according to this process, described in Chapter 1 of the handbook. This process assumes that the first three steps of LbyD approach is done through the use of AR tools (Chapter 5 of the Handbook). The final, fourth, step of LbyD, in which pupils design or produce the problem solutions, is done through the use of Digital Design Tools, presented in Table 7.2 (described in Chapter 6 of the Handbook).

The solutions and products designed and/or produced by pupils during the realization of the modules can be different. It depends of the case studies proposed in the framework of GIFTLED curriculum and in the framework of teachers' propositions during the lessons with the pupils. However, each time they should be adapted to the knowledge level of pupils, their experience and intelligence.

The AR (augmented reality) application that is suggested to use in the realization of the three first steps of the modules according to the LbyD approach supporting the GIFTLED curriculum is the Zappar tool (www.zappar.com). Zappar connects the digital world with the things around the user. It's like opening up to another other dimension where everyday things can transform to unlock a video, game, and even 3D characters that user can play with directly.

The STEAM Digital Design Tool that are suggested to use in the implementation of the particular modules were chosen based on their features, functions, free access and moderate difficulties. They together create the GIFTLED Digital Design Tools set. The suggested tools are presented in table 7.2 divided according to the STEAM disciplines.

	STEAM discipline	**STEAM Digital Design Tools to use**
1	Science	Go-Lab, https://www.tinkercad.com/ Tinkercad, https://www.golabz.eu/
2	Technology/Coding	Code, https://code.org/ Tynker, https://www.tynker.com/
3	Engineering	SketchUp, https://www.sketchup.com/products Algodoo, http://www.algodoo.com/
4	Art	Canva, https://www.canva.com/ Powtoon, https://www.powtoon.com/

5	Mathematics	Geogebra, https://www.geogebra.org/?lang=en Infogram, https://infogram.com/

Table 7.2 Tools divided according to STEAM disciplines suggested for GIFTLED curriculum

4. GIFTLED in STEAM classes: How to implement

This part of the GIFTLED curriculum presents each module in detail, especially specifying how to implement it in STEAM classes by the teachers and gifted/talented individuals.

It is recommend to realize each module in the form of project realized individually by each pupil or by the small groups of pupils.

To specify the implementation methods of GIFTLED curriculum in a class it is necessary to defined for each module the following elements:

1. Aim of the module/project.
2. Module tasks/activities realized both in class and at home using the selected ar applications and steam tools.
3. Resources delivered by the GIFTLED learning program.
4. Time needed to realize the tasks/activities/projects.
5. Formative assessment of the module.

The GIFTLED method integrates AR applications and digital design tools which are used in the “learning by design” approach in STEAM education. Teachers will use AR tools in the first three stages of the “learning by design approach”, so

1. *Situated Practice* – use of AR to experience knowledge field
2. *Overt Instructions* - use of AR to conceptualization
3. *Critical Framing* – use of AR fro analysis, evaluation and application.

In the fourth stage of the approach, so *Transformed Practice*, pupils will use digital design tools (DDTs) for applying the knowledge and design their own creative learning products.

6. Additional resources

Each GIFTLED curriculum module or topic realized in the framework of STEAM disciplines can be supported by the additional resources that will be useful for pupils and teachers to manage their works.

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GIFTLED

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