Journal for the Education of Gifted
Young Scientists, 10(4), 573-590, Dec 2022
e-ISSN: 2149- 360X
jegys.org
dergipark.org.tr/jegys

Young Wise Publishing
youngwisepub.com
gencbilgeyayincilik.com
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The Activities for the Education of the Gifted Young Scientist

Application of design thinking as a differentiation strategy for the education of gifted students: "City X"[1]

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Article Info

Received: 02 October 2022
Accepted: 18 December 2022
Available online: 30 Dec 2022

Keywords:
City X
Gifted student
Design hinking
Differentiation
3D design

Abstract

This research aimed to apply the City X Project as a 6-hour workshop for gifted students and evaluate the workshop. The study group consists of 25 gifted secondary school students (13 Female, 12 Male) who continue their education at the Science and Art Center (SAC) in a city center in Türkiye. During the application process, gifted students were introduced to the City X project, and information regarding the design thinking method was presented. The story of City X was provided to the students via a digital presentation. The given information was as follows: in the recent past, 40 people from the world were sent to a distant planet to form a colony and these people started to found City X city. City X citizens illustrate the specifics of the issues they face through "citizen cards" in many fields such as health, transportation, safety, and communication to the students and ask them for assistance in addressing the problems. The students are divided into 9 groups that have 2 to 3 participants using the game "Team Meter" during the execution of the workshop. Worksheets, a laptop or desktop computer with an internet connection, citizenship cards, a pen and paper were provided to each group to be used at each stage of the design thinking process. Students selected one of the citizenship cards and used the design thinking method to solve the problem written by the owner of the citizenship card. At the stage of empathy, they evaluated the emotions of the person they selected, and in the definition stage, they defined the social area of the problem raised by the City X citizen. The students later generated ideas for the solution of the specified problem, wrote their ideas on the worksheet, and picked an idea to prototype by group decision. The students prototyped their ideas during the prototyping and testing stages by drawing on the worksheet and completed their creations in various versions by providing feedback to each other. In the sharing stage, 2-dimensional drawings are transformed into 3-dimensional forms via Tinkercad and SketchUp programs. The 3D drawings were saved and submitted to the e-mail address of the City X administrator to be printed on the City X 3D printer. The worksheets used in the design thinking process, three-dimensional models, and the working dynamics of the groups were evaluated by students via Kahoot! web 2.0 tool. The criteria stated in the Kahoot! digital evaluation tools were scored in the range of 1-4 points. The views of students about the workshop were also collected verbally. The students reported that they enjoyed the process of design thinking, that they were pleased to do 3D drawings, that they wished to specialize in 3D design, and that they had several problems with teammates occasionally. One can suggest that the methods applied in the City X workshop can also be included in the course designs within the scope of STEM courses and design thinking methods can be adopted in SAC framework programs.

To cite this article:

Avcu, Y. E., & Ayverdi, L. (2022). Application of design thinking as a differentiation strategy for the education of gifted students: "City X". *Journal for the Education of Gifted Young Scientists*, *10*(4), 573-590 DOI: http://dx.doi.org/10.17478/jegys.1183220

Introduction

Gifted students are those who can adapt their knowledge to change settings and enjoy demanding work; they have great recall abilities, imagination, creativity, and motivation (Davis et al., 2014). Giving the gifted students who outperform

[1] The summary of this study was presented as an oral presentation at the 30th Special Education Congress with International Participation in which held online on 16-18 October 2020.

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their peers based on their distinctions and needs, the education services they need and allowing them to specialize in their ability sectors is not a duty but rather a requirement (Avcu, 2019). When adequate learning settings are not developed and essential chances are not provided, gifted students may experience several issues (Preckel, Götz & Frenzel, 2010; VanTassel-Baska & Brown, 2007). As a result, gifted students need to be constantly challenged regarding their interests or skill sets. In order to be successful, these students need to be given enriched learning chances in school settings where they may take risks, learn from their errors, and learn to deal with the circumstance when they fail to be successful (Rogers, 2007). Students' cognition and perception are significantly impacted by the lack of enhanced learning opportunities (Kitsantas et al., 2017; Schultz et al., 1997). In addition to providing differentiated instruction and independent activity possibilities in their areas of interest and skill, chances for them to interact with and learn from their gifted peers should be made available (Coleman & Hughes, 2009).

Since learning environments are created for students with typical talent levels, they might not be sufficient to meet the needs of gifted students, who learn more quickly than their peers with average talent levels, enjoy learning that is deep, complex, and abstract, have a variety of interests, and occasionally exhibit irregular developmental stages (Coleman, Miko & Cross, 2015; Fischer & Rose, 2001; Kalbfleisch &Tomlinson, 1998). Research carried out over the past quarter century on the experiences of gifted students in the context of school and education reveals that schools have high success expectations for students and that there are challenges in providing high- and advanced-level learning opportunities for gifted students (Coleman et al., 2015). Gifted children may have unpleasant school experiences due to the mismatch between the teaching methods and their learning styles, which forces them to wait for their colleagues who are learning at a regular pace, gives them too few challenging tasks, and sometimes they are exposed to bullying (Cross, 1997). All of this has the possibility of diminishing the potential that already exists in gifted students and has an impact on their ability to transform their potential into performance, motivation, and success. Differentiation can encourage student motivation and learning. Similar to other special education areas, giving children the chance to maximize their current potential to the fullest extent might open doors to possibilities that will allow them to benefit both themselves and their surroundings.

Based on the differences in students' preparation, interests, and learning profiles, differentiating teaching requires teachers to develop and apply different content, process, and product approaches (Tomlinson, 1995; 2017). Gifted children are not the only ones that need this approach (Gregory & Chapman, 2002). It entails structuring a learning environment that is inclusive for all students in heterogeneous classrooms with students who have a variety of personality traits. In this environment, students discover the content of the program in different ways. Activities and processes are designed so that students may access their knowledge and ideas and engage in meaningful learning. In addition, students are offered options to evaluate their own learning (Tomlinson, 1995). Under the guidance of differentiation principles (tasks appropriate for student level, flexible grouping, quality education program, ongoing assessment processes, learning-supportive environment), teachers utilize a variety of instructional and management strategies based on student characteristics (readiness, interest, and learning profile), allowing them to respond to student needs by differentiating the content, process, and product, as well as the learning environment (Emir, 2021; Tomlinson & Jarvis, 2009).

Tomlinson (1999) notes that several strategies, including stratified teaching, learning contracts, interest learning centers, independent study, teaching with small groups, group research, and other inquiry methodologies, may be used in the differentiation process. The cubing strategy, which enables students to look at a subject from different perspectives and forces students to think at a higher level, the menu strategy, which gives students the freedom to decide on what to do in the classroom, the choice boards strategy, which allows students to master concept teaching and various skills, and the Role, Audience, Format, Topic, Strong verb (RAFTS) strategy, which helps students think about the roles, the target audience, writing style, and the subject they are going to write as writers, are among the other strategies that can be used to differentiate the content, process, product and learning environment (Kaplan Sayı, 2020). As seen in the concept map in Figure 1, differentiation is the proactive response of teachers to student needs shaped by mindset. In this process, many strategies at the bottom of Figure 1 may be used (Tomlinson, 1999; 2017).

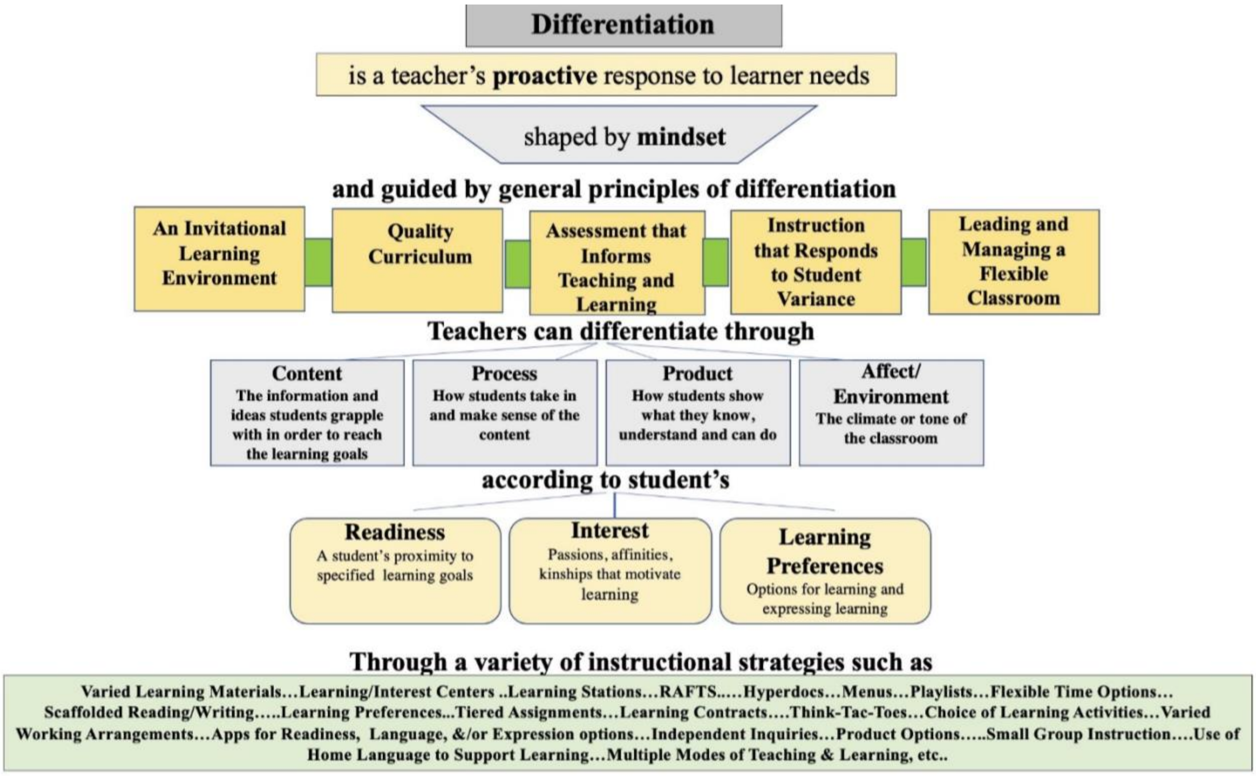


Figure 1. Differentiation Concept Map

Even though a variety of differentiation strategies were discussed in the relevant literature, the distinguishing characteristic of these strategies is that they allow differentiation in at least one of the following dimensions: content, process, product, and environment (Tortop, 2018). In addition, the selected differentiation strategy should

- look interesting to students,
- be directing students to think in higher level thinking steps,
- enable students to use their acquired knowledge, abilities, and understanding, as well as comprehend how these components are related to one another,
- support students to make the best sense of their knowledge and ideas (Tomlinson, 2017).

When the teaching method is implemented in this manner, the amount of information that gifted students can acquire is maximized, and it may also assist to reduce the amount of time and effort that is spent on lower-level courses (VanTassel-Baska, 2003). At this point, it is believed that the most essential thing is to select, execute, and manage the differentiation strategy in line with the criteria provided by Tomlinson (2017) while taking into consideration the learning profiles, interests, and readiness of the students.

To produce innovative solutions to personal, social, commercial, and educational problems, design thinking is a human-centered approach that calls for a thorough understanding of people's needs, in other words, empathizing with the individual and using design tools and the necessary mindset to think design-oriented during this process (Brown, 2008; Kelley & Kelley, 2013, Koh, Chai, Wong & Hong, 2015). The concept of design thinking places a focus on "understanding the needs of a person, also known as the user," as well as conducting experiments, learning from one's failures, developing prototypes, seeking feedback from users, and iteratively redesigning products." (Darbellay, Moody & Lubart, 2017, p.17). The Hasso Platner Design Institute (d.school), which continues its activities at Stanford University, asserts that the design thinking process uses empathizing, defining, ideating, prototyping, and testing to provide creative and inventive solutions to unstructured problems (Bootcamp Bootleg d.school, 2011).

The first step of the design thinking process is to empathize, where the design team may observe the user's everyday experiences, interview the user while interacting with them, and learn more about the user's thoughts and feelings by trying to make sense of the user's experiences (Caroll, 2015). The information gathered during the empathize stage is analyzed and synthesized, and they are then translated into needs and insights at the define stage (Carroll et al., 2010). In the stage of ideation, students initiate the brainstorming process to produce many varied ideas individually or as a group

(Carroll, 2014). During the prototype stage, anything physical that the user can grasp can be created. Presenting tangible products at this point, such as models, drama play, narratives, etc., allows for fast testing and timely improvement of concepts (Odabaşı, Dursun, Ersöz & Kılınç, 2018). The produced prototype is shown to the user during testing which is the last stage when the current solutions are assessed and improved in light of user feedback. Thus, it is aimed to better meet user needs (Carroll, 2015).

Design thinking can be used as a learning-teaching approach (Avcu & Er, 2020; Koh et al., 2015; Lor, 2016; Panke, 2019). At the same time, it is believed that design thinking may be used as a differentiation tool for both gifted and typical students. Gifted students view design thinking as interesting and fun (Avcu & Er, 2020; Avcu & Ayverdi, 2021). Students at normal talent levels also want design thinking to be used in their lessons (Atacan, 2020). In addition, design thinking encourages students to think at a higher level. Each step of the design thinking process encourages creative thinking (Henriksen et al., 2017). Students must use critical and creative thinking abilities, participate in data collecting, editing, analysis, and prototype processes, and monitor and assess their development processes by controlling the team dynamics (Koh et al., 2015).

Students who enter the design thinking process gain 21st-century skills and character traits (Sarıkoç & Ersoy, 2022). According to the findings of their study, VanTassel-Baska and Brown (2007) found that if methods and abilities that can activate multiple higher-level thinking skills are tailored to the subjects being covered in line with the curriculum's essence, learning outcomes for gifted students significantly improve. Using design thinking as a learning-teaching strategy is believed to activate many higher-level skills. Design thinking utilizes active inquiry and conversation, and inquiry-exploration approaches (Walberg, 1991, as cited in VanTassel-Baska, 2003) as the most successful teaching method for gifted students. In the design thinking process, students work on problems, texts, and various materials and create products either individually or as a team. Students have the right to choose for learning and evaluation. These activities provide differentiation of content, process, product, and learning environment according to the peculiarities of gifted students (Maker & Schiever, 2010; Tucker, Hafenstein, Jones, Bernick, & Haines, 1997; VanTassel-Baska & Stambaugh, 2006).

As a differentiation strategy, design thinking can be applied in different contexts such as science education (Atacan, 2020; Çiftçi & Topçu, 2020; Lee, Yoon & Kang, 2014), graphic design (Duman & Kayalı, 2017), social studies education (Aydemir & Çetin, 2021; Koh et al., 2015), teacher education (Carroll, 2014; 2015; Odabaşı et al., 2018; Öztürk, 2020), programming education (Avcu & Er, 2020), STEM education (Arifin & Mahmud, 2021; Avcu & Ayverdi, 2021; Hsiao et al., 2017; Li et al., 2019; Sarıkoç & Ersoy, 2022; Simeon, Samsudin & Yakob, 2022), educational game design (Caferoğlu, 2021), drama education (Polat &Bayram, 2021). Design thinking has been used in many studies concerning the education of gifted students. Ziadad and Sakrneh (2021) presented 77 gifted high school students with 5 problems from science and social studies (water usage for irrigation, waste management, social media addiction, unemployment, awareness regarding bullying, and prevention of it) and offered these students online design thinking training. The research demonstrates that gifted students considered the design thinking approach to be pleasant, engaged in the activities to a high degree, and were more motivated. 22 gifted secondary school students were given the task of redesigning dwellings for people by Avcu and Ayverdi (2021), who used a rubric to assess the students' design thinking skills. The researchers discovered that gifted students enhanced their skills at each phase of the design thinking process as a consequence of doing the activity. Avcu and Er (2020) found that the gifted students used their technical skills and talents, achieved learning outcomes for 21st-century skills, and encountered challenges working with the team as a consequence of the 30-hour design thinking practice. However, it was also recognized in this research that gifted students effectively utilized technology, and digital tools in particular, throughout the design thinking prototyping phase.

While design thinking is used as a differentiation strategy for gifted students, the process can benefit from technology. Technology also referred to as the "great equalizer," is a suggested method for differentiating educational programs and teaching for gifted students (Avcu & Yaman, 2022; Periathiruvadi & Rinn, 2012; Sprague & Shaklee, 2015; Siegle, 2014; Tomlinson, 2017). It is commonly acknowledged that technology has the potential to improve the efficacy and quality of education for gifted students, and some scientists assert that some technologies, such as the internet, 3D design, and programming, are especially advantageous for gifted students (Pyryt, 2009; Shavinina, 2009; Siegle, 2005). Gifted students also state that they want to learn 3D design, programming, animation, and how to use new technologies (Öngöz & Aksoy, 2015). The use of technology in the education of gifted students has three main functions: enabling (performing the tasks), developing (improving the works) and transforming (doing things differently) (Chen, Dai & Zhou, 2013). In the stages of the design thinking process, digital differentiation can also become possible with technology benefiting from these functions. With digital differentiation, the learning process of students may be enhanced by the use of fundamental questions for developing adaptable learning paths and digital resources (Kaplan Sayı & Soysal, 2022).

In this study, design thinking has been seen as a differentiation method that can be used to differentiate the dimensions of content, environment, process and product in the education of gifted students. During the prototyping phase, students were enabled to develop 3D models using digital drawing tools. 3D technologies have an important place in the development of students' knowledge and skills. With these technologies, students can design a new project as well as design products for the projects they are working on and make these products concrete (Akyol, Uygur & Yanpar-Yelken, 2022). In this context, digital differentiation has been applied with the effective use of 3D technologies. With the assistance of design thinking, it is intended for gifted students to come up with inventive answers to unstructured problems in a social setting while leveraging their problem-solving, creativity, critical thinking, 3D technology, and STEM (science, technology, engineering, and mathematics) skills.

Purpose of Study

This research aims to apply the City X Project as a 6-hour workshop for gifted students and evaluate the workshop. City X is a workshop developed by Stanford University that aims at teaching creative problem-solving and 3D technologies to children aged 8-12 using design thinking. Materials related to the City X Project can be found at http://www.cityxproject.com/. Permission was obtained from the project developers via e-mail to implement the project, adapt it for gifted students in Türkiye and share the results for academic literature. The learning outcomes aimed to be achieved by the students participating in the City X workshop are as follows:

- Develops an original project using the design thinking process (design project development- all stages)
- Creates his/her design to achieve the goals that were set in the 3D programs (Information technologies-prototyping phase)
- Compares two or more characters, settings, or events in a story or scenario to demonstrate their differences using particular literary elements (e.g. how the characters interact) (Linguistics-empathize stage)
- Combines information collected from multiple printed and digital sources avoiding plagiarism (Linguistics-ideate stage)
- He/she makes efforts to solve the problem previously identified (Mathematics, defining, ideating stages)
- Performs mathematical modelling (Mathematics, prototyping phase)
- He/she tests the accuracy, certainty, and precision of the model that was developed (Mathematics, testing phase).

The targeted learning outcomes in City X Project can also be associated with achievements in the field of science. Students may use their knowledge of ecosystem components for the City X Project in this context. They may draw a map of City X or the planet it was constructed on, highlighting various aspects. They may share knowledge of the planet's inhabitants, both living and non-living. Students can then use this information to further improve their ideas for design solutions. Examining the teacher guidebook (http://www.cityxproject.com/toolkit/) reveals how City X's achievements might be related to other fields such as history besides science.

Study Group

The study group consisted of 25 gifted secondary school students (13 Female, 12 Male) who continue their education at the Science and Art Center (SAC) in a city center. The mean age of the students was 12.

Application Example: City X

The six-step design thinking strategy used in City X (empathize, define, ideate, prototype, test, and share) is an adaptation of the design thinking process applied by Stanford d.school. The stages of this process were given in Figure 2.

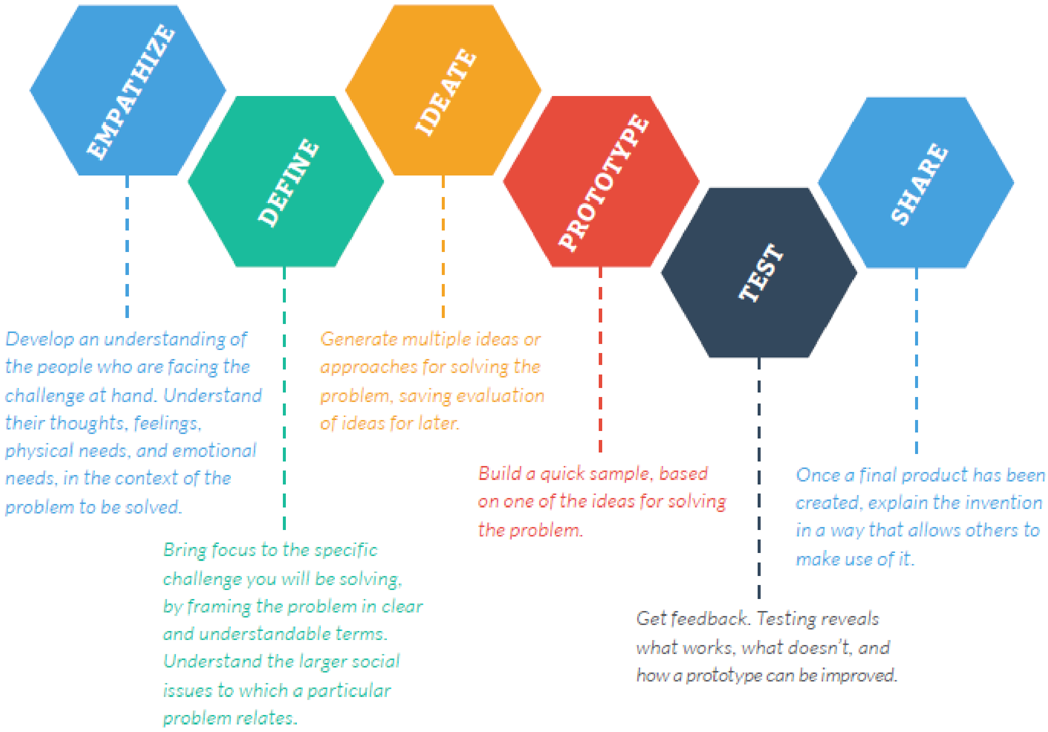


Figure 2. Stages of the Design Thinking Process Used in City X

When Figure 2 is examined, it is seen that the stages of the design thinking process follow the stages of empathize, define, ideate, prototype, test, and share. Unlike the stages of the Hasso Platner Design Institute (d.school), the sharing phase was applied in City X. At this stage, students send the 3D models they have developed to the mayor of City X via e-mail. The materials used in the implementation of the workshop are as follows:

- Digital Presentation
- Team Meter Game
- Citizenship Cards
- Empathize -Define Worksheet
- Ideate Worksheet
- Prototype-Test Worksheet
- Sketch Worksheet
- 3D Drawing Program (Sketch Up and Tinkercad preferred) and Computer, Internet Connection
- 3D Printer (If Possible)

Application Steps

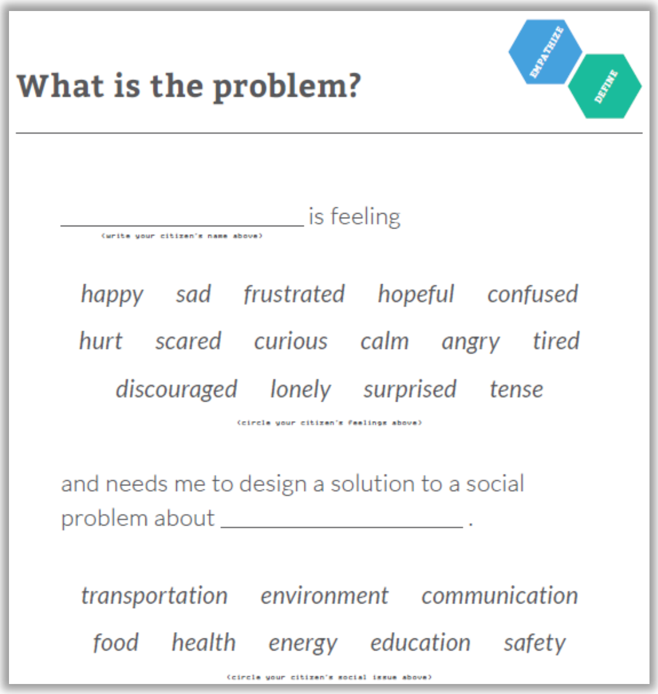
During the application process, gifted students were introduced to the City X project, and information regarding the design thinking method was presented. The story of City X was provided to the students via a digital presentation. The given information was as follows: in the recent past, 40 people from the world were sent to a distant planet to form a colony and these people started to found City X city. City X citizens illustrate the specifics of the issues they face through "citizen cards" in many fields such as health, transportation, safety, and communication to the students and ask them for assistance in addressing the problems. The students were divided into 9 groups that have 2 to 3 participants using the "Team Meter" game during the execution of the workshop. Team Meter Game was presented in Figure 3-a and citizenship cards were presented in Figure 3-b. The problems experienced by different City X citizens included in the citizen cards, and some examples of these cards were given in Annex-1.

a b

Figure 3. Team Meter Game and Citizenship Cards

First Stage: Empathize and Define

At this point, students read the problem of the City X citizen they selected by consensus with their peers and define their problem by empathizing with that individual. At this stage, the worksheet given in Figure 4 was used. A sample worksheet filled by the students during the application process was also presented in Figure 5.


What is the problem?

EMPATHIZE DEFINE

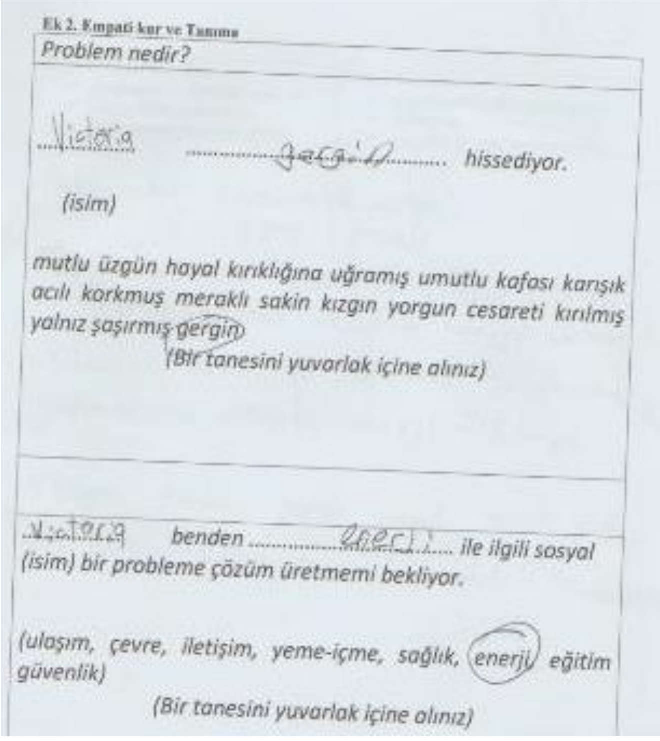
______________ is feeling
(write your citizen's name above)

happy sad frustrated hopeful confused
hurt scared curious calm angry tired
discouraged lonely surprised tense
(circle your citizen's feelings above)

and needs me to design a solution to a social problem about ______________ .

transportation environment communication
food health energy education safety
(circle your citizen's social issue above)

Figure 4. Empathize -Define Worksheet


Ek 2. Empati kur ve Tanıma

Problem nedir?

Victoria ....gergin........ hissediyor.

(isim)

mutlu üzgün hayal kırıklığına uğramış umutlu kafası karışık acılı korkmuş meraklı sakin kızgın yorgun cesareti kırılmış yalnız şaşırmış gergin

(Bir tanesini yuvarlak içine alınız)

Victoria benden ....enerji........ ile ilgili sosyal (isim) bir probleme çözüm üretmemi bekliyor.

(ulaşım, çevre, iletişim, yeme-içme, sağlık, enerji, eğitim güvenlik)

(Bir tanesini yuvarlak içine alınız)

Victoria is feeling tense.

Victoria needs me to design a solution to a social problem about energy.

Figure 5. Example of a Worksheet Filled in By Students to Empathize and Define

Second Stage: Ideate

At this stage, students provide solutions to the problem highlighted for the citizen of City X. In this process, the rules of brainstorming and the rules related to this stage were reminded to the students. An Ideate worksheet and a sample worksheet filled by the students were given in Figure 6 and Figure 7.

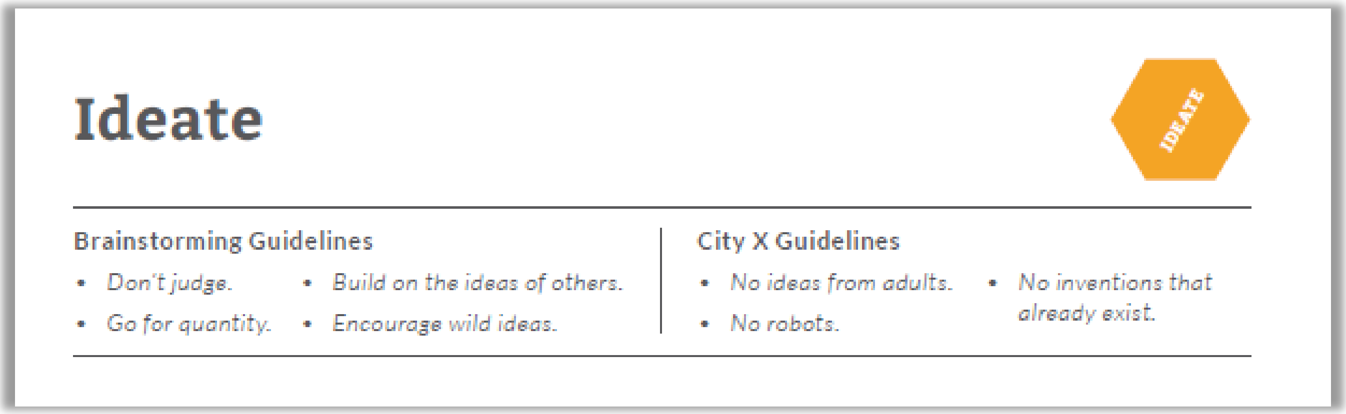
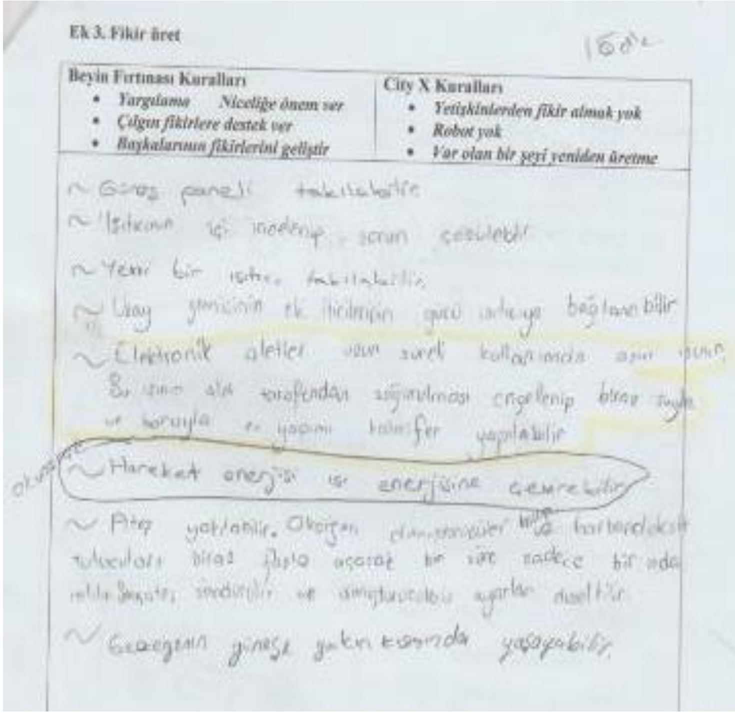


Figure 6. Ideate Worksheet



Solar panel can be installed.
The inside of the heater can be examined, and the problem can be solved.
A new heater can be installed.
The power of the spacecraft's additional thrusters can be connected to the heater.
Electronic tools overheat during prolonged use. By preventing the gamma ray from being cooled by the instrument, a homemade heater can be made with some water and a pipe.
Motion energy can be converted into heat energy.
Fire can be lit. By turning on the oxygen converters and carbon dioxide scavengers a little too much, only one room is heated for a while. Then the fire is extinguished, and the coolers correct the settings.
It is habitable on the part of the planet close to the sun.

Figure 7. Example of Ideate Worksheet Filled in By Students

Third Stage: Prototype-Test

At this stage, students pick one of their collectively generated ideas and go on to the prototype stage. After concretizing their concepts, students get feedback from their peers and test their prototypes. They can give feedback to the drawings using icons suggesting "good idea, I have a question, needs a change". In this process, the prototype was developed in three versions. The worksheet and sample student worksheet for this stage were given in Figure 8 and Figure 9.

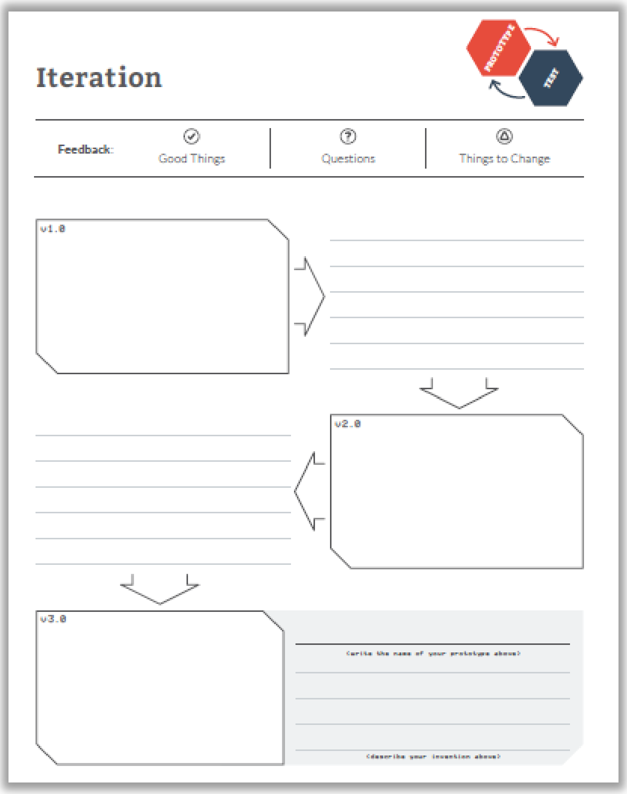
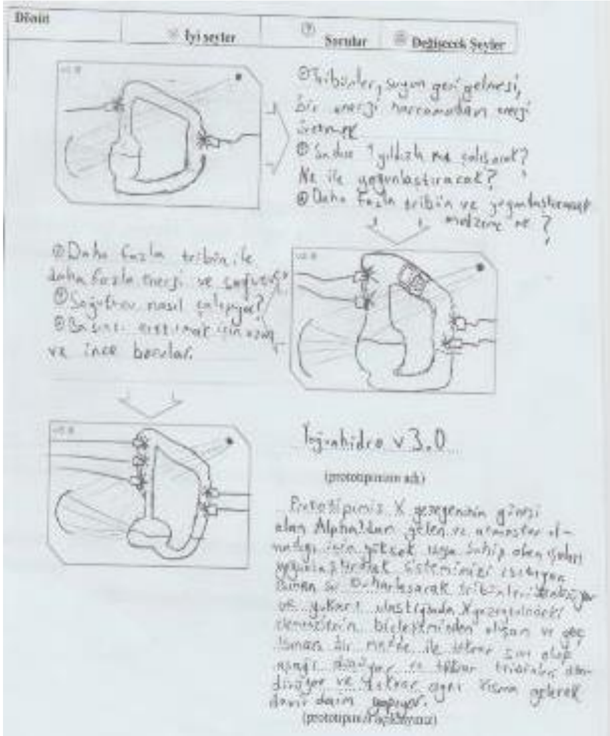


Figure 8. Prototype-Test Worksheet



Tribunes, water return, generating energy without wasting any energy. What will work with a final star? What will it focus on? More grandstands and what material to concentrate?

More energy and cooler with more stands.
How does the incubator work?
Long and thin pipes to increase the pressure.

Name of Prototype: Intensehydro 3.0
Our prototype heats our system by condensing the rays coming from Alpha, which receives the sun of planet X, and which have high temperatures since there is no atmosphere. The heated water evaporates and turns the turbines, and when it reaches the top, it turns into a liquid again with a late-heating substance consisting of the combination of the elements on planet X and turns the tribunes again, reaching the same part again and circulating.

Figure 9. Example of a Prototype-Test Worksheet Filled in by Students

Fourth Stage: Share

Students then draw the 3D version of the prototype they have created. They scale their ideas from the front, side, and top. Here, it is not necessary to sketch in great depth. Students transform their prototypes into a three-dimensional format using 3D drawing programs. The students then save their 3D drawings in "stl" format and submit them to the teacher's email address. Following the City X scenario, students send their e-mails to the Mayor of City X. If a 3D printer is available, student drawings will be printed. Students observe the process and products. The sketch worksheet of the sharing phase was given in Figure 10.

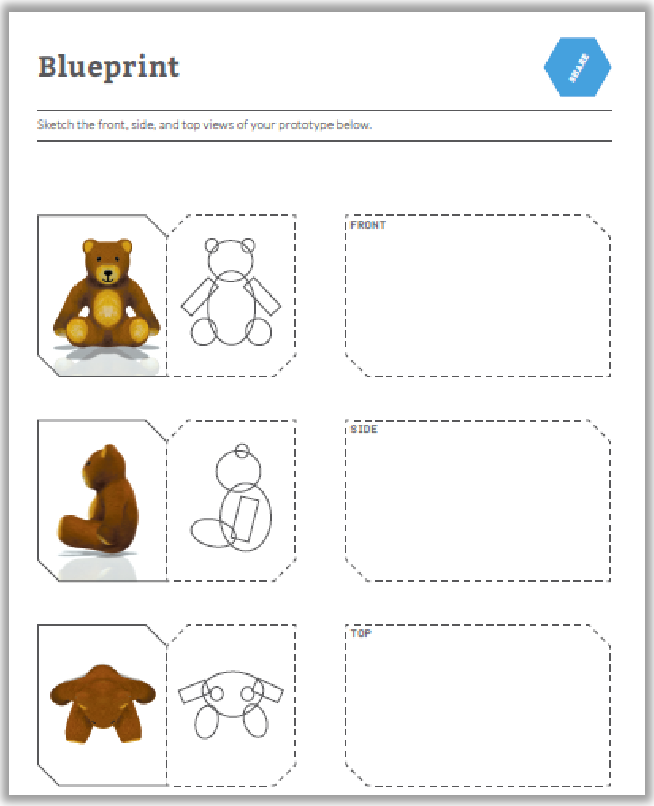


Figure 10. Sketch Worksheet

Figure 11 depicts the visuals associated with the students' three-dimensional drawings, whereas Figure 12 depicts the visuals associated with the student's learning environment and process. In Figure 13, explanations regarding the 3D models of the students were given.

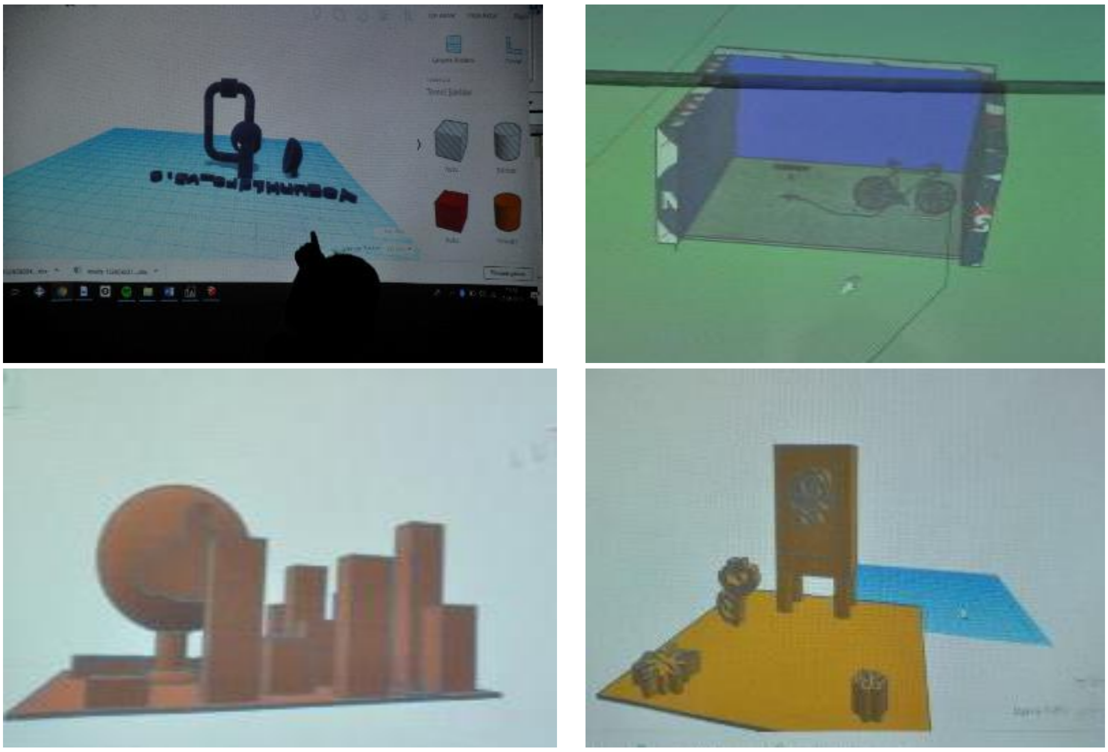
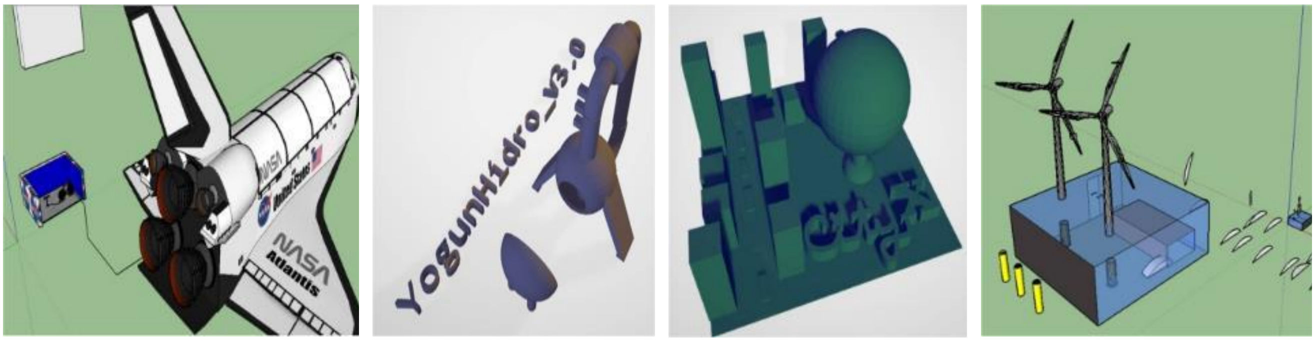


Figure 11. Example 3D Drawings Created by Students

Figure 12. Study Environment



a b c d

Figure 13. Three-Dimensional Models

Figure 13-a depicts the solution that students created for Pim's issue of living in City X during the design thinking prototype phase. The problem of Pim was about the darkness of nights, not how long they are because this was interrupting daily works. The students created a renewable system by combining the solar panel with their weathercock. Figure 13-b shows a structured design that would enable Tim to remember the world where he comes from and can feel at home when he misses the world. In Figure 13-c, students created a prototype for Victoria, who was worried about the declining energy of the space shuttle. In the intensehydro 3.0 prototype, there is a section that heats the system by condensing the rays from Alpha, the sun of Planet X, which are very hot due to the absence of an atmosphere. The heated water evaporates and spins the tribunes; when it reaches the portion above the tribunes, it reverts to a liquid with a less heat-conductive material composed of the combination of elements on Planet X, and then it drops. Thus, the tribunes rotate and recirculate again. In the last prototype 13-d, students solved Marek's problem of feeling cold by installing a small bicycle inside the spacecraft and connecting it to the heater's engine. When Marek rides the bike, the heater turns on and the energy problem will be solved.

Measurement and Evaluation

The worksheets used in the design thinking process, three-dimensional models, and the working dynamics of the groups were evaluated by students via Kahoot! web 2.0 tool. Besides, the views of students about the workshop were also collected verbally. The criteria stated in the Kahoot! digital evaluation tool were scored in the range of 1-4 points. The worksheets used in the design thinking process, three-dimensional models and the working dynamics of the groups were evaluated by students via Kahoot! web 2.0 tool. The questions used in the evaluation tool are as follows:

- The empathy map was carefully filled in
- The design team has produced several ideas for the solution
- The development stages of the prototype are clearly seen in the drawings created by the design team
- The design team has successfully identified the functioning and problematic parts when prototyping
- The three-dimensional design looks interesting, and the features of the design were well described
- The design provides solutions to the problem of the City X citizen
- The design team worked collaboratively
- The design was the collective idea of the team
- There was good communication within the design team
- The design has been presented successfully

Conclusions and Recommendations

Owing to the City X workshop, gifted students experienced the DT process and completed it in teams. Peer reviews conducted by students using the web 2.0 platform Kahoot and their comments showed that they enjoyed the experience, were interested in 3D design, and also had difficulties collaborating with the team. It was observed that the mean score of the groups was 34.6 out of 40.

The groups' scores on the items pertaining to teamwork were the lowest. In a similar vein, Avcu and Er (2020) found that the gifted students used their technical skills and talents, achieved learning outcomes for 21st-century skills, and encountered challenges working with the team as a consequence of the 30-hour DT practice. When gifted students engage in design thinking activities, they also hone their skills related to each stage (Avcu & Ayverdi, 2021). Ziadad and Sakrneh (2021) reveal that gifted students were happy to receive education through the design thinking process, active in design thinking activities highly, and their motivation increased. Additionally, students with typical ability levels express a desire to continue taking part in design thinking activities (Atacan, 2020).

The gifted students' difficulties with teamwork throughout the design thinking process may have been driven by their desire to demonstrate their leadership qualities (Davis et al., 2014). Similar results regarding the difficulties of working as a team in the design thinking process were also obtained in the studies of Avcu and Er (2020), Santos Ordóñez, González Lema and Miño Puga (2017) and Retna (2016). In addition, Dukes and Koch (2012) stated that students enjoyed applying the design thinking process as mentioned in the current study's results.

In this study, it was noticed that students used their knowledge in STEM subjects and adapted this information for problem-solving while using the design thinking process to provide answers to the problems of City X citizens. When choosing from citizenship cards, students chose the problems related to STEM fields. It is believed that students' enthusiasm and good attitudes toward STEM subjects have an influence on this circumstance. As a teaching approach, STEM and design thinking have processes that support each other. Similarities exist between the engineering design cycle used in STEM activities and the design thinking approach (Ayverdi, 2018; Avcu, 2019). In addition, STEM education improves students' design thinking and teamwork skills, as well as boosts their imagination and curiosity (Yıldırım & Türk, 2018). Teachers also believe that STEM applications improve students' design thinking and creativity skills (Taktat Ateş, Saraçoğlu & Ateş, 2022). At the same time, the design thinking process can be used in STEM education (Arifin & Mahmud, 2021; Avcu & Ayverdi, 2021; Hsiao et al., 2017; Li et al., 2019; Sarıkoç & Ersoy, 2022; Simeon, Samsudin & Yakob, 2022). The City X workshop may also be seen as an exploration that combines STEM teaching with design thinking.

The creators of the city X workshop had originally envisioned a three-day workshop; however, this work was redesigned as a six-hour program. In this process, design thinking was applied as a technique for differentiating gifted students, and digital differentiation was accomplished via the use of 3D drawing and internet technologies. Planning and time management were major topics for consideration during the workshop. When implementing the City X workshop, consideration was made to the amount of time allocated to students at each stage. Occasionally, requests for more time were also granted, but no substantial changes were permitted. The application process was facilitated by the preparation of worksheets and materials, the practitioners' existing work with their own students, and their expertise in implementing design thinking activities. The evaluation process took longer than anticipated, necessitating extra time. Girgin (2019) determined that teachers had difficulty in time management, empathizing, and ideating. Gaitas and Martins (2017) listed the five challenges teachers face while implementing differentiated teaching as follows: i) activities and materials, ii) evaluation, iii. classroom management, iv. planning and preparation, and v. classroom environment. Most teachers in conventional classrooms perceive differentiation to be a difficult method (Smets & Struyven, 2020). It is believed that the implementation of this study at SAC, which is an after-school enrichment program, would simplify the differentiation process owing to the environment's flexibility and the presence of teachers with years of experience engaging with gifted students.

Recommendations

Regarding the implementation process of the City X workshop, practitioners may be encouraged to pay close attention to time planning and management, as well as to meticulously prepare and review the materials in advance. The evaluation process should be meticulously planned, implemented and managed. In this study, students' verbal statements and peer evaluation were taken into account. A variety of alternative evaluation methods, including design thinking rubrics and teacher observation forms, may be used to make evaluations. When researching gifted students, it is important to include their leadership qualities as well. It has been recommended that the City X workshop implementation approach to be employed in the course designs being developed for STEM courses, and that design thinking would be included in the SAC framework programs. The application process is expected to be more effective owing to teacher training in differentiation, digital differentiation, and design thinking.

Limitations of Study

This study is limited to a 6-hour adaptation of the City X workshop and its application to 25 gifted students. Assessment and evaluation processes are limited to the evaluation of the activity and teacher observations.

Acknowledgment

We would like to thank SAC administrators, parents, and students for their support in the implementation of the City X Activity. Special thanks to the creators of City X for giving us permission to adapt and implement this unique workshop. We would like to thank the journal referees for their great efforts in the review of the article, and the general editor and field editors of the journal who worked meticulously at every stage of the process.

Conflicts of Interest

I wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

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References

Aspinwall. L., & Shaw, K. L. (2002). Representations in Calculus: Two contrasting cases. *The Mathematics Teacher,* 95(6), 434-439.

Akyol, C., Uygur, M., & Yanpar-Yelken, T. (2022). The use of 3D design programs and 3D printers in the education of the gifted and the opinions of students and teachers. *Journal for the Education of Gifted Young Scientists*, *10*(2), 173-205.

Arifin, N. R., & Mahmud, S. N. D. (2021). A Systematic literature review of design thinking application in STEM integration. *Creative Education*, *12*(7), 1558-1571.

Atacan, B. (2020). *7. sınıf fen bilgisi dersinde tasarım odaklı düşünmeye yönelik etkinliğin öğrencilerin motivasyon, ekip çalışması ve derse ilişkin bakış açılarına etkisi (The effect of a design thinking activity for 7th grade science course on students' motivation, team study and course viewpoints).* Master Thesis. Balıkesir University, Türkiye.

Avcu, Y. E. (2019). *Özel yetenekli öğrenciler için bilişim teknolojileri ve yazilim alanina yönelik bir öğretim tasariminin geliştirilmesi* (*Developing an instructional design for gifted and talented students towards the field of ICT and software).* Doctoral Thesis. Balıkesir University, Türkiye.

Avcu, Y. E., & Er, K. O. (2020). Design thinking applications in teaching programming to gifted students. *Journal of Educational Technology and Online Learning*, *3*(1), 1-30.

Avcu, Y. E., & Ayverdi, L. (2021, November). Özel yetenekli öğrencilerle gerçekleştirilen bir tasarım odaklı düşünme uygulaması (A design thinking practice with gifted students). Paper presented at IGATE21. İnönü University, Malatya, Türkiye.

Avcu, Y. E., & Yaman, Y. (2022). Effectiveness of the differentiated instructional design for value education of gifted: a mixed study. *Journal of Gifted Education and Creativity*, *9*(1), 1-23.

Aydemir, A., & Çetin, T. (2021). Tasarım odaklı düşünme yaklaşımı aracılığıyla sosyal bilgiler dersine yönelik geliştirilen ürünlerin etkililiği (The effectiveness of products developed for the social studies course through the design thinking approach). *Journal of Gazi University Gazi Education Faculty*, *41*(2), 885-910.

Ayverdi, L. (2018). *Özel yetenekli öğrencilerin fen eğitiminde teknoloji, mühendislik ve matematiğin kullanımı: FeTeMM yaklaşımı (Usage of technology, engineering and mathematics in science education for gifted students: STEM approach).* Doctoral Thesis. Balıkesir University, Türkiye.

Bootcamp Bootleg d.school. (2011). *Design Thinking*. Web: http://longevity3.stanford.edu/designchallenge2015/files/2013/09/Bootleg.pdf

Brown, T. (2008). Design thinking. *Harvard business review*, *86*(6), 84.

Carroll, M., Goldman, S., Britos, L., Koh, J., Royalty, A., & Hornstein, M. (2010). Destination, imagination and the fires within: Design Thinking in a middle school classroom. *International Journal of Art & Design Education, 29*(1), 37–53.

Carroll, M. (2014). Shoot for the moon! the mentors and the middle schoolers explore the ıntersection of design thinking and STEM. *Journal of Pre-College Engineering Education Research (J-PEER)*, *4*(1), 14-30.

Carroll, M. (2015). Stretch, dream, and do- a 21st century design thinking & STEM journey. *Journal of Research in STEM Education*, *1*(1), 59-70.

Çiftçi, A., & Topçu, M. S. (2020). Design thinking: Opinions and experiences of middle school students. *Pegem Journal of Education and Instruction*, *10*(3), 961-1000.

Caferoğlu, M. (2021). Tasarım odaklı düşünce yöntemiyle oyun tasarımı: Nunki hikâye bohçası tasarımı örneği (Game design with design thinking method: Nunki story sack design example). *Journal of Social and Humanities Sciences Research*, *8*(75), 2563-2576.

Chen, J., Yun Dai, D., & Zhou, Y. (2013). Enable, enhance, and transform: How technology use can improve gifted education. *Roeper Review*, *35*(3), 166-176

Coleman, M. R., & Hughes, C. E. (2009). Meeting the needs of gifted students within a RtI framework. *Gifted Child Today*, *32*(3), 14-17.

Cross, T. L. (1997). Psychological and social aspects of educating gifted students. *Peabody Journal of Education*, *72*(3-4), 180-200.

Darbellay, F., Moody, Z., & Lubart, T. (2017). Introduction: Thinking Creativity, Design and Interdisciplinarity in a Changing World. In F. Darbellay, Z. Moody and T. Lubart (Eds.), *Creativity, Design Thinking and Interdisciplinarity* (p.xi-xx), New York: Springer.

Davis, G. A., Rimm, S. B., & Siegle, D. (2014). *Education of the gifted and talented* (Sixth Edition). Edinburgh: Pearson Education Limited.

Dukes, C., & Koch, K. (2012). Crafting a delightful experience: Teaching interaction design to teens. *Interactions*, *19*(2), 46-50.

Duman, B., & Kayalı, D. (2017). Teknopedagojik Öğretme Yaklaşımının Tasarım Odaklı Düşünme Becerilerine Etkisi (The Effect of Technopedagogical Teaching Approach on Design Thinking Skills). In B. Akkoyunlu, A. İşman, H. Ferhan Odabaşı (Eds.). *Technology Readings in Education* (pp.176-184). Ankara: TOJET.

Emir, S. (2021). *Üstün zekalı ve yetenekliler için program farklılaştırma (Program differentiation for gifted and talented)*. Ankara: Vize Publishing.

Fischer, K. W., & Rose, L. T. (2001). Webs of skill: How students learn. *Educational Leadership*, *59*(3), 6-123.

Gaitas, S., & Martins, A. M. (2017). Teacher perceived difficulty in implementing differentiated instructional strategies in primary school. *International Journal of Inclusive Education*, *21*(5), 544-556.

Girgin, D. (2019). Öğretmenlerin tasarım odaklı düşünmeye ilişkin bilişsel yapıları ve kavramsal değişimleri (The cognitive structure of teachers concerning design-based thinking and their conceptual change). *Journal of Ahi Evran University Institute of Social Sciences, 5*(2), 459-482.

Heacox, D. (2002). *Differentiating instruction in the regular classroom: How to reach and teach all learners, grades 3-12*. Minneapolis: Free Spirit Publishing.

Henriksen, D., Richardson, C., & Mehta, R. (2017). Design thinking: A creative approach to educational problems of practice. *Thinking Skills and Creativity*, *26,* 140–153.

Hsiao, H. S., Yu, K. C., Chang, Y. S., Chien, Y. H., Lin, K. Y., Lin, C. Y., ... & Lin, Y. W. (2017, November). The study on integrating the design thinking model and STEM activity unit for senior high school living technology course. In *2017 7th World Engineering Education Forum (WEEF)* (pp. 383-390). IEEE.

Kalbfleisch, M. L., & Tomlinson, C. A. (1998). Teach me, teach my brain a call for differentiated classrooms. *Educational Leadership*, *56*(3), 52-55.

Kaplan Sayı, A. (2020). Handling Individual Differences in Generation Alpha. In Nuran Yurtseven (Ed.), *The Teacher of Generation Alpha* (p.75-93), Berlin: Peter Lang GmbH.

Kaplan Sayı, A., & Soysal, Ö. M. (2022). Digital differentiation in gifted Education. In J. L. Nyberg & J. A. Manzone (Eds.), Creating equitable services for the gifted: protocols for identification, implementation, and evaluation (pp. 205-225). IGI Global.

Kelley, T., & Kelley, D. (2013). *Yaratıcı özgüven, içimizdeki yaratıcı potansiyeli serbest bırakmak* (Çev. P. Şengözer). Pasifik Ofset: İstanbul.

Kitsantas, A., Bland, L., & Chirinos, D. S. (2017). Gifted students' perceptions of gifted programs: An inquiry into their academic and social-emotional functioning. *Journal for the Education of the Gifted*, *40*(3), 266-288.

Koh, J. H. L., Chai, C. S., Wong, B., & Hong, H. (2015). *Design thinking for education: conceptions and applications in teaching and* learning. Singapore: Springer.

Lee, D., Yoon, J., & Kang, S. J. (2014). The introduction of design thinking to science education and exploration of its characterizations as a method for group creativity education. *Journal of the Korean Association for Science Education*, *34*(2), 93-105.

Li, Y., Schoenfeld, A. H., diSessa, A. A., Graesser, A. C., Benson, L. C., English, L. D., & Duschl, R. A. (2019). Design and design thinking in STEM education. *Journal for STEM Education Research*, *2*(2), 93-104.

Lor, R. R. (2017, May). Design Thinking in education: A critical review of literature. Paper presented at Asian Conference on Education & Psychology, Bangkok, Thailand.

Maker, C. J., & Schiever, S. W. (2010). *Curriculum development and teaching strategies for gifted learners*. Texas, USA:Pro.ed An Internatinal Publisher.

Odabaşı, H. F., Dursun, Ö. Ö., Ersöz, R. A., & Kılınç, H. (2018). Öğretmen Eğitiminde Yeni Bir Yaklaşım: Tasarımcı düşünme (A New Approach in Teacher Education: DesignThinking). In B. Akkoyunlu, A. İşman, H. Ferhan Odabaşı (Eds.). *Technology Readings in Education* (pp.392-394). Ankara: TOJET.

Ordóñez, A. S., Lema, C. G., Puga, M. F. M., Lema, C. P., & Vega, F. C. (2017). Design thinking as a methodology for solving problems: Contributions from academia to society. In *Global Partnerships for Development and Engineering Education: Proceedings of the 15th LACCEI International Multi-Conference for Engineering, Education and Technology* (pp. 19-21).

Öngöz, S., & Aksoy, D. A. (2015). Üstün yetenekli öğrenciler bilişim teknolojileri dersinden ne bekliyorlar? (What do gifted students expect from the information technologies course?). *Journal of Education & Special Education Technology, 1*(1), 34-47.

Öztürk, A. (2020). *Co-developing STEM activities through design thinking approach for fifth graders* (Unpublished Doctoral dissertation), Middle East Technical University, Ankara.

Panke, S. (2019). Design thinking in education: Perspectives, opportunities and challenges. *Open Education Studies*, *1*(1), 281-306.

Periathiruvadi, S., & Rinn, A. N. (2012). Technology in gifted education: A review of best practices and empirical research. *Journal of Research on Technology in Education*, *45*(2), 153-169.

Polat, S., & Bayram, H. (2021). Drama dersinin tasarım odaklı düşünme becerilerinin gelişimine katkısını araştıran bir durum çalışması (A case study exploring the contribution of drama lesson to the development of design thinking skills). *Journal of Erzincan University Faculty of Education*, *23*(2), 476-497.

Preckel, F., Götz, T., & Frenzel, A. (2010). Ability grouping of gifted students: Effects on academic self-concept and boredom. *British Journal of Educational Psychology*, *80*(3), 451-472.

Pyryt, M. C. (2009). Recent developments in technology: Implications for gifted education. In *International handbook on giftedness* (pp. 1173-1180). Springer.

Retna, K. S. (2016). Thinking about design thinking: A study of teacher experiences. *Asia Pacific Journal of Education*, *36*(1), 5-19.

Rogers, K. B. (2007). Lessons learned about educating the gifted and talented: A synthesis of the research on educational practice. *Gifted child quarterly*, *51*(4), 382-396.

Sarıkoç, Z., & Ersoy, H. (2022). Tasarım odaklı düşünme yaklaşımıyla STEM uygulamaları: SPAM e-twinning projesi örneği (STEM applications with design thinking approach: Example of e-twinning project). *Journal of Science, Mathematics, Entrepreneurship and Technology Education, 5*(2), 98-122.

Schultz, W., Dayan, P., & Montague, P. R. (1997). A neural substrate of prediction and reward. *Science*, *275*(5306), 1593-1599.

Shavinina, L. V. (2009). High intellectual and creative educational multimedia technologies for the gifted. In *International handbook on giftedness* (pp. 1181-1202). Springer.

Siegle, D. (2005). *Using media & technology with gifted students*. Prufrock Press Inc.

Siegle, D. (2014). Technology: Differentiating instruction by flipping the classroom. *Gifted Child Today*, *37*(1), 51-55.

Simeon, M. I., Samsudin, M. A., & Yakob, N. (2022). Effect of design thinking approach on students' achievement in some selected physics concepts in the context of STEM learning. *International Journal of Technology and Design Education*, 185-212.

Smets, W., & Struyven, K. (2020). A teachers' professional development programme to implement differentiated instruction in secondary education: How far do teachers reach? *Cogent Education*, *7*(1), 1742273.

Sprague, D. R., & Shaklee, B. (2015). Differentiating through Technology for Gifted Students. In *Cases on Instructional Technology in Gifted and Talented Education* (pp. 269-286). IGI Global.

Taktat, Y., Saraçoğlu, S., & Ateş, H. (2022). Fen eğitimi alanindaki akademisyenlerin stem eğitimi inançlari (STEM education beliefs of academicians in science education). *Research and Experience Journal (REJ)*, *7*(1), 1-18.

Tomlinson, C.A. (1995). *How to differentiate ınstruction in mixed ability classrooms.* Alexendria VA: Association for Supervision and Curriculum Development.

Tomlinson, C. A. (1999). *The differentiated classroom: Responding to the needs of all learners*. Alexandria, VA, USA: ASCD.

Tomlinson, C.A. (2017). *How to differentiate instruction in academically diverse classrooms* (3rd edition). Alexandria, VA, USA: ASCD.

Tomlinson, C., & Jarvis, J. (2009). Differentiation: Making curriculum work for all students through responsive planning and instruction. In *Systems and models for developing programs for the gifted and talented* (pp. 599-628). Mansfield Center USA: Creative Learning Press.

Tortop, H. S. (2018). *Üstün zekâlılar eğitiminde farklılaştırılmış öğretim müfredat farklılaştırma modelleri (Differentiated instruction and models for gifted)*. Istanbul: Genç Bilge (Young Wise) Publishing.

Tucker, B., Hafenstein, N. L., Jones, S., Bernick, R., & Haines, K. (1997). An integrated-thematic curriculum for gifted learners. *Roeper Review*, *19*(4), 196-199.

VanTassel-Baska, J. (2003). Selecting instructional strategies for gifted learners. *Focus on exceptional children*, *36*(3), 1-12.

VanTassel-Baska, J., & Brown, E. F. (2007). Toward best practice: An analysis of the efficacy of curriculum models in gifted education. *Gifted child quarterly*, *51*(4), 342-358.

VanTassel-Baska, J., & Stambaugh, T. (2006). *Comprehensive curriculum for gifted learners*. Pearson Education.

Yıldırım, B., & Türk, C. (2018). Sınıf öğretmeni adaylarının STEM eğitimine yönelik görüşleri: uygulamalı bir çalışma (Pre-Service primary school teachers' views about STEM education: An applied study). *Trakya University Journal of Education Faculty*, *8*(2),195-213

Ziadat, A. H., & Sakarneh, M. A. (2021). Online design thinking problems for enhancing motivation of gifted students. *International Journal of Learning, Teaching and Educational Research*, *20*(8), 81-107.

Appendix 1. Examples of Citizen Cards