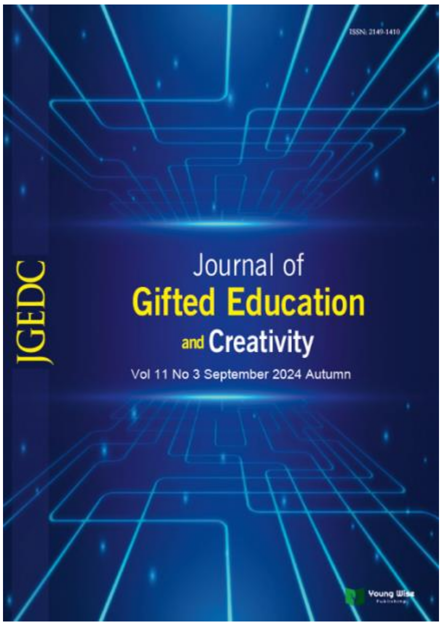
ISSN: 2149-1410

JGEDC

Journal of Gifted Education and Creativity

Vol 11 No 3 September 2024 Autumn

Young Wise Publishing



Journal of Gifted Education and Creativity (JGEDC)
e-ISSN: 2149- 1410

Vol. 11 No. 3 September 2024 (Autumn)

Contents

Absracting & Indexing
EBSCO (HW Wilson-Education Source Fulltext), Index Copernicus, SOBIAD, Udledge, WorldCat, ResarchBib, EZB, Google Scholar Note: You can click on them to check the status of JGEDC in indexes.

Genç Bilge (Young Wise) Publishing
Adress: Bahcelievler District 3015 St. No:9/1 Isparta, Turkiye
Web site: http://gencbilgeyayincilik.com/ E-mail: info@gencbilgeyayincilik.com

Journal of Gifted Education and Creativity
11(3), 91-98, September 2024
e-ISSN: 2149- 1410
jgedc.org dergipark.org.tr/jgedc

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Research Article

Upcycling perceptions of gifted students

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Article Info

Received: 1 June 2024
Accepted: 6 August 2024
Online: 30 September 2024

Keywords
Gifted student
Metaphor
Upcycling
Waste management

Abstract

One of today's most important environmental problems is waste. Separating and recycling waste from garbage is an important part of waste management. One of the concepts within waste management is the concept of upcycling. Upcycling is the reuse of used or unused products for a different purpose. Gifted children, who are important for the growth and development of countries, will undoubtedly take on a social leadership role in the future and their waste management behavior will have an impact on the people around them and on the development of waste management technologies in the future. For this reason, it is necessary to determine the perceptions of gifted students regarding the concept of upcycling within the subject of waste management. In line with this justification, the aim of the study is to reveal the perceptions of gifted primary school students on the concept of upcycling through metaphor. The study was conducted with 92 primary school students studying at a science and art center in the Eastern Mediterranean Region of Turkey in the 2023-2024 academic year. In the study, phenomenology pattern, one of the qualitative research methods, was used. The data obtained from gifted primary school students completing the sentence "Upcycling is like ..." was analyzed according to content analysis. According to the findings of the study, 17 types of metaphors were produced by the students and it was determined that the most recurring metaphors were design, invention and recycling metaphors. The metaphors produced were categorized according to similar characteristics and 3 categories were created. The most metaphors were produced in the "upcycling in terms of re-creation" category, and direct quotations were made from the metaphors created by the students in order to support the findings. In line with the results of the findings obtained in the study, it can be said that the perception of gifted primary school students regarding the concept of upcycling is to design a new product and re-create it and ensure useful use again. In order for students to have a more accurate perception of the concept of upcycling, it can be suggested that students should be given training on this subject.

To cite this article:

Sönmez, D. (2024). Upcycling perceptions of gifted students. *Journal of Gifted Education and Creativity, 11*(3), 91-98. DOI: https://doi.org/10.5281/zenodo.13756761

Introduction

One of the most important problems of our world in the century we live in is the environmental problems that arise as a result of rapid and incorrect consumption of natural resources. Waste is one of the most important environmental problems affecting all humanity on a global scale (Jekria and Daud, 2016). In order to reduce waste materials, waste is evaluated through recycling, reuse and upcycling. Recycling is "the process of converting wastes that can be reused into raw materials or by-products and re-introducing them into production" (Çimen and Yılmaz, 2012). Reuse is the re-use of a product for the same or different purposes after the consumer's use, without being subjected to any chemical or biological processing (Elibol, Bezci, Dündar Türkkan and Varol, 2018). Upcycling is turning old or unwanted products into new and useful items to serve a different purpose (Ersan, 2021).

In the upcycling method, it is possible to recover the waste in a more valuable way than before the natural energy was consumed, and this can only be done through design. The upcycling method, which is more advantageous than recycling

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in this respect, makes it possible for everyone to evaluate their own waste on-site, thanks to various templates created by designers. Upcycled products also have a certain lifespan and eventually turn into waste again. It is very important to recycle the upcycled material that has completed its useful life at this point. The useful life of waste should be extended by first upcycling and then recycling. Although recycling is necessary for nature and humans, the priority should be not to create waste (Demir, 2022).When the studies on students in the literature on zero waste and recycling in Turkey are examined, in the study conducted by Ural Keleş and Keleş (2018), the perceptions of 3rd and 4th grade primary school students about the concept of recycling; In the study conducted by Bulut and Çavuldur (2017), behavioral development of 6th grade secondary school students regarding recycling; In the study conducted by Volunteer and Çelik (2015), the knowledge levels of 3rd and 4th grade primary school students about the recycling of packaging waste; In the study conducted by Mutlu (2013), 8th grade students' perceptions of recycling; In the study conducted by Çimen and Yılmaz (2012), secondary school students' behaviors regarding recycling; In the study conducted by Mrema (2008), recycling knowledge levels of 8th and 11th grade students; In the study conducted by Önal, Kaya and Çalışkan (2019), zero waste policy in environmental education and its appearance in the current textbooks of the 2nd grade life sciences course; In the study conducted by Sönmez (2020), drawings of first grade primary school students regarding the concept of zero waste; In the study conducted by Kara and Dönel Akgül (2021), the metaphors created by 8th grade students for recycling; In the study conducted by Egüz and Gökalp (2023), it was seen that they examined the metaphorical perceptions and awareness of secondary school students towards recycling .

The literature review, in the field of fashion and textiles (Ateş, 2023; Azakoğlu 2021; Erben, 2023; Güner, 2019; Ünlü, 2021), in the field of fine arts for the design of packaging waste (Demir, 2023; Ersoy Yılan 2023), in the field of architecture (Haberal, 2023) includes studies on upcycling. However, no study has been found on the concept of upcycling in the field of education and training. As a matter of fact, it is seen that the concept of upcycling is expressed as the concept of recycling in studies on recycling and zero waste in the field of education and training. For this reason, the concept of upcycling is not known by students. The use of metaphor was used in this study so that students can learn and distinguish the concept of upcycling more easily.

It can be said that metaphors are a tool that teaches unknown concepts more easily, makes them stick in the mind, and has proven validity in this regard (Arslan and Bayrakçı, 2006). Although metaphors can be used in every field, it is seen that studies on metaphor have increased in recent years. Although metaphors are widely used in the field of social sciences, they are generally used in the sense of analogy in the field of educational sciences (Zeren and Yapıcı, 2014). Metaphors are frequently used in education and training processes and play an important role in classroom activities (Akyol, 2017).

Importance must be given to the education of special talents who have strategic importance for the development and development of the country. Gifted child; They are students who are determined by experts to have a high level of performance compared to their peers in intelligence, creativity, artistic capacity or special academic fields or leadership, and who need special education in these areas (Ministry of National Education, 2013). Gifted students will be able to take on a social leadership role in the future and influence other individuals with their behavior, especially regarding waste management (Renzulli, 2007). For this reason, it is necessary to determine the perceptions of gifted students regarding the concept of upcycling within the subject of waste management. Therefore, metaphor was used to reveal the thoughts of gifted primary school students about the concept of upcycling.

Problem of the Study

This research aims to reveal the metaphorical perceptions of gifted primary school students about concept of upcycling. Within the scope of this purpose, answers to the following questions will be sough:

- What are the metaphors that gifted primary school students have about concept of upcycling?
- On which conceptual categories are metaphors collected?

Method

Research Model

The phenomenological pattern, one of the qualitative research methods, was used. The phenomenology pattern, which is one of the patterns of qualitative research , focuses on the underlying meanings of the phenomena that we are aware of but do not have a deep understanding of, and discovers and reveals them (Creswell, 2013; Yıldırım and Şimşek, 2018). In this study, the phenomenological pattern was chosen to reveal the mental schemas of gifted primary school students regarding the concept of upcycling.

Participants

The study group of this study consisted of 92 primary school students studying at a science and art center in the Eastern Mediterranean Region of Turkey in the 2023-2024 academic year. "Easily accessible sampling" method was used when creating the study group, and the study was planned with primary school students studying at the science and art center where the researcher worked and studied. The easily accessible sampling method is a type of sample determination in which individuals from whom data can be obtained most easily are selected in the study (Yıldırım and Şimşek, 2018). Thus, the practitioners and the researcher were given the opportunity to make explanations during the data collection process. Demographic characteristics of the gifted primary school students in the study group are listed in Table 1.

Table 1. Demographic characteristics of participants

Demographic features		**f**	**%**
Gender	female	52	56.5
	male	40	43.5
Grade Level	2nd	20	21.7
	3rd	50	54.3
	4th	22	24
Total		**92**	**100**

When Table 1 is examined; 56.5% of the students included in the study were female (f: 52) and 43.5% were male (f: 40); It is seen that 21.7% of them are 2nd grade (f: 20), 54.3% are 3rd grade (f: 50) and 24% are 4th grade (f:22) students. First grade students were not included in the research because they were not defined as gifted students and were still at the first reading and writing stage.

Data collection tool

A interview as prepared as a tool to collect data from the study group. The interview was created in three parts. In the first part, the purpose of the study, the definition of upcycling, the definition of metaphor and its example were given to the students. In the second part, questions were asked about the demographic characteristics of the students regarding gender and grade level. The third part is where the actual data is collected. In this section, students were asked to fill in the blanks. To students; "Upcycling is like … . Because…" the sentence was directed. In this sentence, students were asked to compare the concept of upcycling to something and to give the reason for this analogy under the because sentence. In this way, students were enabled to provide a justification and logical basis for the metaphors they produced (Saban, 2008).

Data Collection Process

The students were briefly told about the study and their preliminary knowledge about the concept of upcycling was checked. In order to make the study results more accurate, information about what the concept of metaphor is is given. Not only was a definition made, but examples of the concept of metaphor were given from our daily lives, students were asked to produce different examples, and as a result, students were enabled to master the subject. Before the interview was distributed to the students, it was shared with the students that they should not be influenced by metaphors that hurt each other and that each metaphor written was valuable, and then the form was distributed. Approximately 20 minutes was sufficient for all students. The forms filled out completely and without errors by primary school students were organized to be included in the study data set.

Analysis of Data

Content analysis was used to analyze the data. The aim of content analysis is to reach concepts and connections that can make sense of the data. The data obtained in the content analysis are examined in detail (Krippendorff, 2004). The number of repetitions of the metaphors obtained from the students was determined and they were ranked from the most repeated metaphor to the least repeated metaphor. As a result of the examinations, some students were eliminated by consulting expert opinion because they could not create metaphors, and these metaphors were not included in the study. A total of 17 types of metaphors produced by the students were categorized according to their similar features. Within this framework, three categories were created. The number of metaphors under the created categories was determined and presented in tables. Direct quotations are included to support the findings. In direct quotations, taking into account the principle of confidentiality, the students who participated in the research were coded starting from S-1 to S-84.

Validity and Reliability

In order to ensure validity and reliability, all control was provided by the researchers during the application phase, and the researchers were with the students at every stage of the application. While ensuring the reliability of the study, expert opinion was also consulted, and the metaphor list and conceptual categories created and the matches made by the expert were compared. The reliability of the study was calculated using Miles and Huberman's (2021) formula (Reliability: Consensus/Agreement +Disagreement x 100), and it was revealed that the agreement obtained was 78/78+6x100=92%. If the agreement between expert and researcher is 90% or above, sufficient reliability is achieved (Saban, 2008).

Results

The metaphors created by gifted primary school students for the concept of "Upcycling" and the findings of the categories created from the metaphors are included. 92 students participated in the study voluntarily, and the forms of 8 students were not evaluated because they could not produce metaphors or could not justify the metaphors they produced. Findings and frequency values were calculated on 84 student forms.

Metaphors produced by gifted primary school students about concept of upcycling

"What are the metaphors that gifted primary school students have about concept of upcycling?" the answer to the question has been sought. The metaphors developed by gifted primary school students regarding the concept of upcycling are listed in Table 2.

Table 2. Metaphors, frequency and percentage values developed by specially gifted primary school students regarding the concept of upcycling

Metaphor	Frequency (f)	Percentage (%)
Design	24	28.2
Invention	16	19.2
Recycle	15	18
renew	5	6
Useful use	5	6
reboot	3	3.5
not to waste	3	3.5
Science	2	2.4
meet the need	2	2.4
be thrifty	2	2.4
A new world	1	1.2
new product	1	1.2
Raindrops	1	1.2
Innovation	1	1.2
Wash	1	1.2
A new life	1	1.2
a new planet	1	1.2
Total	**84**	**100**

İt is seen that gifted primary school students produced a total of 17 different metaphors for the concept of "upcycling". It was determined that the metaphors focused on design (f: 24, 28.2 %), invention (f:16, 19.2%) and recycling (f:15, 18%) metaphors. It was determined that they produced one metaphor each with the metaphors of a new world, new product, raindrops, innovation, washing, a new life, and a new planet. It has been determined that the majority of metaphors are metaphors aimed at explaining the different and new intended use of upcycling.

Findings regarding the second sub-problem

On which conceptual categories are the metaphors of gifted primary school students regarding the concept of upcycling collected?" The answer to the question has been sought. The distribution of metaphors of gifted primary school students regarding the concept of "Upcycling" according to categories is shown in Table 3.

Table 3. Distribution and Percentage Values of Metaphors Developed by Gifted Primary School Students by Category

Categories	**Number of metaphors**	**Percentage**
Upcycling for regeneration	Design (24), Invention (16), A new planet (1), A new world (1), A new life (1), New product (1), Innovation (1)	53.6
Upcycling for reuse	Recycle (15), Renew (5), Restart (3), Raindrops (1), Wash (1)	29.8
Upcycling for benefit	Beneficial use (5), Not wasting (3), Science (2), Meeting needs (2), Being economical (2)	16.6
Total	**84**	**100**

When Table 3 is examined, metaphors of gifted primary school students regarding the concept of "Upcycling"; It is seen that it creates 3 categories: in terms of regeneration (f: 45, 53.6 %), in terms of re-use (f: 25, 29.8%) and in terms of benefit (f: 14, 16.6%). When the metaphors were examined, it was determined that positive metaphors were generally produced. The resulting categories and sample expressions are as follows;

Category 1. Upcycling in terms of regeneration

Sample expressions obtained in this category are as follows;

S-33: “Upcycling is like designing, because I take a plastic water bottle, decorate it and make a bird feeder.”

S-46: “Upcycling is like invention, because I make something new from items I do not use.”

Category 2. Upcycling for reuse

Sample expressions obtained in this category are as follows;

S-27: “Upcycling is like recycling because we recycle and reuse the items we use.”

S-31: “Upcycling is like raindrops, because raindrops evaporate and fall back to the earth.”

Category 3. Upcycling in terms of utility

Sample expressions obtained in this category are as follows;

S-76: “Upcycling is like beneficial use, because we reuse the items that are useful to us.”

S-19: “Upcycling is like science because it is useful for us.”

Conclusion

Metaphors are frequently used to explain complex and similar concepts by associating them with previously learned concepts in the mind. In this study, the metaphors used by gifted primary school students when explaining the concept of upcycling are also an indicator of the impact of their previous learning and their individual perspectives on waste and how they approach the concepts. The metaphors students use enable them to express the concepts they have difficulty in explaining with concepts they already have in their minds and structure the newly learned concepts in this way (Perry & Cooper, 2001).

Metaphors are included in educational environments to reveal what students already know about subjects and concepts, to change this information if there is any previous incorrect or incomplete learning, and to structure what individuals have learned in their minds and make it permanent (Sadıkoğlu, Mumcu, & Hastürk, 2022). In this study, the results obtained from the study coincide with the findings of the study conducted by Sadıkoğlu, Mumcu and Hastürk (2022), as it changes the missing and incorrect learning about the concept of upcycling and structures new knowledge.

It was concluded that the gifted primary school students, expressed in the first sub-problem of the study, created 17 different metaphors based on the metaphors related to the concept of upcycling , and the most recurring metaphor was the design metaphor. According to this result, it can be said that the perception of gifted primary school students regarding the concept of upcycling is to design a new product. Gifted primary school students also produced a recycling metaphor regarding the concept of upcycling. It can be said that this situation arises from the fact that the concept of upcycling is considered as the concept of recycling in school and daily life. The use of metaphors such as invention and innovation by gifted primary school students draws attention in terms of awareness of invention and innovation.

The metaphors related to the concept of upcycling, expressed in the second sub-problem of the study, the gifted primary school students were grouped under 3 different categories: "Upcycling in terms of re-creation", "Upcycling in terms of re-use" and "Upcycling in terms of benefit", and the most metaphors were collected. It was concluded that the category was "Upcycling in terms of re-creation" category. According to this result, it can be said that gifted primary school students re-created the concept of upcycling and expressed it as beneficial use.

General conclusions that can be drawn from the study can be listed as follows;

- Not many metaphors were produced regarding the concept, which may be an indication that students structure concepts in similar ways in their minds.
- It has been observed that students can easily define the concept of upcycling that they have just learned, thanks to the metaphors they created in their minds by comparing it to the concept of recycling in their previous learning.
- When the metaphors produced and their justifications are examined, it is seen that the students have the basic knowledge they need to know about the concept.
- It can be said that the reason why the recycling metaphor is repeated too much is an indicator of the effect of previous learning at school and in daily life.

Recommendations

In this section, based on the results of the study, suggestions can be listed as follows to guide those who will conduct similar studies;

- Interviews can be held to examine students' mental schemas regarding the concept of upcycling in depth.
- In order for students to have a more accurate perception of the concept of upcycling, it can be suggested that students should be given training on this subject.
- In this study, the sentences and metaphors made by the students were determined. In cases where concepts cannot be expressed in sentences or in younger age groups such as pre-school and 1st grade students, studies can be planned by having students draw drawings related to the concepts and interpreting the drawings.
- This study was conducted only with gifted primary school students. Similar studies can be conducted with students at different levels. In addition. Since metaphors are linked to individuals' own lives and sociocultural environments, similar studies can be conducted with different student groups in different residential areas.

Limitations of Study

This study;

- With the 2023-2024 academic year,

- With primary school students studying at Osmangazi Science and Art Center in Onikişubat district of Kahramanmaraş province,
- It is limited to one metaphor for each student in the "Upcycling Metaphor Form".

Acknowledgment

For this research, the researcher applied for the 2024/2 period from the Turkish Scientific and Technical Research Council (TÜBİTAK) 2224/B Domestic Scientific Activities Participation Support Program. This research was presented as an oral presentation online at the International Eurasian Educational Research Congress on 21-24 May 2024.

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Journal of Gifted Education and Creativity
11(3), 99-106, September 2024
e-ISSN: 2149- 1410
jgedc.org dergipark.org.tr/jgedc

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Research Article

The mediating role of coping skills in the relationship between technology addiction and emotion regulation skills in gifted adolescents

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Article Info

Received: 1 June 2024
Accepted: 12 September 2024
Online: 30 September 2024

Keywords
Coping skills
Emotional regulation
Gifted adolescents
Technology addiction

Abstract

Gifted adolescents are individuals who can combine knowledge, skills and creativity and use them effectively in one or more of the valuable areas of human performance. The importance of examining technology addiction, emotion regulation and coping skills in adolescents is increasing. The main purpose of this study is to examine the mediating role of coping skills in the relationship between technology addiction and emotion regulation skills in gifted adolescents. In this direction, the relational screening model was applied in this study. The study group of the study is 246 adolescents between the ages of 10-18 who study at Science and Art Centers and volunteered to participate in the study. In the study, "Demographic Information Form", "Technology Addiction Scale", "Emotion Regulation Scale in Children and Adolescents" and "Coping Scale for Adolescents" were applied and data were obtained. In demographic variables, the means of two groups were compared and independent sample t-test was performed. One-way ANOVA test was used in comparisons of more than two independent groups. In the evaluation of the dependent variable by the independent variable/variables, both univariate and multivariate regression analysis were performed. Pearson correlation coefficient was calculated in the relationship analysis of the scales. As a result of the data analysis, it was determined that the level of technology addiction of adolescents was significantly high. The "negative coping" and "avoidant coping" levels of adolescents were significantly high. "Active coping" levels were significantly low. When the mediating role of coping skills in the relationship between technology addiction and emotion regulation skills in gifted adolescents was examined; according to the results obtained, it was determined that there was a negative and significant relationship between technology addiction and active coping. It was determined that there was a positive and significant relationship between technology addiction and negative coping. Coping strategy does not play a mediating role in the relationship between technology addiction and emotion regulation skills. However, in the analyses performed; it was shown that "avoidant coping strategy" played a full mediating role in the relationship between technology addiction and emotion regulation skills. When the mediating role of active coping strategies in the relationship between technology addiction and emotion regulation skills was examined; it was determined that active coping strategies did not play a mediating role. It is anticipated that the research will provide important information infrastructure for interventions regarding technology addiction, emotion regulation and coping skills of gifted adolescents.

To cite this article:
Yalcin, H., and Sur, S. (2024). The mediating role of coping skills in the relationship between technology addiction and emotion regulation skills in gifted adolescents. *Journal of Gifted Education and Creativity, 11*(3), 99-106. DOI: https://doi.org/10.5281/zenodo.13756776

Introduction

Gifted children are defined as individuals who exhibit advanced talent or potential in one or more specific areas when compared to their peers or others in the environment. Gifted individuals stand out in their ability to think, compare, and interpret (Kitsantas et al., 2017). Special talent, on the other hand, is the individual's ability to be different in their knowledge and practices and to perform a special skill specific to a field better than others (Özer, 2023). If an individual

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is naturally good at something, it can be interpreted as having a special talent (Renzulli, 1998, p. 134). Individuals with special talents generally have superior potential for success in intellectual-academic abilities, creative thinking styles, leadership potential, and artistic-psychomotor abilities (Davis & Rimm, 2004). If an individual works to be good at something, or needs to receive education, that person is thought to have a skill (Pfeiffer, 2002). Therefore, giftedness is an open, dynamic, multidimensional concept that has the capacity to create increasingly complex behaviors through self-organization and self-direction (Cresswell, 2007) should be defined

Gifted children are defined as extraordinary children due to the special skills they possess. There are studies emphasizing that being gifted occurs in a specific area, such as those who are scientifically, mathematically, and even artistically gifted (Kiewra & Rom, 2019; Stuart & Beste, 2011). Gifted individuals tend to use technological tools frequently to access fast and accurate information (Mudrak & Zabrodska, 2015). The use of technology and computers is a frequently used method in the education of gifted and talented individuals (Moqbel & Kock, 2018). Since gifted and talented children have special needs that require the integration of different types of technology into their curricula, the use of technology and computers in the education of gifted and talented individuals is recommended (Kurnaz & Tepe, 2019). Technological applications appeal to many characteristics of gifted and talented children, such as rapid information processing, complexity and depth capacity, and inductive learning (Clark, 2015). In a study examining the attitudes of gifted and talented high school students towards technology, it was explained that many of them use technology throughout their learning process (Hökelekli and Gündüz, 2004). Studies on technology addiction should be defined show that addiction is rapidly spreading (Karabulut-Coşkun and Akar, 2022; Khan, 2019; Turkey Digital Report, 2023). It is important to examine the technology use of gifted and talented children because they can quickly learn how to use technology and use it in their studies and projects.

Gifted and talented individuals need to use emotion regulation skills to control technology addiction. Emotion regulation is defined as the ability to exert control over one's own emotional state (McMahon & Naragon-Gainey, 2019). Hill and Updegraff (2012) state that emotion regulation involves not only regulating negative emotions but also regulating positive emotions. Rey and other researchers (2020) state that emotion regulation is the neural, cognitive, and behavioral processes that maintain, strengthen, or weaken emotional arousal and behavioral tendencies. Therefore, the intensity and duration of emotional reactions are important in emotion regulation. Emotions can be sustained, adjusted, or changed (Özbay et al., 2012). Emotional intensity is higher in gifted and talented children than in their peers (Eren et al., 2018). Gifted children with higher emotional intensity need to develop coping skills for emotion management (Hughes et al., 2020). It is important to investigate how gifted individuals manage their emotions and cope with problems in situations such as technology addiction. Coping skills are behaviors aimed at maintaining internal integrity at the highest level in stressful situations encountered in life, calming the individual down, and continuing their daily life at an optimal level (Parker & Endler, 1992). Using certain coping attitudes to minimize the negative effects of stressful events or factors is a universal behavior (Falsetti & Resnick, 1997). In addition, coping is related to the ability to eliminate the damage caused by stress and to use stress as a tool for development (Özbay et al., 2012). Therefore, it is important to reveal the factors that affect coping skills in gifted individuals. In this context, this study aims to shed more detail on the complex relationship between emotion regulation skills and technology addiction of gifted adolescents and to reveal the effect of coping skills. This analysis has the potential to understand the effects of technology use on the emotional development of gifted individuals and to fill the gaps in knowledge in this area. In this context, the findings of the study may help us better understand the interactions of gifted children with technology and develop special education strategies for this group. This study aimed to determine the mediating role of coping skills in the relationship between technology addiction and emotion regulation skills in gifted adolescents.

Method

Research model

The relational screening model was applied in this study. Relationships between concepts are investigated through relational analysis applied in quantitative research. Relationships between concepts determined in line with the main purpose are the situation that helps the researcher answer the research questions (Akarsu and Akarsu, 2019).

Study group

The sample of this study consists of 246 participants between the ages of 10 and 18. Adolescents between the ages of 10-18 who are studying at Science and Art Centers (SAC) in Konya province and who volunteered to take part in the research were included in the study. The criteria for inclusion in the study were determined as being between the ages of 10-18; studying at BİLSEM; and volunteering to participate in the research. The sample of this study consists of 246 participants, 122 (% 49.6) female and 124 (% 50.4) male. 35 (% 14.2) of the participants were an only child; 147 (% 59.8) were the first child. 130 (% 52.8) of the participants' mothers were 40 years old or younger and 63 (% 25.6) of the mothers were high school graduates. 66 (% 26.8) of the fathers were 40 years old or younger; 197 of the fathers (% 80.1) have a university degree or higher.

Data collection tools

This study was conducted to examine the mediating role of coping skills in the relationship between technology addiction and emotion regulation skills in gifted children and data were obtained by applying the "Demographic Information Form", "Technology Addiction Scale", "Emotion Regulation Scale in Children and Adolescents" and "Coping Scale for Adolescents".

Technology Addiction Scale

A validity and reliability analysis of the scale in Turkish was conducted by Aydın (2017) and the scale consists of 24 items and 4 dimensions. The scale has four sub-dimensions: "using social networks" (6 items), "instant messaging" (6 items), "playing online games" (6 items), and "using websites" (6 items). The highest score that can be obtained for the entire scale is 120 and the lowest score is 24.

Scale for Emotion Regulation in Children and Adolescents

The scale was adapted to Turkish by Tetik (2019). In the development of the scale, the scale was applied to 1048 adolescents between the ages of 10-18. The scale's language validity was performed, and then Confirmatory Factor Analysis was performed to measure its structural validity. The scale has sub-dimensions of "reappraisal" (items 1, 3, 5, 7, 8, 10) and "suppression" (items 2, 4, 6, 9). There is no reverse-scored item in the scale. A 5-point Likert-type assessment is applied. There are 10 items in total in the scale. It is understood that the use of emotion regulation strategy increases as the scores obtained in the scale increase (Tetik, 2019).

Coping Scale for Adolescents

The scale was adapted to Turkish by Bedel, Işık, and Hamarta (2014). The study was conducted on 453 adolescents. The scale consists of 15 items. The scale has "active coping", "avoidant coping" and "negative coping" sub-dimensions. The scale is a 4-point Likert type. A minimum of 3 and a maximum of 33 points can be obtained from the scale.

Data analysis

SPSS program was used in the analysis of the data. In the evaluation of demographic characteristics and scale scores, descriptive statistics such as frequency, percentage, arithmetic mean, standard deviation, minimum, maximum, normality distribution analysis were performed. Independent sample t-test was applied in the comparison of the means of two groups in demographic variables. One-way ANOVA test result was used in the comparison of more than two independent groups. Pearson correlation coefficient was calculated in the relationship analysis of the scales. All statistical analysis test results were evaluated at the 0.05 significance level.

Results

In this study conducted to examine the mediating role of coping skills in the relationship between technology addiction and emotion regulation skills in gifted adolescents; the lowest-highest values, mean-standard deviation values and skewness-kurtosis values were examined in the variables. The findings are presented in Table 1.

Table 1. The lowest-highest values, mean-standard deviation values and skewness-kurtosis values of the research variables

Variables	n	Lowest	Highest	Mean	S	Skewness	Kurtosis
Technology Addiction	244	21	112	50.65	17.73	.71	.15
Social Networking	243	6	30	13.72	5.19	.61	-.13
Instant Messaging	244	6	30	12.16	4.97	.81	.28
Online Gaming	243	6	30	13.00	5.61	.70	-.29
Website Usage	244	6	30	11.87	5.59	.81	.83
Emotion Regulation	246	10	50	31.70	7.00	-.39	.46
Suppression	246	4	20	11.59	3.58	.15	-.06
Reappraisal	246	6	30	20.11	5.18	-.32	.00
Negative Coping	246	0	9	2.57	1.62	.66	.81
Active Coping	246	0	12	6.80	2.48	-.38	.35
Avoidant Coping	246	0	12	5.98	2.23	.29	.68

According to Table 1; technology addiction average was calculated as 50.65±17.73, social network usage average was 13.72±5.19, instant messaging average was 12.16±4.97, online gaming average was 13.00±5.61, and website usage average was 11.87±5.59. These results show that the data meets the normality assumption.

In the study group; it was determined that variables such as gender, mother and father education status, mother and father employment status, family type, family economic status and number of siblings were not affected by the factors of "technology addiction, emotion regulation" and "coping skills".

In order to compare the participants' technology addiction, emotion regulation and coping levels according to age group, a t-test was conducted for independent groups. The findings are presented in Table 2.

Table 2. Comparison of technology addiction, emotion regulation and coping levels according to age group

Variables	Age	n	Mean	S	Lower	Upper	*t*	*p*
Technology Addiction	10-12 years	89	45.27	14.60	-12.99	-3.94	-3.682	.000*
	13-18 years	155	53.74	18.65				
Emotional Regulation	10-12 years	91	30.63	7.23	-3.51	.12	-1.843	.067
	13-18 years	155	32.32	6.81				
Negative Coping	10-12 years	91	2.05	1.46	-1.23	-.41	-3.920	.000*
	13-18 years	155	2.87	1.64				
Active Coping	10-12 years	91	7.41	2.49	.32	1.59	2.964	.003*
	13-18 years	155	6.45	2.41				
Avoidant Coping	10-12 years	91	5.57	1.83	-1.22	-.07	-2.196	.029*
	13-18 years	155	6.21	2.41				

According to Table 2; the technology addiction level of gifted adolescents is significantly high ($t_{(242)} = -3.682$, $p<.001$). In addition, the negative coping and avoidant coping levels of gifted adolescents are significantly high ($t_{(242)} = -3.920$, $p<.001$; $t_{(242)} = -2.196$, $p<.05$, respectively). On the contrary, their active coping levels are significantly lower ($t_{(242)} = 2.964$, $p<.01$).

In line with the main purpose of this study, the mediating role of coping skills in the relationship between technology addiction and emotion regulation skills in gifted children and adolescents was examined from here on. The criteria of Baron and Kenny (1986) were taken into consideration as the basic starting point in the mediating variable analysis. According to Baron and Kenny (1986), in order for a variable to be a mediating variable, the following 4 criteria must be met. These are; (1). The relationship between the predictor and the predicted variables should be significant, (2). The relationship between the mediator and the predictor variable should be significant, (3). There should be a significant relationship between the mediator and the predicted variable, (4). When the mediator and the predictor variable are entered into the regression analysis simultaneously, the previously significant relationship between the predictor and the predicted variable should cease to be significant or the previous significance level should decrease (Baron & Kenny, 1986). For this reason, Pearson correlation analysis was conducted to examine the relationships between all variables. According to the results obtained, it was determined that there was a negative and significant relationship between technology addiction and active coping (r = -.144, p < .05). On the contrary, there was a positive and significant relationship between technology addiction and negative coping and avoidant coping (r = -.475, p < .001; r = .375, p < .001, respectively). There is also a positive and significant relationship between technology addiction and emotion regulation (r = .290, p < .001). The findings are presented in Table 3.

Table 3. Relationships between technology addiction, emotion regulation and coping levels

Variables		TA	ER	AcC	NC	AvC
Technology Addiction	*r*	1				
	p	-				
Emotional Regulation	*r*	,290***	1			
	p	,000	-			
Active Coping	*r*	-,144*	,192**	1		
	p	,024	,002	-		
Negative Coping	*r*	,475***	,219**	-,235**	1	
	p	,000	,001	,000	-	
Avoidant Coping	*r*	,375***	,558****	,050	,368***	1
	p	,000	,000	,434	,000	-

TA: Technology Addiction **ER**: Emotional Regulation **AcC**: Active Coping **NC**: Negative Coping **AvC**: Avoidant Coping

These results show that the three criteria listed above by Baron and Kenny (1986) are met; negative coping strategies and active coping strategies do not play a mediating role.

Discussion, Conclusion and Recommendations

In this study, it was shown that the level of technology addiction of adolescents is significantly high. The participants' technology addiction, emotion regulation and coping levels were compared according to gender, number of children in the family, birth order, age of mother and father, education level of mother and father, income status of the family, presence of a special needs individual in the family or a sick/elderly individual cared for by the parent, and the results obtained did not show a significant difference between the groups in terms of the mean of any variable.

When the mediating role of coping skills in the relationship between technology addiction and emotion regulation skills in gifted adolescents was examined, the results obtained showed that there is a negative and significant relationship between technology addiction and active coping. On the contrary, there is a positive and significant relationship between technology addiction and negative coping and avoidant coping. There is also a positive and significant relationship between technology addiction and emotion regulation.

The use of technological devices is an indispensable element of adolescents' lives. Internet use is common in gifted children (Arslankoç et al., 2023). Access to information on the Internet is fast, but it also carries risks for adolescents. It is thought that the steps to be taken to prevent and intervene in these risks are important.

A study examined the effect of internet and computer game addiction of gifted children on school social behavior. As a result of the research, it was determined that boys' internet use and computer game playing time were more than girls. Internet and computer use increases with age. Yavuz (2018) examined the levels of internet and game addiction and perceived social support in gifted adolescents. In this study, it was determined that internet addiction did not differ according to gender, and it was emphasized that game addiction was high in boys. Internet and game addiction levels differ according to age. Technology addiction is high in adolescents aged 12-17. Ayhan-Bostancı (2020) examined the relationship between computer addiction and social skill levels of gifted children. According to the results of this study;

computer, internet and computer game addiction did not change according to gender. Factors in the internet environment such as computer games, especially online games, and chat rooms attract more attention from boys.

Gifted adolescents have higher emotional sensitivity (Ackerman, 1997) and are more likely to experience social exclusion (Jost, 2006) than their typically developing peers. Peer relationships can be useful in regulating the intense emotional sensitivity of gifted adolescents. However, technology addiction can cause them to experience limitations in peer relationships. As a result, they may be more dependent on the internet for emotional regulation than their normal peers.

When the mediating role of coping strategies in the relationship between technology addiction and emotion regulation skills was examined, it was determined that technology addiction had a positive and significant difference in emotion regulation skills. This result showed that the avoidant coping strategy played a full mediating role. In this study, the regression analyses on technology addiction and emotion regulation explained this positively and significantly.

In the study conducted by Braunstein, Gross, and Ochsner (2017), it was reported that depression and technology addiction were present in adolescents with emotion regulation problems. Gavriel-Fried and Ronen (2016) stated that there was a relationship between self-control and social support in adolescents with risky behaviors. According to this study, the probability of technology addiction is high in adolescents with emotion regulation problems. Ivcevic and Brackett (2014) compared school success and emotion regulation skills. They stated that emotion regulation problems were higher in adolescents with technology addiction.

In our study, the technology addiction average was calculated as 50.65±17.73, the social network usage average was 13.72±5.19, the instant messaging average was 12.16±4.97, the online game playing average was 13.00±5.61, and the website usage average was 11.87±5.59. In addition, the emotion regulation average was 31.70±7.00, the suppression average was 11.59±3.58, and the reappraisal average was 20.11±5.18. Roberts and other researchers (2014) reported that as the duration and frequency of technological device use increased in gifted and talented adolescents, technology addiction increased. Technology addiction creates deprivation, difficulty in control, functional disorder, and social isolation. In our study, it was determined that there was a negative relationship between technology addiction and coping. On the contrary, a positive and significant relationship was found between technology addiction and negative coping. When the literature is examined, it is seen that it is important to address stress and coping issues during adolescence for healthy development (Khan, 2019; Kurnaz and Tepe, 2019; Zammuner, 2019). Adolescence is a complex period in which adaptation is made to internal and external environmental challenges. Therefore, how adolescents cope with such changes and challenges is of great importance. According to the results of the study; It is thought that comparative studies can be conducted between adolescents who go to the Science and Art Center and students who do not; cognitive behavioral-based group guidance programs can be organized to prevent technology addiction in gifted adolescents and experimental studies can be conducted on their effectiveness. The research was conducted with adolescents who attend BİLSEM. Similar studies can be conducted with primary school students who attend SAC. Most technological devices are used with the internet. It can be preferred to have only one computer connected to the internet at home for a certain order and controlled use of the internet. In this way, the gifted adolescent will not be able to access the internet during the hours when other family members will be online and will be able to learn to postpone this desire. Instructors working in schools and SACs can meet with adolescents who have technology addiction and low coping and emotion regulation skills and provide one-on-one and group guidance. Seminars can be organized for the families of these students to explain how gifted children can be taught anger coping and emotion regulation skills in a healthy family environment. Since emotion management can determine the choice of coping style that affects technology addiction levels, it is important to develop awareness in gifted adolescents on these issues.

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Journal of Gifted Education and Creativity
11(3), 107-123, September 2024
e-ISSN: 2149- 1410
jgedc.org dergipark.org.tr/jgedc

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Research Article

A gifted and talented middle school material science investigation: utilizing engineering practices to develop sustainable and benign particleboard

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Article Info

Received: 1 June 2024
Accepted: 12 September 2024
Online: 30 September 2024

Keywords
Engineering investigation
Gifted and talented
Material science
Middle school
STEM

Abstract

Gifted learners are often intellectually curious and require meaningful learning opportunities. This engineering investigtion fosters curiosity while also generating useable knowledge that connects to global issues through a STEM lens. This engineering exercise presents a valuable experience for gifted learners because it not only fosters creativity and is environmentally relevant, but it also compels students to develop and practice academic competencies. This investigation is designed to harness most gifted learners' strong sense of empathy and heightened sense of justice to spawn useable knowledge that can help inform decisions and actions today and in the future. Specifically, the investigation will have gifted students determine if cellulose nanofibrils (CNF) are suitable as a non-toxic, environmentally benign adhesive for the construction of particleboard. Students become heavily invested in the project when they know they are working towards a more sustainable and safe product. In this study, the case study method was used. The project work conducted with middle school gifted students was handled as a case study, focusing on the process and outcomes. Students are able to meet many of the Next Generation of Science Standards (NGSS) enginerring performace expectations, complete aspects of all of the science and engineering practices, explore several engineering disciplinary core ideas, and consider several crosscutting concepts. This project can be fine-tuned to best meet the needs of any gifted student. This investigative approach incorporates science and engineering practices and encourages students to combine their previous and new science content knowledge with procedural knowledge in relevant ways. Gifted students gain valuable STEM experiences and use novel science equipment to solve a real world problem. This activity exercises students' executive functions for problem solving, organizing, and develops skills including the ability to interpret data and draw pertinent conclusions. The next step in this research is to use pre and post student surveys to quantitatively show the impact of this engineering investigation on improving science and engineering practices, attitudes, content knowledge, and to see how it may influence authentic STEM research projects.

To cite this article:
Vassiliev, T., Gardner, D.J., and Neivandt, D. (2024). A gifted and talented middle school material science investigation: utilizing engineering practices to develop sustainable and benign particleboard. *Journal of Gifted Education and Creativity, 11*(3), 107-123. DOI: https://doi.org/10.5281/zenodo.13756806

Introduction

As a middle school grade level and gifted and talented science teacher, the lead author, Vassiliev, is fortunate to spend her summers as a United States Department of Energy RET (research experience for teachers) with the Hub & Spoke SM^{2}ART (Sustainable Materials & Manufacturing Alliance) research collaborative between the Advanced Structures and Composites Center at the University of Maine and the Department of Energy's Oak Ridge National Laboratory Alliance for Renewable Technologies. This RET opportunity allows her to be surrounded by passionate real world problem solvers who want to share their research in the hopes of igniting similar passions in middle school students.

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When teachers are provided the opportunity to spend significant time focusing on authentic scientific studies, they can develop a much more sophisticated understanding of the nature of science and better appreciate teaching through inquiry and not just approach it as a body of knowledge (Vassiliev, et al., 2020). According to Crawford (2012), when *"teachers are given opportunity to participate in authentic science, they demonstrate greater confidence in enacting inquiry-based instruction in their classrooms; their enthusiasm, in turn, increases, and we see evidence of motivated and engaged students in their classrooms (p. 38)"* Authentic science research provides teachers the background they need to better connect research experiences to the Next Generation of Science Standards' disciplinary core science and engineering practices (NGSS, 2013) while students are immersed in topical science and engineering practices.

Kaplan (2022) found that inquiry and the ability to think independently were the most important learning-to-learn skills (p. 6-7). According to Vassiliev et al., (2020) "*If science is taught without inquiry, you cannot reasonably expect students to ask profound and thoughtful questions, form inspiring and deliberate hypotheses, conduct methodical experiments, decide which measurements to collect, and make connections and construct meaning in the world (p. 9).*" If we amplify the ideas of STEM related inquiry projects we start to modify the nomenclature of inquiry to science and engineering practices. The description of practices encompass more than the word inquiry. When students are engaged in science and engineering practices *"they use the discourse of science and they work with scientific representations and tools. In this way, conceptual understanding of natural systems is linked to the ability to develop or evaluate knowledge claims, carry out empirical investigations and develop explanations (Michaels, et al., 2008, p. 34)."*

Gifted and talented students and/or first-time science fair participants require a tangible reason that resonates with them before they would consider choosing to invest their time in an esoteric undertaking. Superficially, material science research might not appear to be much of a hook to gain the attention of young students. However, if students are exposed to how sustainable materials have the ability to save energy, reduce waste, and improve safety then the idea of making a difference or creating change becomes the motivator that can ignite the middle school students' imagination. These points make such a project "*proactively responsive to the learner and his or her world (Tomlinson et al., 2009, p. 2),*" an important component of effective science curriculum. In addition, problem-solving opportunities are an essential component of learning for gifted students: they require a more sophisticated curriculum and they must be continuously challenged (Gavin et al., 2007; Graffam, 2006). By investigating real-world projects with tangible and positive outcomes, students can be engaged in science and engineering practices while also developing their own sense of altruism (Chase, 2015).

Importance of Study

According to Amini et al., (2017) "*particleboard is a wood composite panel typically manufactured from discrete wood particles combined with a resin or binder under heat and pressure. The resins used in particleboards are mostly made up of formaldehyde-based adhesives (p. 4093).*" Human concerns for the off gassing of formaldehyde are well documented (Frihart, *et al.* 2021). Off gassing is the process of when harmful chemicals from furnishings and finishes are emitted into the air over time (Gray, 2020). Some of the detrimental affects of formaldehyde exposure are breathing problems or irritation of the eyes, nose, throat, or skin. Long-term formaldehyde exposure can also cause cancer (*Formaldehyde and Your Health | ATSDR*, 2018). This real world problem is the catalyst to hook gifted students into investing their time and cognitive abilities into providing a possible remedy to this engineering design challenge.

This article presents a middle school scientific and engineering investigation that was developed to challenge students' problem solving skills and get them to produce scientifically sound results while using sophisticated but simple tools in the laboratory. The investigation employs the critical issue of the need for safe particleboard binders as a motivating factor. Critically, the investigation was designed to encompasses several Next Generation of Science Standards (NGSS) engineering performance expectations (Table 1).

Table 1. The connection between the instructional design and NGSS engineering performance expectations[4]

NGSS Engineering, Technology and the Application of Science
MS-ETS1-1 Define the criteria and constraints of a design problem with sufficient precision. This particleboard project requires students to construct different concentrations of nanocellulose (CNF) and sawdust composite panels and test their strength of each.
MS-ETS1-2 Evaluate competing design solutions using a systematic process. Students are asked to compare the strength of different CNF and sawdust concentrations of panel composites.
MS-ETS1-3 Analyze data from tests to determine similarities and differences. Students will average the trials in each treatment to see if there is a significant difference between all of the treatments.
MS-ETS1-4 Develop a model to generate data for iterative testing. Students will construct and experiment with CNF and sawdust panels to model particleboard strength. Each treatment (different concentrations of CNF to sawdust) will have three trials. The class will pool and compare their data to see which concentration is the strongest.

Purpose of Study

Following Gagné's (2004) Differentiated Model of Giftedness and Talent (DMGT), this engineering investigation is designed to utilize gifted middle school students' natural cognitive abilities (intellectual, creative, social, and perceptual) to better develop their academic, technical, and engineering competencies. This investigation engages and strengthens students' logical, mathematical, critical thinking and organization abilities while simultaneously tapping into students' innovativeness and assisting in the development of usable knowledge. This is not a static inquiry but instead grows and evolves as more data is collected and shared. This type of dynamic challenge incorporates many STEM principles and promotes collaboration, transparency, and environmental ideals as students propose possible sustainable composite solutions. This engineering investigation is a vehicle for middle school gifted students to cultivate their talents.

Method

In this study, the **case study** method was used. The project work conducted with middle school gifted students was handled as a case study, focusing on the process and outcomes. Throughout the project, students developed solutions for real-world problems, and the set objectives were achieved. The study aims to document the students' participation in the project and the resulting outcomes (Yin, 2014).

Results

In this section, the processes related to the project will be presented in detail. This detailed presentation outlines the framework of the model for the instructional application.

Implementation of Project Process

In this investigation students are asked to manufacture strong particleboard panels using sawdust and cellulose nanofibrils (CNF), the latter of which acts as a natural adhesive. CNF is derived from trees and is generated by subjecting wood pulp to high shear, thereby breaking down the cellulose fibers into fibrils with nanoscale dimensions (between 1-100 nm in diameter). CNF also has a high aspect ratio (the length of the fibrils are much larger than the width). Due to its nanoscale dimensions, CNF has unique physical properties. For example, nanocellulose-based materials have high strength and low weight, and a great capacity for hydrogen bonding (Liang et al., 2022). As such CNF has great potential as a unique, renewable, and biodegradable advanced material.

Students will be able to determine if an aqueous slurry of CNF is suitable as a non-toxic, environmentally benign adhesive for the construction of particleboard. Sawdust and a 3wt% aqueous slurry of CNF (3% dry CNF by weight to 97% water) make-up the particleboard panels in this investigation. The wet composite material is placed in a mold and then the water is squeezed out to form a dewatered panel. Each panel is then dried before testing. The panel can be air-dried, placed in a food dehydrator, or oven dried at about 95°C. It is proposed that upon drying, the hydrogen bonding between the CNF and the larger wood particles of sawdust will produce solidified particleboard without the use of

[4] The NGSS (Next Generation of Science Standards) engineering standards, science and engineering practices, the disciplinary core ideas, and crosscutting concepts the particleboard research covers for grade 6-8 and an explanation of how students can meet the standards during this investigation.

synthetic polymers derived from petroleum resources (Gardner & Tajvidi, 2016). In practice, students will test different ratios of CNF to sawdust to determine which ratio creates the strongest particleboard panel.

The materials needed for the research activity are bowls (1 per group), digital scales (1 per group), rulers (1 per group), an A-frame hydraulic bench press (1 per class), baking sheets (9"x 12") (1 per group), rubber spatulas (1 per group), panel molds which include wooden and a metal arbor plates (1 per group), graduated cylinders (1 per group), 3wt% CNF (University of Maine Process Development Center ~$75/2 gal), sawdust, masses/sand, 1 gallon buckets (1 per group) and safety goggles (1 per student), access to Google Suite (1 per student).

Personal protective equipment is nominal, but students should wear eye protection. It is noted that the sawdust used should not be sourced from pressure treated lumber. A link to the CNF safety data sheet may be found in resources. It is noted that CNF is relatively safe.

The particleboard research outlined in the present paper entailed making composite panels with different percentages of CNF relative to sawdust, and then testing the panels' strength. Wooden molds were created to assist with forming and pressing the water out of the panels, see Figure 1. Both a wooden and a metal arbor plate were employed to help evenly distribute the applied pressure.

A person with basic woodworking skills and equipment may construct the molds. The blueprints to the molds can be found in the resource section of this paper. Use of these molds resulted in panel dimensions of 21 cm long by 6.4 cm wide and 0.5 cm thick. A relatively inexpensive 6-ton A-frame hydraulic bench press was used to apply pressure to the arbor plates and hence dewater the panels (Figure 2).

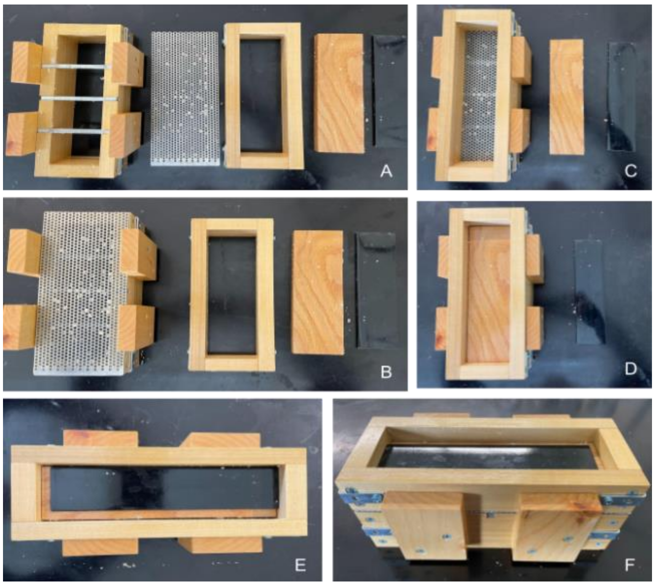

Figure 1. Particleboard Panel Mold

The molds used to make the particleboard panels were a heavy-duty wooden base with reinforcement bars, steel mesh screens, removable frame, a solid top, and both a wooden and a metal arbor plate. Detailed notes and drawings created by the Advanced Manufacturing Center at the University of Maine can be found at the following link (URL 1).

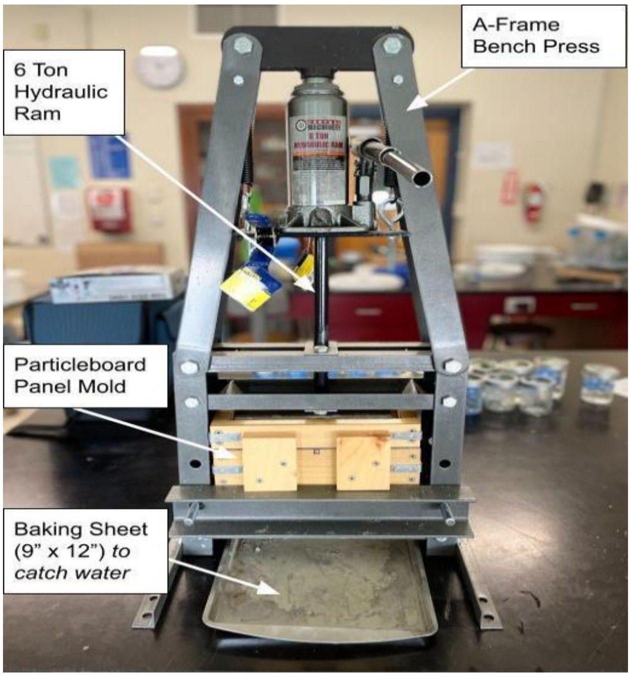

Figure 2. The 6-ton a-frame bench shop press from central machinery (model number 63995).

Once each panel is pressed and dried, the strength is determined by applying a force to the center via a bucket containing masses (for more precision, sand can be used), which is progressively increased until panel failure.

To help students calculate the relative amounts of sawdust and 3wt.% CNF slurry to mix for a given panel, instructions for a spreadsheet calculator (Appendix 1) are provided which enables production of panels of consistent dry mass (33.6 g). The spreadsheet ensures that each panel contains a precise and known ratio of dry CNF to sawdust. See Table 2 for an example.

Table 2 presents a sample calculation from the spreadsheet calculator for the production of 14 wt% CNF to sawdust ratio panel. It is assumed that the mold employed is dimensionally the same as those employed in the present work and has a volume of 67.20 cm^3 (21 cm x 6.4 cm x 0.5 cm). Column (A) is the approximate mass of a dried panel (g). Column (B) enables entery of the desired percentage of CNF per panel. Column (C) is the calculated amount of dry CNF in each panel, which is calculated by multiplying the approximate mass of panel (g) by the percentage of overall CNF per panel (14% in this example). Column (D) is the weight percent solids of the standard starting CNF slurry (3% is typical). Column (E) is the mass of sawdust to be added for each panel and is calculated by subtracting the target mass from the total dry CNF in the panel (column C). Column (F) is the amount of 3 wt.% CNF slurry to be used by mass, which is calculated as the quotient of total dry CNF (column C) and the weight percent of the CNF slurry employed (14%). Finally, Column (G) is the total mass of material needed to make the panel.

Table 2. Calculating the amounts of wet CNF and dry sawdust to use for the determined percent of dry CNF per panel

A	B	C	D	E	F	G
Approx. mass of dried panel (g) (standard)	Enter: the % of overall CNF desired per panel	The total amount of dry CNF in panel (approx. mass (g) * CNF content (%))	Starting % of CNF (standard)	The amount of sawdust (grams)	The amount of wet CNF to add (total dry CNF / starting % of CNF)	Total mass (g) of material needed
Target mass (g)	CNF content (%) ENTER Desired % Below	Dry CNF (g) in Film	CNF (%)	Sawdust furnish (g)	Wet CNF (g)	Total mass (g)
33.6	14	4.70	3	28.90	156.80	185.70

Class Introduction

As a classroom investigation, the research will likely require a one-week time period for classes that meet each weekday for at least 40 minutes. On the first day teachers may present background information, which could include a 10-minute video by Going Green (2021) called "10-Eco-Friendly Building Materials: Sustainable Design." The class might also watch another 8 minute TEDX Video about CNF called Nanocellulose: It's A Wrap (2017). Teachers should sShare the focus of this investigationresearch project where students will be making composites of sawdust and CNF to build the strongest particleboard panel possible without using petroleum derived adhesive.

The teacher may Sshare or have students create a data collection spreadsheet (Table 3). The data to collect inof Table 3 aligns with the wooden molds used to make panels that are 21 cm long x 6.4 cm across x 0.5 cm thick and a volume of 67.2 cm^3. The column for density contains a formula that calculates the density once the dry panel mass has been entered. Density is a physical property that many middle school students struggle to fully understand. According to the research done by Gotzer et al., (2005) students tend to hold several misconceptions on the concept of density and find it arduous to reconcile their instinctive understanding and the formal characteristics of density. So by including density in the data table it becomes an applicable physical property that requires students to focus on the relationship between mass and volume, which the concept of density requires.

Table 3. Sample Group Spreadsheet

sample group data spreadsheet for _________% cnf to sawdust						
Panel	**Panel Volume** =(21cm L * 6.4 cm W * 0.5 cm H)	**Water released** (mL)	**Panel-Wet Mass** (g)	**Panel-Dry Mass** (g)	**Dry Density** (g/cm3)	**Max Mass held** (g)
1	67.2				0	
2	67.2				0	
3	67.2				0	

Table 3 is an example of the student spreadsheet, which each group can use when collecting data. The water released and the mass of the wet panels can be used to help evaluate the panels and justify abnormal results. The mass of the dry panels and density can be compared to the original table to make sure the panels are close to the predicted specifications. The maximum mass average is the responding variable results students will pool and graph. The formula to find the average data for column 7 row 6 is "=AVE(G3:G5)".

Making Panels

On the second and third days of the investigation the students should make the sawdust/CNF panels. The time needed to press the panels will depend on the number of A-frame hydraulic bench presses available in the laboratory. The authors have one bench press and assuming each group has a particleboard panel mold, the pressing of 15 panels (three panels per 6 groups) requires approximately 80 minutes.

Students should add their specified amounts of 3 wt.% CNF slurry and sawdust by mass (g) (information gathered from Table 2) into a bowl and mix well. Once completely mixed the students should transfer the composite mixture to the panel mold and spread evenly. The wooden arbor plate followed by the metal arbor plate should be placed on the top of the composite mixture and compressed with the A-Frame hydraulic bench press. A small cooking sheet should be placed under the press to collect the liberated water once the panel mixture is compressed. (Table 3 and Figure 2). The compression lever of the hydraulic lift should be actuated until it no longer moves. A rubber spatula may be used to ensure as much of the water is collected onto the cooking sheet as possible. Water from the cooking sheet should be measured with a graduated cylinder and volume recorded in the appropriate section on the student spreadsheet (Table

3). When the pressing of each panel is completed, the panel should be carefully removed from the mold, and labeled with the panel number and percentage of CNF (e.g., with a permanent marker). The panel should then be carefully moved to a digital scale to measure its wet weight before being taken to a drying station. The panels should be weighed a couple times hours before testing to make sure drying is complete, as evidenced by a plateaued mass. Drying typically is completed in a 24 - 48-hour time period (depending on the temperature and humidity). If a food dehydrator or ovens are available they may be used to speed the drying process.

Testing the Panels

On the fourth day students should record the mass of each of their dried panels (Table 3) and calculate the density of each to ensure that they are between 0.2 - 0.5 g/cm3. The load bearing capabilities of each panel can subsequently be determined. The load bearing procedure requires the following equipment: 1-gallon buckets, rulers, and masses or for more precision, sand. Students should employ a similar procedure to that presented in the September 2013 Science Scope article “Innovative Composite Research Modeled in the Middle School Classroom” by Vassiliev, Bernhardt, & Neivandt (p. 42 – 52). Two desks or chairs of the same height should be set approximately 15 cm apart from each other and one of the composite panels placed across the gap with approximately 2 cm of each end of the panel resting on the desk/chair. The mass of a 1-gallon bucket should then be measured before it is hung from the center of the panel to be tested. Once it is evident that the panel is capable of bearing the weight of the bucket, students should start progressively placing additional weight within the bucket. It is important to wait at least 30 seconds and listen for cracking before each sequential addition of weight. Should cracking sounds be noted, students should wait until the panel settles before the addition of further weight. Care should be exercised at all times to avoid the bucket falling to the floor when the panel fails, indeed a student should be in place to catch the bucket should this eventuate. When the panel cracks or breaks, students should record the mass of the bucket and contents. The broken panels may be disposed of in a garbage can. Table 4 is representative data collected by Grade 8 Science Fair students from Doherty Middle School, Bangor, Maine, for panels containing 14 to 20 wt.% CNF.

Table 4. Individual panel data along with average mass held for each weight percentage CNF vs. sawdust

Representative Student Science Fair Data							
% CNF	**Panels**	**Water released (mL)**	**Panel Wet Mass (g)**	**Dry Mass (g)**	**Density (g/cm^3)**	**Max Mass Held (g)**	**AVERAGE Max (g)**
14%	**Panel 1A**	52	103	31.8	0.318	389	
	Panel 2A	70	104.3	32.6	0.326	395.77	
	Panel 3A	69	108	32.87	0.3287	389	
	Panel 4A	65	113	33.35	0.3335	389	390.69
16%	**Panel 1B**	78	115	34.67	0.3467	1054	
	Panel 2B	69	129	34.69	0.3469	1573	
	Panel 3B	90	110	34.76	0.3476	1053	
	Panel 4B	91	97	34.83	0.3483	389	1017.25
18%	**Panel 1C**	97	107.26	36.5	0.365	1774.7	
	Panel 2C	94	117	34.5	0.345	1079	
	Panel 3C	100	116	34.55	0.3455	649	
	Panel 4C	97	109.6	37.1	0.371	1949	1362.92
20%	**Panel 1D**	109	119	34.4	0.344	3048	
	Panel 2D	106	115	34.67	0.3467	2249	
	Panel 3D	128	112.2	37.57	0.3757	3056	
	Panel 4D	108	124	25.23	0.2523	3554.13	2976.78

Pooling Class Data

On the fifth day, the instructor should create and share a pooled classroom data spreadsheet in Google Drive, which is accessible to all students in the class (See Table 5). The average maximum mass held by each group's panel should be entered into the spreadsheet, thereby collecting data for the mass held at each sawdust/CNF ratio. The class may then create a bar graph of all the treatments (weight percentage of CNF to sawdust as the manipulated variable and the average maximum mass held (g) as the responding variable). Figure 3 is a representative graph created by 8th grade science fair and engineering fair participants. Standard error lines may be added to the bar chart if desired (described in Figure 3).

Table 5. Pooled Classroom Data

Template for Pooled Particleboard Classroom Results	
% CNF	Average Max Mass Held (g)
14%	
15%	
16%	
17%	
18%	
19%	

Spreadsheet of pooled average maximum mass held each group's three panels. These data may then be graphed as a bar chart with standard error bars, see Figure 3. To include the standard errors on the bar chart your click on edit chart, select customize, go to series and select standard errors.

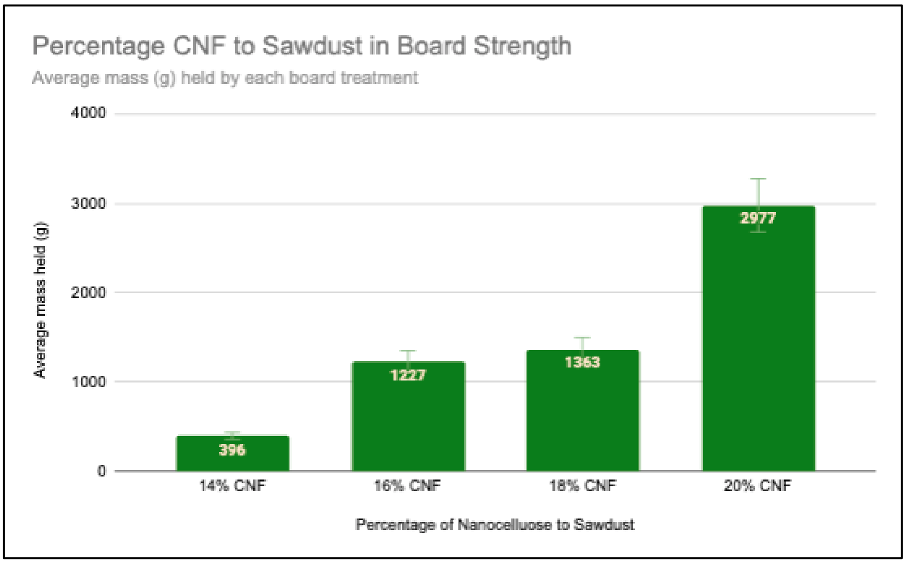

Figure 3. Representation of percentage CNF to sawdust in board strength

Investigation of Figure 3 revels that the panel comprising 20wt% CNF held the most mass.

Communicating Results

At this point in the investigation students may be asked to collaborate within their groups to generate a digital (Google Slides or Canva) or physical (poster paper or trifold) quad chart (Table 6) outlining and communicating their findings. A quad chart is a simplified poster presentation that divides the investigation into four concise sections (Vassiliev et al., 2024). The first section is where students introduce and summarize their rational for using certain ratios of CNF to sawdust. The next section is for the procedure. Then the results are displayed and finally the last section is for each group to reflect upon the experiment and articulate any weaknesses or suggest means to improve and extend the research process. Each student group will copy the graphed results into their own quad chart but approach the procedure and conclusion from the perspective of their chosen panel ratio (CNF/sawdust). A Google Slide (Google Suites) version of the Quad Chart Template and Scoring Guide can be found in Appendix 2. Each research group will present their own quad chart from their research perspective.

It is noted that the use of a shared data allows instructors to perform timely formative assessment feedback of group work and progress and encourages classroom discussion. Instead of having students write full laboratory reports, the quad charts are more condensed summative assessment, which simulates one-approach scientists and engineers use to report and share their own research findings. Once the investigation is completed it opens the door for students to take this research further as a science and engineering fair project. More ratios can be tested and/or alternate inorganic or organic materials added to the composite to try and make the panels even stronger.

Table 6. Outline and scoring guide for a group particleboard quad chart

<table>
<tr><td colspan="2">THIS IS WHERE YOUR TITLE GOES
(Title needs to be detailed and give the reader a good idea of what the research is about)
Student Names</td></tr>
<tr><td>Research Questions</td><td>Data Analysis And Results</td></tr>
<tr><td>• Put your research question here.
• Please do not write in 1st person. Try just stating what you want to say without “I think” or “my research.”
• Provide background information. What does the audience need to know about your research topic?
• Hypothesis: what do you think will happen and why?
• Pictures of your experimental design or other important aspects of your research.
* 25 points section contains all of the above, 24 - 20 missing one to two aspects, 19 - 15 missing 3 aspects, 14 - 0 missing 4 aspects or all.</td><td>• Data analysis and group results should go here, including graphs and other visual data.
• You should have a brief description under each graph (use a smaller font) that describes the graph, diagram, image, etc....
• Highlight JUST THE FACTS.
• Make sure each graph, diagram, etc. has a title and all the necessary labels.
• Use standard error bars when appropriate or linear regressions for correlations.
*25 points section contains all of the above, 24 - 20 missing one to two aspects, 19 - 15 missing 3 aspects, 14 - 0 missing 4 aspects or all.</td></tr>
<tr><td>Methodology</td><td>Interpretation and Conclusion</td></tr>
<tr><td>• Your methodology should go here. Consider using something like a flow chart or numbered list to help break up the words into manageable chunks.
• Provide enough details so that the reader could repeat your experiment and expect to get the same results. You do not have to include incidental information (ex. where you purchased your materials), but you must include the fundamental aspects of your research (ex. Explain what each treatment is and how many trials you did).
• You can discuss the statistical approach, but do not state the obvious like you collected the data in a spreadsheet.
*25 points section contains all of the above, 24 - 20 missing one to two aspects, 19 - 15 missing 3 aspects, 14 - 0 missing 4 aspects or all.</td><td>• This is where your conclusions should go.
• Now discuss your results. You may include inferences here if they are supported by your data.
• Address your original hypothesis. If the hypothesis was not supported address it. If you believe there was a flaw in your experimental design, discuss it here.
• What is the next step to your research? What would you like to investigate next to expand on this research question?
* 25 points section contains all of the above, 24 - 20 missing one to two aspects, 19 - 15 missing 3 aspects, 14 - 0 missing 4 aspects or al</td></tr>
</table>

Concluison

The student outcomes for this activity not only meet the performance expectations outlined in Table 1, but also many of the Next Generation of Science Standards (NGSS) enginerring performace expectations. In addition, students will complete aspects of all of the science and engineering practices, explore several engineering disciplinary core ideas, and consider several crosscutting concepts. Introducing students to the importance and necessity for sustainable and safe building materials is the means to tap into their empathy and social righteousness. This challenge is truly rooted in real world cutting edge problem solving that makes these student outcomes applicable and powerful.

Science and Engineering Practices

Science and engineering practices are the tasks, skills, and explicit knowledge students employ to make sense of the world around them. These science and engineering practices guide students to start internalizing and transferring their explicit knowledge to tacit knowledge and therefore wisdom. Evidence of where each practice is undertaken in the present investigation can be seen in Table 7. The first practice is about having students “**ask questions and define problems.”** Not only do students asked questions about how they can develop a strong and environmentally stable particleboard panel, but they are also asked to pontificate about future research that could be pursued to piece together another part of this material science investigation.

For "**developing and using models**" students model the material science research being done at the University of Maine. Manufacturing and then testing CNF and sawdust composite panels produce scientifically sound results while also being relatively straightforward to implement in a gifted middle school laboratory. The class has the flexibility to "**plan & carry out an investigation**" the way they feel works best to answer the questions they put forth. These questions can focus solely on ratios of sawdust to CNF or students can choose to expand on the components of the composite to determine what makes the strongest panels in their study.

Quantitative literacy is established with students collecting, and "**analyzing and interpreting data.**" Students will collect and manipulate spreadsheet data to determine derived units such as density and averages. Students will create and interpret graphs. Since the class is pooling their data each group will come to understand that they must help in maintaining the integrity of the class data. A representative graph can been seen in Figure 3 where panels made with 20% of dry CNF were shown to be significantly stronger than any other ratio of CNF panels to sawdust. "**Mathematics and computational thinking**" is also required of the students as they not only use Google spreadsheets to collect, pool, and graph their data but they are also required to interpret their results to "**construct explanations.**" The ability to make such connections and employ abstract thinking is relatively standard for gifted students.

Middle school is when students start really building their executive functioning skills. The present investigation requires students' focus, planning/prioritization, and organizing of data in spreadsheets. Observations must be meticulously recorded and simple statistical formulas inserted into spreadsheets as well. Testing panels requires patience, accuracy, and precision. Students collaborate to explain their results by "**engaging in argument from evidence**" by presenting their work in quad charts (Table 6), which is how, students "**obtain, evaluate, & communicate information.**" Quad charts are a quick means for students to articulate the purpose, process, and main findings of their research. Gifted students are able to be metacognitive of how their group results fit (supports or not supports) the overall class results. The quad charts model is one-way scientist and engineers share their results and engage in conversations that help make sure the science and engineering results and analysis are sound.

Disciplinary Core Ideas

The NGSS engineering disciplinary core ideas that are met with this investigation are the "designing and delimiting engineering problems," the "developing possible solutions" and "optimizing the design solutions." This engineering challenge brings students full circle with them initially designing a project on which they want to focus and then defining the parameters of the experiment to test the strength of alternative particleboard panels. The equipment used during the entire process is unique and more sophisticated than what students typically use in a middle school science laboratory. Using these manipulatives to dewater and dry each panel before testing helps students to better conceptualize a solution by making them consider possible physical and chemical interactions going on at the microscopic level. Each group tests and averages the results for their panels and then the investigative results are optimized when students pool their group's data with the entire class to determine which CNF and sawdust panel composite performed the best in holding the most weight.

Crosscutting Concepts

Students will enforce their quantitative literacy skills as they collect, manipulate, and analyze patterns in their data. Students witness the effect of adding different amounts of CNF to sawdust in panels which in turn causes the panels to increase or decrease in strength. Based on the evidence that is collected, students are able to make predictions about the strength of the panels based on the different ratios of sawdust to CNF. In addition, students gain first-hand experience in how science, engineering, and technology directly influence the innovation of developing stronger particleboards without using synthetic binders and resins.

Table 7. The connection between the instructional design and NGSS science and engineering practices, disciplinary core ideas, and crosscutting concepts

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Asking questions and defining problems. Students determine the best ratio of sawdust to CNF that constructs the strongest panel. **Developing using models.** This entire research project is a model in investigating alternative particleboard strength. **Plan & carry out an investigation.** Students will select the different concentrations of CNF to make that strongest panels **Analyzing and interpreting data.** Students will collect data. They will then average the max mass that broke each panel of all the different treatments to discover which composite could hold the most weight. **Use mathematics and computational thinking.** Students will use Google spreadsheets to collect, pool, and graph their results. **Construct explanations.** Students will be able to explain their results and come to a conclusion as well as explain any data anomalies. **Engaging in argument from evidence.** Once students pool and graph their data they will use the evidence to determine what concentration of CNF and sawdust makes the strongest panels **Obtain, evaluate, & communicate information.** Students will communicate their results to the class and make recommendations for the next steps.	**ETS1.A Designing and Delimiting Engineering problems.** This project asks students to test the strength of an alternative particleboard. To find one that is more environmentally friendly. **ETS1.B: Developing Possible Solutions.** Students will use their critical thinking skills to test a possible CNF to sawdust ratio pane that could be used as an alternative to traditional particleboard. **ETS1.C: Optimizing the design solutions.** Students will compare the results from their entire class to a control to see which CNF and sawdust panel composite performs the best in holding the most weight.	**Patterns.** Students will use their research to identify patterns in their data **Cause and effect.** Students will be able to make predictions about the strength of the panel based in the ratio of sawdust to CNF. In addition, students will experience the influence of science, engineering, and technology have in the innovation of developing stronger particleboards without using synthetic resins. **Structure and Function.** Students will discover how the composition of sawdust and CNF can affect the strength of the panel.

Disucssion

This gifted middle school material science investigation, in which students evaluate the potential of an environmentally benign binder (CNF) to replace petreoleum-derived resins in the production of particleboard panels, provides real world experiences, relevant solutions, and useable knowledge. This investigation into sustainability combines two innovative pedagogical strategies, the engineering design process and challenge-based learning. The goal is to *"foster student ownership of real-world problems (Meyer et al., 2020, p. 5)"* and get students to implement science and engineering practices in a meaningful way. When students are tasked with finding safer, more energy efficient, and environmentally friendly building materials then the research takes on greater importance. According to Tomlinson (2009) "*A theory of knowledge that has, as its goal, helping learners experience and appreciate real-world applications for the knowledge they learn in school should also emphasize the appropriate use of methods, tools, and techniques used by experts in and contributors to a field (p. 9).*"

The open-ended particleboard investigation discussed in this paper accomplishes this along with highlighting several sciences and engineering practices that challenges advanced middle school learners. In the authors' experience, students increasingly care about sustainability and safety; we as teachers can assist them by highlighting actionable research, which can be brought to bear. Students can be shown that engineering, math and science are meaningful tools, which can be used and honed to make impactful changes in the world and our communities. Professional development opportunities like the Hub & Spoke SM^{2}ART project's RET program with the support of the U.S. Department of Energy (DOE) are also a crucial parts of this equation. It was this program's expertise that allowed for the collaboration, development, and classroom optimization of this curriculum module and is the inspiration behind the present activity.

Overall, this sustainable and eco friendly materials science investigation mirrors the current engineering explorations being done at a plethora of research facilities like the University of Maine. In this article, students are asked to investigate a sustainable and non-toxic particleboard composite that is more environmentally friendly. The research is challenging, relative, and requires science and engineering practices. Students are asked to work in small groups to make and test their particleboard panels to determine the average maximum weight each panel can hold. They are asked to be metacognitive of their methodology and use extenuating data to justify the integrity of their results before pooling their data with the class. Having students use spreadsheets with formulas requires strong procedural knowledge, which reinforces their critical thinking and problem solving skills. The group quad chart summative assessment allows students to assess their own work and how it fits in with the class results. The ability to critically examine, understand, and communicate how their group results melds, supports, or does not support the overall results, is evidence, in itself, of high-level learning.

"Design challenge units are an effective way for teachers to guide students in the construction of useable knowledge within and across content domains, as they work on complex problems" (Meyer et al., 2020 p.21). Engineering design challenges connect students' previous content knowledge and new information in meaningful ways with real world applications. Teachers of gifted and talented students can easily tap into students' elevated sense of empathy and justice to create a solid, humanitarian hook. Gifted students are better able to understand more abstract concepts and more readily make connections between their middle school science content knowledge and the new information they take in during an engineering challenge. Inquiry investigations like the one described in this article open the door for students to tailor and level up the research for a science and engineering fair project that requires an even deeper dive into the topic. All of nuances found within this activity can be overwhelming for grade level students, but for gifted learners they often excel and better appreciate the experiences they get with science and engineering practices. It is the author's experience that gifted students become more intellectually curious about the world around them and their possible impact for improvement when they are exposed to design challenges like the one described above.

Recommendations

This material science investigation was developed to provide a meaningful and challenging activity for middle school gifted students. It is a robust activity that encapsulates and distills the cutting edge research being done at the University of Maine and is being successfully used as a vehicle to get gifted middle school students invested in a real world problem solving activity. The engineering design challenge engages and reinforces executive functions, metacognition, and helps to foster the talents of gifted students.

The particleboard challenge can easily be modified for gifted student pullout programs or gifted classes. As a physical science teacher, the lead author conducts this particular engineering challenge early in the school year after reviewing physical properties of matter. While grade level classes are exploring particular physical properties of objects like density and viscosity, she is able to easily intergrade all the same content and more within the engineering challenge for the gifted students. This particular engineering design project evolves each year. If teachers are able to keep the posters from year to year it adds another layer to the project by pushing students to expand on the research from previous years.

More academic research is recommended to scientifically evaluate the effectiveness of such instructional design on students. This could be done with pre and post quantitative surveys to probe attitudes toward science and engineering practices, content knowledge, and the impact of engineering challenges on authentic and independent research projects.

Limitation od Study

This research is limited primarily to curricula activities implemented in 8th Grade at the James F. Doughty School, in Bangor, ME, USA physical science class in the period 2021-2024. A total of approximately 80 students have undertaken the activity, instructed by lead author Vassiliev. In addition, the activity served as the basis for a statewide middles school science competition in which two 8th grade students won the Lemelson Award. The activity has been disseminated to both the grade 6 middle schools in the Bangor School District via a teacher-in-service workshop and it is anticipated that it will be implemented in several grade 6 earth science classes during the current academic year.

Acknowledgments

This research is supported by the US Department of Energy (DOE), Office of Energy Efficiency and Renewable Energy, Advanced Materials and Manufacturing Office (AMMTO), Oak Ridge National Laboratory/University of Maine SM^{2}ART program with research and resources used at the Manufacturing Demonstration Facility (MDF), a DOE AMMTO User Facility, and the Advanced Structures and Composites Center (ASCC), a University of Maine research center under CPS Agreement and 38563. This work was supported in part by funding from UT-Battelle LLC with the U.S. Department of Energy under contract DE-AC05-00OR22725 (subcontract # 4000174848).

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URL

URL 1. https://drive.google.com/file/d/1RctCdkofATW_NEz6V3gbLgh2I9FDJHXh/view

Technical drawings for making the particleboard panels

URL 2.

https://secure.touchnet.com/C22921_ustores/web/store_cat.jsp?STOREID=216&CATID=392&SINGLESTORE=true

Purchase CNF

URL 3. https://umaine.edu/pdc/wp-content/uploads/sites/398/2022/07/SDS-CNF-v2.pdf

Safety data sheet fro CNF

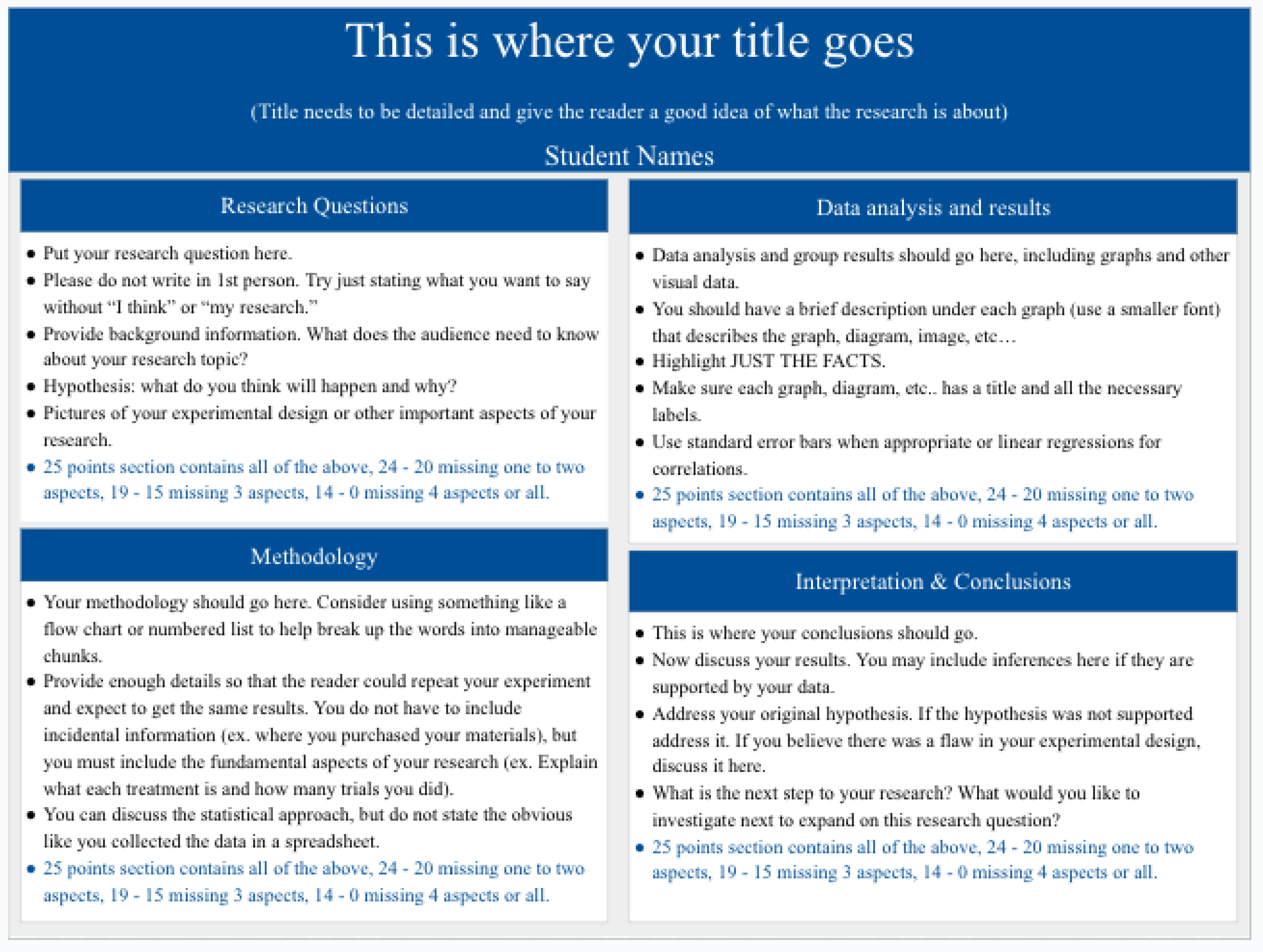
Appendix 1. Spreadsheet instructions for calculating the amount of wet CNF and sawdust to us for a desired percent of CNF per panel

A	B	C	D	E	F	G
Approx. Mass of Dried panel (g) (Standard)	Enter the % of overall CNF desired per panel	The total amount of dry CNF in panel (approx. mass (g) * CNF content (%))	Starting % of CNF (Standard)	The amount of sawdust (grams)	The amount of wet CNF to add (Total dry CNF / Starting % of CNF)	Total mass (g) of material needed
Target mass (g)	CNF content (%) ENTER Desired % Below	Dry CNF (g) in Film	CNF (%)	Sawdust Furnish (g)	Wet CNF (g)	Total Mass (g)
33.6	14	4.70	3	28.90	156.80	185.70

- Column (A) is the approximate mass of a dried panel (g). The standard mass for a panel with the following dimensions: 21 cm x 6.4 cm x 0.5 cm.
- Column (B) is where you enter the desired percentage of CNF per panel.
- Column (C) is the calculated amount of dry CNF in each panel, which is calculated by multiplying the approximate mass of panel (g) by the percentage of overall CNF per panel (14%). The cell formula is "=A3*B3/100"
- Column (D) is the standard starting CNF slurry (3% is typical).
- Column (E) is the mass of sawdust to be added for each panel and is calculated by subtracting the target mass from the total dry CNF in the panel (column C). The cell formula is "=A3-C3"
- Column (F) is the amount of 3 wt.% CNF slurry to use by mass that is calculated as the quotient of total dry CNF (column C) and the weight percent of the CNF slurry employed (14%). The cell formula is "C3/(D3/100)"
- Column (G) is the total mass of material needed to make the panel. The cell formula is "=Sum(E3:F3)"

Appendix 2. Quad Chart Template and Scoring Guide

A quad chart template and scoring guide made with Google Slide (Google Suites). Each research group will present their own quad chart from their research perspective.



https://docs.google.com/presentation/d/1DATLRw4mPWjvxZqei_Kd5gohck9Oryir3Nx9yLcHn0Y/edit?usp=sharing

Journal of Gifted Education and Creativity
11(3), 125-130, September 2024
e-ISSN: 2149- 1410
jgedc.org dergipark.org.tr/jgedc

Genc Bilge Publishing Ltd.
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Interview Article

An interview with Dr. Joanne Foster: igniting creativity in childhood and beyond

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Article Info

Received: 17 August 2024
Accepted: 13 Sept2024
Online: 30 Sept 2024

Keywords
Joanne Foster
Creativity
Giftedness

Abstract

The nurturing of creativity and talent seems increasingly apparent and needed. In this interview, Dr. Joanne Foster calls on several decades of experience working with teachers, parents and children to foster the creative potential of children. She discusses the elements that promote creativity and enhance the development and learning of the child. Some suggestions for future reference are noted.

To cite this article:

Shaughnessy, M.F. (2024). An interview with Dr. Joanne Foster: igniting creativity in childhood and beyond. *Journal of Gifted Education and Creativity, 11*(3), 125-130. DOI: https://doi.org/10.5281/zenodo.13756834

Michael F. Shaughnessy: How did you first get involved with creativity?

Joanne Foster: I've always loved creative writing. I'm very curious, and I enjoy asking questions and discovering new perspectives. When I became a teacher, I realized that creative expression inevitably invigorated my work with children, and motivated them to be creative, too. Whenever I taught prospective teachers, I found that the best classroom dynamics were those that catapulted from initiatives that tapped the imagination and invited free-wheeling ideas.

As an author, I seek information from different sources, collaborate with others, and incorporate fresh ideas into my work—all of which serves to infuse creative vibes. I'm not afraid to pivot, or to try going in unchartered directions because I've always believed that creativity lies at the core of forward momentum. And, if I'm not going forward then

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I'm standing still, and I know I can do better than that! For me, creativity is incendiary—like fuel for the many sparks that ignite my mind, and the sizzle that enlivens my days.

Michael F. Shaughnessy: Let's start with parents. What do they need to be aware of in terms of their child's potential? And what are your top tips for fostering kids' creativity, talent, and intellect?

Joanne Foster: We can't determine what anyone's potential might be because it's an unknown. Potential is a horizon of sorts, with unpredictable and fluctuating trajectories enroute, and over time. However, parents can encourage children to develop a creative outlook, to push beyond the status quo, and to embrace new ways of doing things—and those initiatives can certainly enhance kids' potential. Here are three tips: 1) match tasks to your child's abilities and interests across subject areas; 2) support your child's efforts, and their investment in learning; 3) co-create with your child an environment that's welcoming, safe, inclusive, supportive, and accepting of diversity.

Michael F. Shaughnessy: How can educators support gifted/high-ability learners—those who excel in the sciences, or in other areas of study—and also those whose development varies across different domains?

Joanne Foster: Stay attuned to a student's individual learning needs. These are always changing, in concert with support mechanisms, developmental pathways, asynchrony, shifting circumstances, and more. Advancement in the sciences, languages, the arts, social/emotional growth, or other facets of development demands an understanding of an evolving landscape relating to instruction, assessment, provisions, and encouragement. It requires appreciation of inquiry, and critical and creative thought processes.

Albert Einstein said, "To raise new questions, new possibilities, to regard old problems from a new angle, requires creative imagination and marks real advance in science." I interpret this as awareness of the promise of possibilities—and the vast scope of that promise—which is foundational for teaching and learning. It can, and should, underlie what educators do, and the dynamic they create. Afterall, there are no limits to when or where learning can happen. Moreover, technology is empowering, and informational sources are everywhere.

Throughout all that, educators can instill a love of learning, and then be attentive to the nuances as these relate to the individual. That's vital for supporting gifted/high-ability learners!

I'm reminded of the following words by Astronaut Sally Ride, who appreciated the importance of scientific endeavors, and opportunities for excellence in many pursuits. She said, "Science is fun. Science is curiosity. We all have natural curiosity. Science is a process of investigating. It's posing questions and coming up with a method. It's delving in." I believe learning of any kind can be fun—embracing curiosity, investigation, problem-solving, effort, and agency. When educators encourage these ways of thinking and doing, it can lead to wonderful outcomes!

Michael F. Shaughnessy: Let's face it, teachers have impossible jobs. How can educators best work with parents to encourage children's creative, critical, divergent, and flexible thinking?

Joanne Foster: Teachers can model effective coping skills, solid attitudes, and strong work habits, including how to prioritize, respond effectively to adversity, and be resilient. In *Being Smart about Gifted Learning* (p. 37), Dona Matthews and I write that each child needs "*learning opportunities that challenge them sufficiently and appropriately, along with the right kinds of guidance and support so they can meet and enjoy those challenges, and feel good about themselves at home and at school*" (p. 36).

Therefore, it's important for teachers to seek, select, and offer a suitable array of options to nurture individuals' high-level development—and this can happen in regular classrooms. "*The objective is to find a good match between the learning needs of the child, and the range of learning opportunities that are available, thinking as broadly as possible*" (p. 209).

Working together, parents and teachers can stretch boundaries. For example, they can participate in conferences and workshops; form study groups; stay apprised of current resources (including journals such as this one!); network with others in gifted associations and community organizations; observe and share exemplary and emerging practices; increase competency in technology; and collaborate with educational specialists in areas they want or need to know more about. Respectful connectivity, and engagement in advocacy for gifted-related provisions and services, are paramount.

Michael F. Shaughnessy: As noted in your response above, in "*Being Smart about Gifted Learning, 3rd Edition*," you and co-author Dona Matthews emphasize the importance of "matching" a child's learning opportunities and their developmental needs, over time. Can you briefly summarize how you structured the book, what you convey—and why it matters?

Joanne Foster: On page 37 say: *"There's so much about human development that remains mysterious, so much we still don't know about what fosters expertise, exceptional accomplishment, and creativity, all components of gifted-level development. There's much we do know, however, about how to nurture interest into ability, and then to support ability into gifted-level achievement."*

To that end, we begin by discussing perspectives and paradigm shifts pertaining to giftedness, and the role of creativity. We move on to diagnostic considerations, wherein we address questions and answers about testing, and clarify understandings about assessment processes, and also labeling issues. Then, over the course of two chapters, we present myriad suggestions for meeting gifted learning needs—including differentiation in regular classrooms, plus lots of other options. The focus of the next section is gifted-level development, and we pay attention to motivation and achievement; to social, emotional, and behavioral considerations; and to parents' roles and responsibilities in helping to further children's abilities. The final section of the book is about changing realities in gifted education, including how parents and teachers can support optimal learning in an increasingly challenging world. The book concludes with 24 pages of endnotes, and 30 pages of reference material. Readers will also find informative charts and real-life anecdotes strategically located within the 460 pages.

Throughout the twelve chapters, we raise awareness about "*the authentic, interactive, and dynamic nature of learning*" (p. 90). We are pleased that Kirkus Review hailed the book as "*an authoritative, up-to-date- and comprehensive manual*."

Michael F. Shaughnessy: You also have a book *for kids, Ignite Your Ideas,* wherein you empower them to "spark" creativity—and thereby enhance their skills and abilities. Why is it important for kids to engage in creative expression? How can they maximize their creativity?

Joanne Foster: Creativity empowers humankind. It underlies all endeavors and discoveries. Creativity is a *choice*—something to embrace. Whether it is "*softly lit, smouldering, or scorching*," creativity is open-ended! It warms the soul and brightens the day.

There are endless ways kids can invigorate their creativity. For example, they can build upon what they already know; amplify fun factors; find purpose that gives meaning to their creative pursuits; collaborate and share ideas; welcome spontaneity and aha! moments; look for opportunities to tap resources; and use the imagination across different domains.

In *Ignite Your Ideas*, I discuss the essence, limitlessness, and value of creativity so kids can appreciate that it's like having a superpower! I discuss several questions and answers that readers want to know about; offer suggestions for seizing creativity and nurturing it in the context of everyday family life; and convey how kids can overcome struggles with creativity (such as impatience, embarrassment, lack of provisions, perceived risk, and more). The final segment of this book for kids includes 100 sure-fire strategies to ignite creativity—and there is a 15-page resources and references section as well. The information applies to sciences, the arts, languages, and other areas.

For kids to become invested in creativity, they have to put forth time, patience, and effort. However, those who appreciate a creative edge, and who are willing to crack open doors to the imagination, reap joyful benefits, including learning possibilities that will resonate now, and into the future.

Michael F. Shaughnessy: We all know about "science fairs"—typically in middle school—which provide outlets for students to highlight their thinking and creativity. Any ideas here?

Joanne Foster: Science is fundamentally the pursuit and study of discovery—and any opportunity to advance that kind of learning is advantageous for the here-and-now, and for the future. Ideally, the emphasis should not be narrowed to science fairs; it should pervade the daily activities and learning experiences in which kids engage all the time, at home, school, and elsewhere.

There's technology, inquiry, data collection, and countless other aspects of science that children can investigate. However, science is not only about facts and research. It's about exploration, trial and error, perseverance, and more. For example, composer Vangelis notes, *"Music is science more than art, and it is the main code of the universe."* And astrophysicist Carl Sagan wrote, *"Science is a way of thinking much more than it is a body of knowledge*."

Most importantly, science is about imagination, and curiosity–which need not be restricted to science fairs!

So yes, let's continue with those fairs but let's stretch far beyond them, too, because our future depends on it. I'll sum up this answer with the words of theoretical physicist Stephen Hawking who said, "*Scientists have become the bearers of the torch of discovery in our quest for knowledge*." It is a calling, and a necessity!

Michael F. Shaughnessy: How can parents demonstrate their own creativity in the sciences (and elsewhere), and act as models for their kids?

Joanne Foster: Regardless of age, we're all active agents in creating our own intelligence. And we're influenced by those around us. Thus, parents are well-positioned to "show the way" as kids embark on various activities. Parents can share their experiences about how to maximize learning environments; appreciate cultural, generational, developmental, and other differences; maintain life-balance; and navigate day-to-day circumstances. Parents can demonstrate the power of resilience, creativity, and a positive attitude. They can emphasize the importance of reading and reflection. They can enable kids to have choices, providing them with safe and nurturing milieux as they make those choices, venture into unfamiliar territory, and gain independence and confidence.

Each family has its own unique blend of individuals (immediate and extended), mode of functioning, and constellation of interests, priorities, challenges, problem solving approaches, and skill sets. There's no one blueprint for parents to follow, or beacon to hold aloft. Nevertheless, parents can (and should) demonstrate a lifelong love of learning, a willingness to embrace creativity, a desire to ask questions and ponder answers, and a healthy respect for the aspirations of others—most notably their children!

Michael F. Shaughnessy: Some kids procrastinate, and this can interfere with their learning and creativity. You've written extensively about procrastination. What underlies it, and what suggestions do you have to help children and teens become happily productive?

Joanne Foster: Procrastination involves willfully putting things off. It's a form of avoidance behavior. However, people can take control of their actions and attitudes, and choose what to do.

Why do kids procrastinate? There are *personal reasons* (such as too many demands, boredom, perfectionism, or fear of failure or success); *skill-related reasons* (such as disorganization, or trouble with goal-setting, prioritizing, or time management); and *external reasons* (such as distractions, lack of materials, insufficient structure, or being influenced by others who procrastinate).

An upside to procrastination is that it can allow a person to plan carefully, think things through, acquire resources, and pay attention to detail. The downside is that procrastination can compromise achievements, relationships, and productivity.

In my books on procrastination, I share hundreds of tips for overcoming avoidance behavior. These align with various underlying causes and circumstances, and I include recommendations to help children and teens develop personal strengths.

For now, though, here are three key suggestions:

Value attribution: When kids see a task or activity as worthwhile, they're more likely to become invested, and to see it through. Let's say they have a science project relating to robotics, aerodynamics, physics, or marine conservation. If they can appreciate value in the learning process (and if expectations are fair), they will be more motivated to engage.

Supports: Who can encourage and assist? Friends, family, teachers, mentors? Consider who might be able to offer useful feedback, and help kids explore options, make sensible decisions, find resources, and aspire toward reachable and fulfilling outcomes.

First steps: Kids can proceed bit by bit, take pride in their initial steps, and then continue. As they do so, they can envision progress and positive goals, set manageable timelines, pace themselves, and check things off along the way. Kids may be able to start a task with an aspect that seems most enjoyable, or cluster things together, and also take short breaks as needed.

There's an old saying, "*Every great journey starts with one small step*."

Michael F. Shaughnessy: Do you have a web for parents and teachers to get more information and resources, and what will they find there?

Joanne Foster: Yes, my website is https://joannefoster.ca. I provide an extensive assortment of articles and blogs, under the overarching headings of creativity; learning and development; motivation and productivity; and children's well-being. There's podcast and interview material, presentation descriptors, and information about each of my books (including tables of contents, reviews, short excerpts, and more). Visitors to my website can also subscribe to my free quarterly newsletter, and they can connect with me directly through my contact page.

Michael F. Shaughnessy: What have I neglected to ask?

Joanne Foster: I think we are good! Your questions were interesting, and I enjoyed answering them. Thank you for inviting me to share my views in your esteemed journal!

Biodata of Joanne Foster

Joanne Foster, Ed.D. has worked in the field of Educational Psychology, and also Gifted Education, for over 35 years. She has a Master's degree in Special Education and Adaptive Instruction, and a Doctoral degree in Human Development and Applied Psychology. She taught for many years in the teacher training program at the Ontario Institute for Studies in Education of the University of Toronto, where she also served as the gifted liaison, and provided broad-based community support and targeted expertise relating to learning, teaching, and high-level development. She's the award-winning author of eight books. Her writing reflects her extensive experience as a parent, teacher, consultant, university instructor, and community advocate.

Dr. Foster's most recent book is *Ignite your Ideas: Creativity for Kids*(August, 2023). She co-authored (with Dona Matthews) the multiple award-winning *Being Smart* series , including the fully updated 3rd edition entitled *Being Smart about Gifted Learning: Empowering Parents and Kids Through Challenge and Change*. (Fall 2021). Dr. Foster also wrote *ABCs of Raising Smarter Kids: Hundreds of Ways to Inspire Your Child* (2019 Award Finalist, American Best Books), *Bust Your BUTS: Tips for Teens Who Procrastinate* (recipient of the Independent Book Publishers Association's 2018 Silver Benjamin Franklin Award for teen non-fiction), and *Not Now, Maybe Later: Helping Children Overcome Procrastination* (2015).

She is co-author (with Dona Matthews), of *Beyond Intelligence: Secrets for Raising Happily Productive Kids* (2014).Dr. Foster's articles are featured in numerous publications, including online in her column at *The Creativity Post*, for *First Time Parent Magazine*, and in issues of *Best Version Media's* Neighbours Magazines across many regional areas. She offers a Master Class on Igniting Your Child's Creativity—and Why It's Important in association with *BabySparks,* an online parenting platform that is used by millions of parents around the world. She is also listed on the Writers Directory for *Parenting Media Association*.

Dr. Foster gives keynote addresses, offers presentations on a wide range of topics, and shares information and insights on podcasts, in interviews, and in interactive forums. Throughout her writing, and in the course of her work with parents, teachers, and other professionals across North America and beyond, she provides leadership in areas of learning, children's well-being, and optimal educational processes for supporting gifted/high-level development. Dr. Foster also provides lots of resource material, listed here, which is updated regularly.

Web: https://joannefoster.ca/

Biodata of Author

Prof.Dr. **Michael F. Shaughnessy** is currently Professor of Educational Studies at Eastern New Mexico University in Portales, New Mexico USA. He has served as Editor in Chief of Gifted Education International and can be reached electronically at Michael.Shaughnessy@enmu.edu. His orcid i.d. is 0000 0002 1877 1319. His current research interests include talent development and intellectual assessment as well as the role of personality in giftedness, talent and creativity.

References

Web 1. https://joannefoster.ca/

Journal of Gifted Education and Creativity
11(3), 131-131, September 2024
e-ISSN: 2149- 1410
jgedc.org dergipark.org.tr/jgedc

Retracted Article

At a glance of twice-exceptional children on psychological perspective

Author: Mahsa Amiri

Issue/Year: 7(3), December 2020

Retreaction Date: September 30, 2024

Reason: This article, published in the December 2020 issue, has been retracted due to incorrect scientific citation.

Journal of
Gifted Education
& **Creativity**

Vol. 11 No. 3 September 2024 Autumn

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ISSN: 2149-1410