American Journal of Occupational Therapy

Improving executive functions using the Engineering Design Process: A peer-mediated problem-solving approach for autistic adolescents

Journal:	*American Journal of Occupational Therapy*
Manuscript ID	AJOT-2022-050166.R1
Manuscript Type:	Column: The Issue Is
Research Methodology:	
Keywords:	adolescents, autism, executive function, school-based therapy, problem solving
Domain & Process:	education < Occupations and Everyday Activity, social participation < Occupations and Everyday Activity, environmental factors < Contexts, group interventions < intervention types, participation < outcomes
Practice Settings:	secondary school < schools, early intervention, and community education settings, transition program < schools, early intervention, and community education settings
Client Groups:	age 6-14 < children and youth, age 15-21 < children and youth
Audience:	client, educator, policymaker
Conditions:	autism < mental, behavioral and neurodevelopmental topics, anxiety disorders < mental, behavioral and neurodevelopmental topics
Payer:	
Advocacy:	scope of practice
Professional Topics:	diversity, equity, and inclusion, quality and value-based care
Abstract:	Executive functions, specifically problem-solving skills, are crucial for school success. Challenges in these functions faced by autistic adolescents are often unrecognized or are viewed using a behavioral lens that requires correction or normalization (Cramm et al., 2013 a,b). Lack of development of these higher-order problem-solving skills leads to increased instances of secondary mental health issues like stress and anxiety, creating further behavioral and social challenges (Cramm et al., 2013a). This paper proposes a flexible, cyclical, top-down, self-sustaining approach that uses peer mediation to teach group problem-solving skills called the Engineering Design Process. This cycle is then positioned within existing OT models to demonstrate its adaptability and flexibility, and its seven steps are described. After this step, the distinct features of this problem-solving strategy, including 1) systems thinking, 2) collaboration, 3) communication, and 4) creativity, are described. Finally, a real-world case study is presented where the EDP is currently

	used as a problem-solving approach in an afterschool program. EDP develops crucial social and interpersonal skills using interest-driven occupations and can be organically utilized as a group strategy.

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Abstract

Executive functions, specifically problem-solving skills, are crucial for school success. Challenges in these functions faced by autistic adolescents are often unrecognized or are viewed using a behavioral lens that requires correction or normalization (Cramm et al., 2013 a,b). Lack of development of these higher-order problem-solving skills leads to increased instances of secondary mental health issues like stress and anxiety, creating further behavioral and social challenges (Cramm et al., 2013a). This paper proposes a flexible, cyclical, top-down, self-sustaining approach that uses peer mediation to teach group problem-solving skills called the Engineering Design Process. This cycle is then positioned within existing OT models to demonstrate its adaptability and flexibility, and its seven steps are described. After this step, the distinct features of this problem-solving strategy, including 1) systems thinking, 2) collaboration, 3) communication, and 4) creativity, are described. Finally, a real-world case study is presented where the EDP is currently used as a problem-solving approach in an afterschool program. EDP develops crucial social and interpersonal skills using interest-driven occupations and can be organically utilized as a group strategy.

Introduction

Learning in academic contexts is an intricate and dynamic process where students are expected to portray knowledge, share experiences, pay attention to information, engage with learning resources, contextualize and collaborate with teachers and peers effectively (Bolton & Plattner, 2020; Cahill & Lopez-Reyna, 2013; Cahill & Bazyk, 2020). As more children and adolescents are diagnosed with autism and are increasingly studying in inclusive and mainstream schools, school-based Occupational Therapy practitioners (OT) must facilitate their participation and engagement in the roles related to the school's academic and non-academic occupations optimally. Hence, there is an ongoing need for school-based OT practitioners to develop evidence-based interventions that meet the needs of autistic[1] adolescents during this phase of physical, emotional, social, biological, and cognitive growth and transitions.

Kornblau and Robertson (2021) note that " all autistic individuals experience atypical thinking and its associated strengths, talents, and challenges in the areas of language and communication, social interactions, executive functions (EF), and sensory processing." These differences, including in EF, must be included while designing interventions for them in various contexts. EF enable the association of two pieces of information, manipulation, and data comparison, shifting perspectives, initiation, maintenance, completion of tasks, and self-regulation of emotions (Cramm et al., 2013a; Gardiner & Iarocci, 2018; Poon, 2018; Vaidya et al., 2020). These skills are an amalgamation of cognitive abilities (working memory[2] and cognitive

[1] This paper will use the identity-first language "autistic individuals." This non-ableist language describes their strengths and abilities and is a conscious decision. This language is favored by autistic communities and self-advocates and is adopted by healthcare professionals and researchers (Bottema-Beutel et al., 2020, Kenny et al., 2016).
[2] Working memory is the capacity to hold information mentally and manipulate, associate and use it (Diamond, 2013).

flexibility[3]) with emotional elements (motivation and emotional control) (Poon, 2018; Vaidya et al., 2020). They are also foundational skills for developing complex functions like planning, organization, and problem-solving (Poon, 2018). Considered to be crucial for academic success, goal-oriented performance, and self-regulation, EF are directly linked to effective participation in student role both academically and non-academically (American Occupational Therapy Association [AOTA], 2017; 2020; Cahill & Lopez-Reyna, 2013; Cahill & Bazyk, 2020; Mann et al., 2015).

However, challenges in EF can hinder progress in learning and engagement in school activities, thus impeding social, behavioral, and emotional participation, leading to poorer academic performance and engagement in non-academic spaces (Cramm et al., 2013a,b; Cahill & Lopez-Reyna, 2013; Ashburner et al., 2014; Cahill & Bazyk, 2020). Furthermore, Cramm et al. (2013a) contend that while EF challenges are prevalent in many autistic children and adolescents, they are often misunderstood or masked due to their outward manifestations as social and behavioral deficits. Developing both EF and problem-solving skills is crucial (Drigas and Karyotaki, 2019) which has the potential to augment autistic adolescents' capacities to make informed decisions that can counteract any deficits in self-regulation, thus mitigating challenging behaviors.

The EDP is open-ended problem-solving strategy engineers use to solve complex design challenges by creating tangible products or solutions. It is cyclical and highly iterative as it augments users to engage in analytical reasoning and constant social collaboration to solve real-world challenges (Dym1994; Dym et al., 2005; Gardiner & Iarocci, 2018; Householder & Hailey,

[3] Cognitive flexibility refers to the ability to shift and change perspectives by processing multiple information sources, responses, use mistakes as learning opportunities, switch between tasks and adapt to new demands (Diamond, 2013; Drigas & Karyotaki, 2019).

2012; Kaboski et al., 2015; Katehi et al., 2009; Martin et al., 2020). It is a seven-step cyclical process where users are expected to define and scope the problem, plan their process of solving the problem, develop a prototype (the first iteration of the solution), test, and iterate the prototype to satisfy the problem. If the prototype fails, the user retests and reiterates to improve it, and in this way, the solution is achieved and disseminated (Householder & Hailey, 2012; Khandani, 2005).

As a result, EF deficits can go untreated, hindering educational performance and participation in the student role by causing secondary mental health challenges (e.g., anxiety) in this population (Kaboski et al., 2015; Webb, 2004). To address this gap in the current evidence base, we propose including a unique peer-mediated problem-solving strategy called the Engineering Design Process (EDP), as presented in figure 1, that can develop EF along with problem-solving. Hence, we advocate for the benefits of EDP by introducing this approach to school-based OT practitioners. Furthermore, we present a real-world case study where we have implemented this problem-solving approach to develop and expand the EF and problem-solving skills of autistic adolescents.

Understanding the merits of the Engineering Design Process: a strength-based problem-solving approach for autistic adolescents

The EDP incorporates a framework to approach problem-solving systematically, and EF enables users to identify a problem, find potential solutions by understanding the constraints in the context, and then finalize a solution through communication and collaboration (Householder & Hailey, 2012; Khandani, 2005; Papert & Harel, 1991). This augments users to incorporate available resources and work through contextual constraints to solve problems realistically, adapt to failed opportunities, and improvise to develop optimal solutions to design challenges (Ehsan & Cardella, 2020). Also, by following the EDP, EF can improve as autistic adolescents can analyze problems from multiple angles, work with peers to employ their strengths and insights, and explore creative solutions to problems (Chen et al., 2021; Ehsan & Cardella, 2020; Gardner & Iarocci, 2018). EDP's flexible nature makes it adaptable to any context, age group, ethnicity, and socio-economic class (Katehi et al., 2009).

When we compare the EDP with existing OT models, we note that this framework has the potential to meld with an existing OT model- the Cognitive Orientation of Occupational Performance (CO-OP). Ikiugu, Plastow, and van Niekerk (2019) have emphasized the importance of combining models of practice with each other in a systematic manner by adopting the eclectic framework to address clients' needs to an optimal level. The EDP has the potential to be used flexibly along with CO-OP as a complementary tool to facilitate peer-mediated problem-solving. Designing such interventions will allow OTs to develop autistic adolescents' coping skills required in the classroom and non-academic spaces. Students can learn from their peers and try leading the teaching process if they desire (Bustamante et al., 2018; Martin et al., 2020; Bond et al., 2016). While working together, they can capitalize on team members' individual strengths to solve a problem (Householder & Hailey, 2012; Ehsan & Cardella, 2020).

OT practitioners integrate the domain-general process of Goal-Plan-Do-Check in CO-OP to mediate the problem-solving process with guidance and solution interpretation to promote learning generalization (Missiuna et al., 2001; Polatajko, 2017). For example, in a study by Rodger and Vishram (2010), therapists co-set goals chosen by children, including completing homework and managing anger on the playground. These goals were then addressed using the domain-general process (Goal-Plan-Do-Check), and specific skill deficits were addressed through skill acquisition. Although the CO-OP can be used with a group using an adapted strategy, a therapist must guide the problem-solving process (Chui et al., 2020; Polatajko, 2017). In contrast, the EDP primarily uses a collaborative peer-mediated problem-based learning approach where the strengths of individual autistic students can be harnessed to solve problems collaboratively (Bustamante et al., 2018; Martin et al., 2020).

Along with this emphasis on peer-mediated problem solving, the EDP can be amalgamated with the CO-OP due to its adaptive and flexible structure. Bidirectional mobility between the seven steps facilitates failure accommodation and gives students a chance to improve their solutions through each iterative attempt (Lottero-Perdue & Parry, 2017). In this way, students can move between the Goal-Plan-Do-Check process without completing a full iteration to determine if their solution is effective with the EDP. Thus, they can potentially correct their errors in the problem-solving process (Cunningham & Lachapelle, 2016). In addition, incorporating individual students' inner curiosity, interests, and motivation provides them with the agency and persistence to solve their problems using their natural environments and resources. Students also learn to creatively use existing resources in novel ways, like how engineers solve complex real-life problems (Cahill & Bazyk, 2020). As a flexible and peer-mediated problem-solving strategy, the EDP has other crucial advantages that make it well-suited to be included in the OT toolkit for use with autistic adolescents in the school setting.

Elements of EDP that enhance peer-mediated problem solving

The elements of the EDP that make it well-suited for peer-mediated problem-solving are *1) systems thinking, 2) collaboration, 3) communication, and 4) creativity* (Ehsan & Cardella, 2020; Greene & Papalambros, 2016; Householder & Hailey, 2012; Khandhani, 2005). In addition, the EDP highlights students' strengths and propels them to adapt and solve the situation presented to them with their resources. The impact of each component on EDP and problem-solving is presented below.

Systems thinking (ST) skills expose learners to competencies and routines that equip them to see emerging patterns and relationships (Greene & Papalambros, 2016; Householder & Hailey, 2012). The EDP enhances ST (or an 'engineering frame of mind') by promoting critical analysis, flexible thinking, and pattern recognition so a specific problem can be imagined in a grander systemic context (Householder & Hailey, 2012; Katehi et al., 2009; Sneider, 2011, 2012). In a comparative study by Kapur (2008; 2011 as cited in Householder & Hailey, 2012), students engaged in deeper learning when using ST to solve ill-structured, challenging, complex problems with multiple solutions with exposure to failure. Here, failing in complex tasks resulted in more profound subject matter expertise amongst these students. They tried different ways to solve the problem and pushed them to undertake more challenges in class and non-academic spaces. Also, developing ST can improve problem-solving as additional possibilities for solving challenges can be considered by learners with their resources.

Collaboration and communication are critical skills built into the core of EDP, where collaboration is unique to this process (Householder & Hailey, 2012; Katehi et al., 2009). Students can engage, coordinate, organize, and adapt through open negotiations, shared understandings, and dialogue (Khandhani, 2005; Scardamalia & Bereiter, 2003). When solving problems collaboratively, students seek advice, support, and critical feedback on their ideas about shared work without judgment or criticism from therapists, teachers, and peers (Bustamante et al., 2018; Householder & Hailey, 2012). As students engage in activities of high interest, they are motivated to persist through frustration and regulate each other as a group, thus building crucial self-regulatory skills like frustration management that increase willingness and openness to accept constructive criticism (DiDonato, 2013; Householder & Hailey, 2012). These skills align with typical Response to Intervention goals at Tier 1 and Tier 2 levels, often addressing group social skill enhancement (Cahill & Bazyk, 2020).

Householder and Hailey (2012) discuss how collaboration also improves ST as a whole classroom strategy through the example of a project where student groups work to build individual parts of a sustainable energy source and then collaborate to combine these individual components into a holistic project. Each team's success depends on other teams; hence there is built-in accountability to brainstorm practical solutions. Leveraging intentional grouping that combines complementary strengths can give teams the skills to brainstorm effectively (Householder & Hailey, 2012). In a study by Martin et al. (2020), autistic students' capacity to problem-solve with peers increased as they participated in the EDP process. Such intentional grouping based on organic interests rather than forming groups based on deficits can augment social skill building in an authentic and strength-based manner (Kaboski et al., 2015; Martin et al., 2020)

Communication is another component ingrained in the EDP (Householder & Hailey, 2012; Khandhani, 2005). The OTPF-4 emphasizes the role of communication as crucial through which a therapist can create collaborative partnerships with their clients (students) (AOTA, 2020). When students' voices are heard and respected, a power shift occurs, giving students an agency in their intervention process (AOTA, 2020). As Cahill and Bazyk (2020) asserted, social skill interventions in the school context must center around autistic adolescents forming peer relations alongside an increased agency to participate in their social roles.

Furthermore, EDP can accommodate various conventional and non-conventional communication practices (Householder & Hailey, 2012; Khandhani, 2005). Autistic students experiencing challenges using verbal and written expression can incorporate various metarepresentational approaches like graphic organizers (e.g., storyboards), visual tools (e.g., videos, graphs, tabs, charts, lists), and symbols (Householder & Hailey, 2012). Using the EDP in combination with different channels (e.g., writing, text-to-speech, texting, graphs, symbols) can encourage participants to communicate however is effective for them, thus individualizing this process to their unique needs (Householder & Hailey, 2012). Emphasis should be placed on exchanging ideas rather than language, diction, grammar, or syntax. Additionally, groups should be assembled with the intent to minimize power hierarchies between members to ensure each member has equitable participation and that every member has an opportunity to ensure their voice is heard (Householder & Hailey, 2012).

The EDP can foster *creativity* and innovation in school contexts by incorporating iterative systems thinking, collaboration, and effective communication (Dym et al.,2005). Creativity is expanded through iterative loops of convergent thinking (when analytical skills are used to reach a confirmable answer) and divergent thinking (when a variety of strategies and possible solutions are considered before a response is confirmed) (Householder & Hailey, 2012), and this can augment autistic adolescents to convert their ideas into tangible solutions with real-world implications. OT practitioners can use this to their advantage by incorporating the EDP into interventions where autistic adolescents are propelled to problem solve in real-world scenarios using convergent and divergent thinking and use the feedback from these situations to develop and enhance their skills in academic and non-academic situations. Furthermore, OT practitioners can also help them participate and engage in their student roles in the classroom and outside.

Case study: Using EDP to solve tricky challenges about robots

The IDEAS (Inventing, Designing, Engineering for All Students) is an inclusive afterschool maker program developed to teach engineering, tinkering, designing, and technical skills to middle school students across three public schools in a large urban city (Martin et al., 2020; Chen et al., 2021). Both autistic and non-autistic students interested in engineering and tinkering were invited to participate in this club every year**.** Two teachers ran the club, and students acted as 'maker experts.' The EDP is integrated within the twelve-part core curriculum as a peer-mediated problem-solving approach every year.

Let us learn from Ms. Sandy and Ms. Katerina's (pseudonyms) experiences running the Maker club with their middle school students in an inclusive setting. The students are working on motors as the week's activity. First, Ms. Sandy and Ms. Katerina introduce them to the conceptual idea of motors, and the students and their teachers build their knowledge by discovering how motors work, how they get energy, and what objects have motors. Students are then introduced to the different types and parts of motors with which they can build their robots or other creations. Some parts included insulated wires, AA batteries, paper plates, cups, and sticks. The whole club then brainstorms together using ST and collaborative communication to develop creative ideas to make small machines or robots that work on motors. The challenge is to make these machines or robots move so they can have robot wars with their peers or complete a challenge to develop a new design.

Once this step is completed, students and teachers start working on their individual prototypes, discussing their ideas, correcting their errors, and thinking with their resources realistically. Then students match their prototype with expected outcomes and start iterating their designs while fixing errors and making changes. Finally, students present their finished products to peers and teachers while disseminating information about their finished products. Ms. Sandy and Ms. Katerina participate as peers throughout this cycle without taking the role of an expert or providing instructive feedback while working on their motor-controlled robots.

When Ross, an autistic student interested in robotics, approaches the teachers to take on the role of an expert, they create a leadership position for him, and he guides his peers through the process of robot-making while answering their questions. As Ross becomes the maker expert for the day, he helps his peers' problem-solve through collaborative brainstorming to meet their design goals. When Jamie is stuck in the prototype revision phase, Ross helps him by teaching him how to fix his motor to the robot, secure it and then test-run his robot. Once all the students build their robots, they spar or fight them against each other to find the best robot in their club.

While two teachers oversaw this group activity in this exemplar, the process can be easily adapted by OTs in individual or group settings as the process of problem-solving using the EDP is very adaptable. Furthermore, it can also be a curriculum-driven activity in which all students in a classroom can participate. Through this process, OTs can meaningfully integrate crucial age-appropriate occupations and performance skill development. The EDP has successfully been adapted to different activities like planning a taco party, creatively adapting a science class, or helping a student build a simple organizer for their school locker (EiE Spotlight, 2017; KQED Quest, 2017; Teach Engineering, 2018). For all these examples, the skills used by teachers, researchers, and practitioners included collaboration, facilitation, creativity, and the use of ST. OT practitioners are already adept at incorporating these skills into their intervention planning and delivery.

Clinical implications and assimilation of the EDP within OT interventions

Occupational Therapy's primary focus in schools is to propel students to obtain education despite any shortcomings by augmenting their environmental access to participation in a successful manner (Cahill & Bazyk, 2020). While conventional OT interventions focus on remediating negative behaviors like ABA (Anderson, 2022), communication and behavioral interventions

(Maw & Haga, 2018) to increase participation, such interventions focus only on adolescents' behaviors, not top-down capabilities like EF and problem-solving (Bustamante et al., 2018; Gardner & Iarocci, 2018; Patten-Koenig, 2020; Urbanowicz et al., 2019). OTs can adapt the EDP without using sophisticated engineering activities (Engineering Design Process, n.d.) to develop interest-based, top-down approaches that expose adolescents to generalized learning and adaptive strategies. Moreover, the EDP provides a self-sustaining system where students can learn and practice ST in real-world, contextually relevant, and interest-driven situations. Furthermore, they can make errors as a normalized part of problem-solving.

The dynamic and continuous nature of the collaborative partnership is ingrained in each step of the EDP. It can transcend home or classroom contexts, after-school activities, and non-academic spaces, leading to organic friendships. This creative problem-solving can effectively increase students' participation in academic and non-academic occupations in their classrooms by tackling daily challenges in these contexts. In addition, participation in shared occupations can lead to a sense of community among adolescents as they learn to work together on shared interest areas, leading to organic, spontaneous conversations initiated and sustained by autistic adolescents (Chen et al., 2021; Martin et al., 2020). Since such interactions are collaborative, the power of expressing ideas, finding solutions, and voicing concerns is distributed equally between the team members: OTs and students. Goals for school-based group interventions include collaborative and didactic interaction, which can be achieved with the EDP authentically and organically (OTPF-4 AOTA 2020; Householder & Hailey 2012; Katehi, 2009).

The EDP philosophy is consistent with OTs' multi-tiered interventions (Cahill, 2019). Whole classroom strategies, as Cahill notes, benefit all students. The EDP can be effectively adapted to fit school OT interventions. There is a potential to reduce challenges associated with traditional pull-out services that increase social isolation risk for autistic adolescents (Bolton & Plattner, 2020). Teachers and OTs can also develop and strengthen a critical collaborative relationship to ensure the attainment of educational goals for students (Bolton & Plattner, 2020).

Conclusion

EF are domain-general skills that help autistic adolescents to adapt and solve daily challenges encountered at school. Improving these skills must be a focus of OT as they propel participation in academic and non-academic school occupations and encourage integration in school communities. Problem-solving with peers expands collaborative and communicative skills. The EDP is structured to include collaborative work and improve cognitive flexibility, self-regulation, and working memory. OTs can implement the EDP in the whole classroom or small groups to solve daily challenges and act as collaborators, solving problems alongside each other, leading to more natural and context specific social skills. This democratizes and builds authentic partnerships by promoting the inclusion of disabled students by providing them with an agency in the learning process. The EDP's flexibility encourages the assimilation of students' interests and curiosity to solve daily challenges. It has the potential to level the playing field for children from marginalized and minority contexts, giving exposure to science and engineering alongside problem-solving skills. As Papert says, "We need to produce people who know how to act when they are faced with situations for which they were not specifically prepared (Papert, 1998)." The EDP has the potential to empower autistic adolescents through the development of fundamental learning, literacy, and life skills that prepare them to face the dynamic competitive, and dynamic employment market (Stauffer, 2020).

References

American Occupational Therapy Association (2017). Guidelines for Occupational Therapy Services in Early Intervention and Schools. American Journal of Occupational Therapy, *71*(Suppl. 2):7112410010p1–7112410010p10. DOI: 10.5014/ajot.2017.716S01

American Occupational Therapy Association. (2020). Occupational therapy practice framework: Domain and process (4th Ed.). *American Journal of Occupational Therapy*, *74*(Suppl. 2), S1–S87. doi: 10.5014/ajot.2020.74S2001

Anderson, L. K. (2022). Autistic experiences of applied behavior analysis. Autism. DOI: 10.1177/13623613221118216

Ashburner, J., Rodger, S., Ziviani, J., & Jones, J. (2014). Occupational therapy services for people with autism spectrum disorders: current state of play, use of evidence and future learning priorities. *Australian Occupational Therapy Journal*, *61*(2), 110–120. doi: 10.1111/1440-1630.12083

Bolton, T. & Plattner, L. (2020). Occupational Therapy Role in School-based Practice: Perspectives from Teachers and OTs. *Journal of Occupational Therapy, Schools, & Early Intervention, 13*(2), 136-146, doi:10.1080/19411243.2019.1636749

Bond, C., Symes, W., Hebron, J., Humphrey, N., & Morewood, G. (2016). Educating persons with autistic spectrum disorder–A systematic literature review. *The National Council for Special Education,[NCSE]*, *20*, 1-246. Retrieved from: https://hacerlobien.net/lego/Ter-030-Educating-Asd-Review.pdf

Bottema-Beutel,K., Kapp, S.K., Lester, J.N., Sasson, N. J., & Hand, B.N. (2020). Avoiding Ableist Language: Suggestions for Autism Researchers. *Autism in Adulthood,* [Ahead of print] doi: 10.1089/aut.2020.0014

Bustamante, A.S., Greenfield, D.B., & Nayfeld, I. (2018). Early Childhood Science and Engineering: Engaging Platforms for Fostering Domain-General Learning Skills. *Education Sciences, 8*(3), 144. doi: 10.3390/educsci8030144

Cahill, S. & Lopez-Reyna, N. (2013). Expanding school-based problem-solving teams to include occupational therapists. *Journal of Occupational Therapy in Schools & Early Intervention, 6*, 314–325.

Cahill, S. (2019). Multi-tiered systems of support. In G. Frolek, Clark, & J. Polochino (Eds.), *Best practices for occupational therapy in schools* (2nd ed), (pp.211-223). Bethesda, MD: AOTA Press.

Cahill, S. & Bazyk, S. (2020). School-based occupational therapy. In J.O'Brien & H. Miller-Kuhaneck (Eds.), *Occupational Therapy for Children and Adolescents* (8th ed.). St.Louis: Elsevier.

Chen, Y.L., Murthi, K., Martin, W., Vidiksis, R., Riccio, A. & Patten, K. (2021). Experiences of Students, Teachers, and Parents Participating in an Inclusive, School-Based Informal Engineering Education Program. *Journal of Autism and Developmental Disorders,(52),* 3574–3585 DOI: https://doi.org/10.1007/s10803-021-05230-2

Chui, A., Mazzitti, D., Nalder, E., Cameron, D., Polatajko, H., J. & Dawson, D.R. (2020). Therapists' experience of the cognitive orientation to daily occupational performance (CO-OP) approach: Shifting from conventional practice. *Scandinavian Journal of Occupational Therapy, 27*(2), 133-141, doi: 10.1080/11038128.2018.1483424

Cramm, H., Krupa, T., Missiuna, C., Lysaght, R. M., & Parker, K. C. H. (2013) a. Broadening the occupational therapy toolkit: An executive functioning lens for occupational therapy with children and youth. *American Journal of Occupational Therapy, 67,* 139–147. doi:

10.5014/ajot.2013.008607

Cramm, H. A., Krupa, T. M., Missiuna, C. A., Lysaght, R. M., & Parker, K. H. (2013) b. Executive functioning: a scoping review of the occupational therapy literature. *Canadian journal of occupational therapy, 80*(3), 131–140. https://doi.org/10.1177/0008417413496060

Cunningham, C.M., & Lachapelle, C.P. (2016). Designing Engineering Experiences to Engage All Students. *Educational Designer: Journal of the International Society for Design and Development in Education. 3*(9). Retrieved from: https://www.educationaldesigner.org/ed/volume3/issue9/article31/

DiDonato, N.C. (2013). Effective self- and co-regulation in collaborative learning groups: An analysis of how students regulate problem solving of authentic interdisciplinary tasks. *Instructional Science, 41,* 25–47. doi: 10.1007/s11251-012-9206-9

Diamond, A. (2013). Executive Functions. *Annual Review of Psychology, 64,* 135-168. doi: 10.1146/annurev-psych-113011-143750

Drigas, A., & Karyotaki, M. (2019). Executive Functioning and Problem Solving: A Bidirectional Relation. *International Journal of Engineering Pedagogy (iJEP), 9*(3), pp. 76–98. DOI: https://doi.org/10.3991/ijep.v9i3.10186

Dym, C. L. (1994). Engineering design: A synthesis of views. Cambridge, UK: Cambridge University Press.

Dym, C. L., Agogino, A. M., Eris, O., Frey, D. D., & Leifer, L. J. (2005). Engineering design thinking, teaching, and learning. *Journal of Engineering Education, 94*(1), 104-120.

Ehsan, H., & Cardella, M. E. (2020). Capturing Children with Autism's Engagement in Engineering Practices: A Focus on Problem Scoping. *Journal of Pre-College*

Engineering Education Research (J-PEER), *10*(1), 2. doi:10.7771/2157-9288.1262

EiE Spotlight. (2017). The Engineering Design Process in Action. *www.youtube.com.* Retrieved July 6, 2022. Retrieved from: https://www.youtube.com/watch?v=NeVxOAceij0&t=124

Engineering Design Process. (n.d.). *Teach Engineering*. Retrieved February 24, 2021, from https://www.teachengineering.org/design/designprocess

Gardiner, E., & Iarocci, G. (2018). Everyday executive function predicts adaptive and internalizing behavior among children with and without autism spectrum disorder. *Autism, 11*(2), 284–295. DOI: https://doi.org/10.1002/aur.1877

Greene, M.T. & Papalambros, P.Y. (2016). A Cognitive Framework for Engineering Systems Thinking. *2016 Conference on Systems Engineering Research,* 1-7. Retrieved December 24, 2020, from: https://www.nasa.gov/sites/default/files/atoms/files/42_greene_a_cognitive_framework_for_engineering_systems_thinking_1.pdf

Householder, D.L. & Hailey, C.E. (2012). Incorporating Engineering Design Challenges into STEM Courses. *National Center for Engineering and Technology Education.* Paper 166. https://digitalcommons.usu.edu/ncete_publications/166

Ikiugu, M.N., Plastow, N.A. & van Niekerk, L. (2019) Eclectic Application of Theoretical Models in Occupational Therapy: Impact on Therapeutic Reasoning. *Occupational Therapy In Health Care, 33*(3), 286-305, DOI: 10.1080/07380577.2019.1630884

KQED Quest. (2017). The Engineering Design Process: A Taco Party. *www.youtube.com.* Retrieved February 16, 2022, from https://www.youtube.com/watch?v=MAhpfFt_mWM&t=1s

Kaboski, J. R., Diehl, J. J., Beriont, J., Crowell, C. R., Villano, M., Wier, K., & Tang, K. (2015).

Brief Report: A Pilot Summer Robotics Camp to Reduce Social Anxiety and Improve Social/Vocational Skills in Adolescents with ASD. *Journal of Autism and Developmental Disorders, 45*(12), 3862–3869. doi: 10.1007/s10803-014-2153-3

Kapur, M. (2008). Productive failure. *Cognition and Instruction, 26*(3), 379–424. doi:10.1080/07370000802212669.

Kapur, M. (2011). A further study of productive failure in mathematical problem solving: Unpacking the design components. *Instructional Science, 39*(4), 561-579. doi: 10.1007/s11251-010-9144-3.

Katehi, L., Pearson, G., & Feder, M. (2009). Engineering in K-12 Education: Understanding the Status and Improving the Prospects. *National Academy of Engineering and National Research Council.* Washington, DC: A consensus report. doi:10.17226/12635

Kenny, L., Hattersley, C., Molins, B., Buckley, C., Povey, C., & Pellicano, E. (2016). Which terms should be used to describe autism? Perspectives from the UK autism community. *Autism, 20*(4), 442-462. doi:10.1177/1362361315588200

Khandani, S. (2005). Education Transfer Plan. Retrieved December 24, 2020, from: http://www.frlr.utn.edu.ar/archivos/alumnos/electronica/catedras/41-proyecto-final/Engineering_Design_Process_Seyyed_Khandani.pdf

Kornblau, B.L. & Robertson, S.M. (2021) Special Issue on Occupational Therapy With Neurodivergent People. *American Journal of Occupational Therapy*. 75(3), 7503170010. doi: https://doi.org/10.5014/ajot.2021.753001

Lottero-Perdue, P. S., & Parry, E. A. (2017). Perspectives on Failure in the Classroom by Elementary Teachers New to Teaching Engineering. *Journal of Pre-College Engineering Education Research (J-PEER), 7*(1), Article 4. doi: 10.7771/2157-9288.1158

Mann, D., et al. (2015). Executive functioning: Relationship with high school student role performance. *Open Journal of Occupational Therapy, 3*(4), Article 2. doi: 10.15453/2168-6408.1153

Martin,W.B., Yu, J., Wei, X., Vidiksis, R., Patten, K.K., & Ricco, A. (2020). Promoting Science, Technology, and Engineering Self-Efficacy and Knowledge for All With an Autism Inclusion Maker Program. *Frontiers in Education, 5*(75). doi:10.3389/feduc.2020.00075

Mandich, A. D., Polatajko, H. J., Macnab, J. J., & Miller, L. T. (2001). Treatment of children with developmental coordination disorder: What is the evidence? *Physical and Occupational Therapy in Pediatrics, 20,* 51–68. DOI: 0.1080/J006v20n02_04

Maw, S.S., & Haga, C. (2018). Effectiveness of cognitive, developmental, and behavioural interventions for Autism Spectrum Disorder in preschool-aged children: A systematic review and meta-analysis. Heliyon, 4(9), e00763. DOI: 10.1016/j.heliyon.2018.e00763

Missiuna, C., Mandich, A. D., Polatajko, H. J., & Malloy-Miller, T. (2001). Cognitive Orientation to daily Occupational Performance (CO-OP): Part I: Theoretical foundations. *Physical and Occupational Therapy in Pediatrics, 20,* 69–81. DOI: 10.1080/J006v20n02_05

Papert, S., & Harel, I. (1991). Situating constructionism. *Constructionism*, *36*, 1-11.

Papert, S. (1998). Child Power: Keys to the New Learning of the Digital Century. *Eleventh Colin Cherry Memorial Lecture on Communication.* Lecture presented at the Imperial College in London, UK.

Patten Koenig, K. (2020). Authentic strength-based practice: Can Neurotypical professionals make a paradigm shift? *Autism Spectrum News.* Retrieved from:

https://autismspectrumnews.org/authentic-strength-based-practice-can-neurotypical-professionals-make-a-paradigm-shift/

Polatajko, H.J. (2017). Cognitive Orientation to daily Occupational Performance (CO-OP) Approach. In. Hinojosa, J., & Paula, K. (Eds.) *Perspectives on Human Occupation: Theories Underlying Practice* (2nd ed), (pp. 183-206). F.A. Davis.

Poon, K. (2018). Hot and Cool Executive Functions in Adolescence: Development and Contributions to Important Developmental Outcomes. *Frontiers in Psychology, 8,* 2311. doi: 10.3389/fpsyg.2017.02311

Rodger, S., & Vishram, A. (2010). Mastering social and organization goals: Strategy use by two children with Asperger syndrome during cognitive orientation to daily occupational performance. *Physical and Occupational Therapy in Pediatrics, 30,* 264–276. doi: 10.3109/01942638.2010.500893

Scardamalia, M., & Bereiter, C. (2003). Knowledge building. In J. W. Guthrie (Ed.), *Encyclopedia of Education*, 1370–1373. New York: Macmillan.

Sneider, C. (2011). A possible pathway for high school science in a STEM world. *National Center for Engineering and Technology Education.* Retrieved December 24, 2020, http://ncete.org/flash/pdfs/Possible%20Pathway%20Sneider.pdf

Sneider, C. (2012). Core ideas of engineering and technology: Understanding a Framework for K-12 Science Education. *Science Teacher,* 32-36.

Stauffer, B. (2020). What Are 21st Century Skills? *Applied Education Systems.* Retrieved from: https://www.aeseducation.com/blog/what-are-21st-century-skills

Teach Engineering. (2018). Solving Everyday Problems Using the Engineering Design Cycle. *www.youtube.com.* Retrieved July 6, 2022, from https://www.youtube.com/watch?v=JyHwsKm-TKo&t=2s

Thiessen, S. (2019). Trial and Error Problem Solving Creates Problems. *Problem Solving.* Retrieved February 24, 2021, from https://inharmonytraining.com/trial-and-error-problem-solving/

Urbanowicz, A., Nicolaidis, C., Houting, J. d., Shore, S. M., Gaudion, K., Girdler, S., & Savarese, R. J. (2019). An expert discussion on strengths-based approaches in autism. *Autism in Adulthood, 1*(2), 82-89. DOI: 10.1089/aut.2019.29002.aju

Vaidya, C. J., You, X., Mostofsky, S., Pereira, F., Berl, M. M., & Kenworthy, L. (2020). Data-driven identification of subtypes of executive function across typical development, attention deficit hyperactivity disorder, and autism spectrum disorders. *Journal of Child Psychology and Psychiatry*, *61*(1), 51-61. doi: 10.1111/jcpp.13114

Webb, B. J., Miller, S. P., Pierce, T. B., Strawser, S., & Jones, W. P. (2004). Effects of social skill instruction for high-functioning adolescents with autism spectrum disorders. *Focus on Autism and Other Developmental Disabilities, 19*(1), 53–62. doi: 10.1177/10883576040190010701

Figure 1: EDP cycle

Adapted from (Martin et al., 2020)

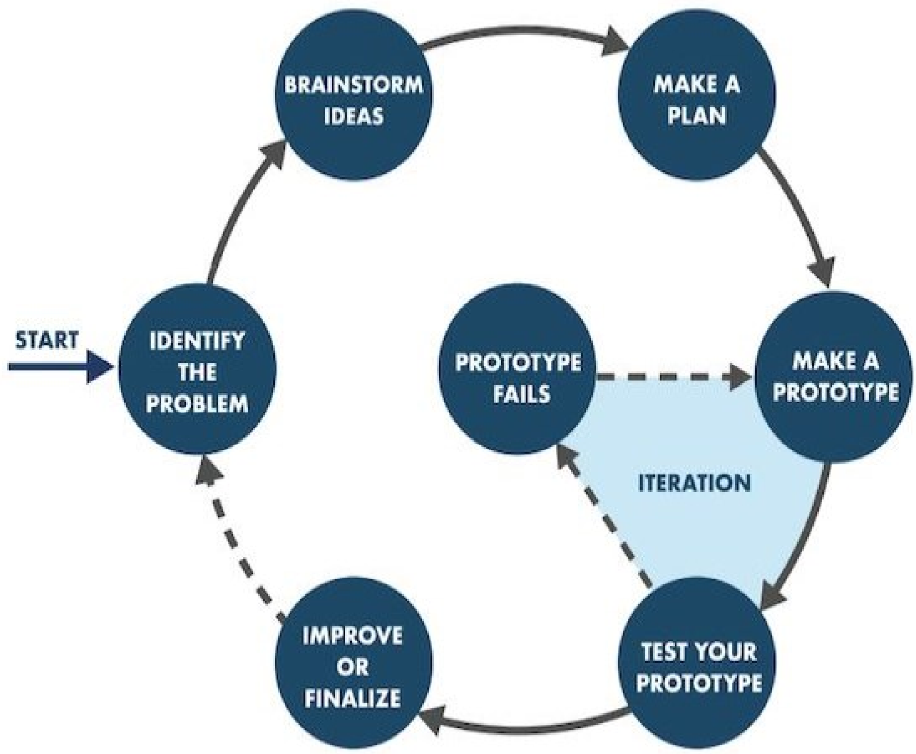

Table1: Elements of EDP that enhance EF and problem-solving skills

Component of EDP	Step of EDP cycle	EF skill that can be developed	Problem-solving skill that can be developed	How do users of EDP learn these skills?
Systems Thinking	Problem-scoping/ problem defining stage (1st stage of EDP)	Cognitive flexibility and working memory	Problem identification (Brown et al., 2021)	Students can learn about the problem deeply and from different angles to find information about its nature, complexities, challenges to solve the problem, and availability of resources (Khandani, 2005).
Collaboration	Problem identification and scoping, identifying possible solutions, building, refining, and evaluating prototype	Self-regulation and co-regulation	Self-regulation	Students can be motivated to persist through frustrations and regulate each other as a group, thus building crucial self-regulatory skills (DiDonato, 2013).
Communication	Identifying possible solutions, building, refining, and evaluating the prototype, and dissemination	Cognitive flexibility, working memory	Reflection, critical analysis, and brainstorming	Students learn to ensure that a proposed solution is feasible, accurate, appropriate, easy to use, and appealing, along with developing expressive skills (Khandhani, 2005).
Creativity	Identifying the problem, finding possible solutions, creating, refining, and testing prototypes	Cognitive flexibility, working memory	Organization, planning, sequencing, and correcting errors to achieve a final creative thought or a novel product (Diamond, 2013; Householder & Hailey, 2012).	Diamond (2013) underscored that engaging in activities that foster creative thinking can boost the capacity to visualize connections between apparently unconnected ideas by disassembling and recombining ideological elements in new ways (Diamond, 2013).

Response to Associate Editor:

Comments to the Author:

While the reviewers are generally enthusiastic about this paper, I see several areas where it could be strengthened. Please consider the comments below as part of the revision process:

Thank you so much for reviewing our paper and providing us with an opportunity to revise and resubmit. We have made our changes in red font in our paper.

1. The authors do not present a clear or strong issue, problem, or argument, but rather describe an approach.Please restructure to provide less of a description and more of an argument as per the Author Guidelines. For example, The Issue Is.. is designed to "provide a forum for scholars to debate professional issues that have an impact on the evolution of the profession."

Thank you for this suggestion. We have revised this section to include a clearer issue on pg. 5. Please find it here. *As a result, EF deficits can go untreated, hindering educational performance and participation in the student role by causing secondary mental health challenges (e.g., anxiety) in this population (Kaboski et al., 2015; Webb, 2004). To address this gap in the current evidence base, we propose including a unique peer-mediated problem-solving strategy called the Engineering Design Process (EDP), as presented in figure 1, that can develop EF along with problem-solving. Hence, we advocate for the benefits of EDP by introducing this approach to school-based OT practitioners. Furthermore, we present a real-world case study where we have implemented this problem-solving approach to develop and expand the EF and problem-solving skills of autistic adolescents.*

2. There are some unsupported statements in various places such as line 263 where the authors say "While conventional OT interventions focus on remediating negative behaviors to increase participation..." (no citations). Suggesting the this approach can be 'amalgamated' with CO-OP is somewhat problematic in that CO-OP is a structured, evidence-based practice.

We have reviewed the paper to include references in areas with unsupported statements. We edited this statement to add examples and bolstered it with citations. Please find the revisions here, and you can find the revisions on pg. 13. *While conventional OT interventions focus on remediating negative behaviors like ABA (Anderson, 2022), communication and behavioral interventions (Maw & Haga, 2018) to increase participation, such interventions focus only on adolescents' behaviors, not top-down capabilities like EF and problem-solving (Bustamante et al., 2018; Gardner & Iarocci, 2018; Patten, 2020; Urbanowicz et al., 2019).*

We have revised our statements on pg. 6 by converting our assertive statements into possibilities using the eclectic approach. Please find our revisions here. *When we compare the EDP with existing OT models, we note that this framework has the potential to meld with an existing OT model- the Cognitive Orientation of Occupational Performance (CO-OP). Ikiugu, Plastow, and van Niekerk (2019) have emphasized the importance of combining models of practice with each other in a systematic manner by adopting the eclectic framework to address clients' needs to an optimal level. The EDP has the potential to be used flexibly along with CO-OP as a complementary tool to facilitate peer-mediated problem-solving.*

3. As one of the reviewers points out, Figure 2 needs to be revised.

Thank you for this suggestion. We have decided to remove figure 2 as it was redundant and did not present extra information to our manuscript.

4. There are quite a few APA errors (e.g., reference list, authors not cited in alphabetical order in text, etc.) that should be corrected.

We have edited the reference list. Please find the revisions in the manuscript between pages 16-23. All the edits are in red font.

Response to Reviewer 1
Comments to the Author

Wonderful article. Will contribute to the profession. Thanks for letting me review it.
We thank you for taking the time to review our manuscript and for providing your wonderfully positive feedback! We appreciate your feedback greatly!

Response to Reviewer 2
Comments to the Author

I found this manuscript very engaging, unique, and timely. Executive functions as well as afterschool occupations are of increasing interest and concern to OTPs. The manuscript is very clear and, though situated in school-practice, I think that there are a number of relevant contexts to which the ideas presented can be applied. The only thing that I would change is the final figure (Figure 2). The relationships are made very clear in the manuscript but not in the illustration. Every step in the EDP appears to impact, in different ways, EFs and that does not come across in Figure 2. I would eliminate it or redo it.
We want to take this opportunity to thank you very much for your thoughtful consideration of our manuscript, appreciated its value outside school-based practice and provided constructive feedback! We appreciate it greatly! We decided to eliminate figure 2 as it couldn't capture the essence of our written manuscript and it seemed redundant after we edited our manuscript. But we appreciate your comments. Thanks again!

Some thoughts and questions that come to my mind in Figure 2:

1. It seems to me that Step 1 and 2 are not ordered properly in Figure 2. In Figure 1 it implies that the data is gathered when identifying the problem. It would seem to make better sense to me that all the information (systems thinking) would be gathered and then an identification of the problem would be made. To me that's a process of collecting data from all sources while simultaneously activating prior knowledge. This steps seems heavily reliant on communication and collaboration which only show up later in step 3 and 7.

2. I am not clear why you eliminated the brainstorming step that is illustrated in the EDP. That creativity step seems to be a central component of the manuscript and it is a central part of EDP. I would suggest leaving that step in and making the links between self regulation, cognitive flexibility, working memory, and convergent thinking more explicit.

3. Having done a fair amount of work in robotic afterschool programs with this population, making a plan that results in a prototype is very difficult and, as as noted above, relies on considerable scaffold in self regulation, cognitive flexibility, working memory, and convergent thinking (along with communication and collaboration). Figure 2 would make better sense, again, if those relationships were clearer. In addition, I think that it would align better with your argument that the Go-Plan-Do-Check and Co-Op approaches align.

4. If you leave step 3 labeled as ID Possible Solutions rather than Make Prototype as depicted in Figure 1, I think that I would include something about forming a working hypothesis, again to align with Co-Op. Again, aligning quite significantly on self-regulation, this iterative cycle, is not clear on Figure 2. I think you could tie in your ideas re: divergent thinking (finding the dis-confirmatory evidence), pattern recognition, and hypothesis generation more clearly.

5. It looks like you are adding an additional iterative cycle in Figure 2 - that seems redundant to me. I would use the EDP process as illustrated in Figure 1 to show the iterative evaluative process.

6. Lastly, as I note in #1 above, I think you describe communication and collaboration as central and overarching tenets to this process. I do not think that is clear at all in Figure 2.

We revised the sentence on pg. 8 as follows: The impact of each component on EDP and problem-solving is presented below.