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Spatial development program for middle school: teacher perceptions of effectiveness

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Abstract
International comparisons suggest that middle school American students compare poorly to their international peers in tasks that require spatial skills. This deficiency in spatial skills is more prominent in females and has been linked to a lack of developmental activities influenced by gender norms. These deficiencies are especially concerning as increased spatial skills have been repeatedly linked to success in technology and broader STEM learning environments. In females, increased spatial skills have also been linked to positive affective outcomes. Formalised approaches to spatial skill development in middle school are rare and their effectiveness is often limited due to a failure to incorporate the perspectives of practitioners when developing said programs. This paper analyses teacher perceptions of a program designed to address spatial skill development in middle school children. The analysis is based on data collected from the 13 teacher participants at the end of each the 9 modules within the initial program delivery. An outline of program development and examples of materials used are provided. Thematic analysis is used to examine teacher perceptions of program effectiveness and student affect. The findings highlight the impact of teacher perceptions on fidelity of implementation and the need for tailored professional development. Implications for further program development, teacher professional development opportunities and the role of the practitioner in curriculum development are discussed.

Keywords Spatial skills · Spatial development · Curriculum development · STEM

Introduction

Increased spatial skills have been linked to problem solving in technology education (Buckley et al. 2019; Williams et al. 2008). In addition research has consistently highlighted a relationship between spatial skills and performance in broader STEM learning

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environments (Ramey and Uttal 2017; Wai et al. 2009). Similar links between the most basic mathematical abilities (e.g. counting) and spatial skills have been observed in pre-school populations (Hoshi et al. 2000; Zhou et al. 2006). The importance of spatial skills relative to more complex forms of STEM achievement has also been observed at middle school (Newcombe 2010), high school (Lubinski 2010) and university level (Maloney et al. 2012). In addition Sorby et al. (2018) present 5 years of program implementation data, with over 3000 participants, at university level and highlight links to future STEM performance. In this study, not only did spatial skills improve, but students earned higher grades in a variety of STEM courses and women, in particular, were retained in engineering at a higher rate compared to those who did not go through the intervention. While further research is required to more fully understand the causal nature of the relationship between spatial skills and STEM achievement, a critical mass of research supports the supposition that "spatial ability plays a critical role in developing expertise in STEM" (Wai et al. 2009, p.817).

In light of recent PISA findings, the need to enhance STEM achievement in middle school level is more pressing than ever before (OECD 2016). PISA results have repeatedly highlighted the gap between American middle school mathematical achievements relative to their international peers. When this gap is further examined spatial skills are highlighted as one of the primary sources of this underachievement (OECD 2016). Sorby and Panther (2020) examined student scores on the four mathematics constructs included in PISA testing. They found that US students are consistently behind students from high-performing Asian countries on the Space and Shape construct and also behind many of the other G7 countries. The poor performance of American students on the Space and Shaped construct of PISA results in lower than expected mathematics performance overall, especially when considering that per student education spending in America is among the highest in the world. From a pragmatic perspective, it makes sense to target this under developed skill set as a starting point in a wider effort to enhance STEM achievement.

Spatial skills also play a particularly interesting role in the observed gender divide in STEM achievement. Within the last 40 years, differences across gender in math performance have continually narrowed, yet differences remain in spatial domains (Else-Quest et al. 2010). A large scale meta-analysis noted that the "largest mean effect size in math achievement [between gender] was in the content domain of Space/Shape on PISA (d 0.15)" (Else-Quest et al. 2010, p.122). These differences have been attributed to environmental factors that influence spatial skill development from a young age (Voyer et al. 1995). The gender difference is especially evident in 3D rotations. A study on mental rotation-based data from 53 countries noted significant differences between gender (Lippa et al. 2010) across all countries. Gender differences in spatial skills have not decreased in line with broader mathematics assessments which saw the gender gap significantly reduced (Voyer et al. 1995). Gender differences in spatial skills have serious implications for addressing current gender imbalances within STEM learning environments and highlights the need to address spatial deficiencies at a young age.

Gender differences in spatial tasks have been observed in children as young as 5 months as well as in adult populations. However, multiple intervention-based studies have demonstrated that this gap can be reduced significantly (e.g., Sorby 2009). Improving spatial skills has also led to improvements in STEM achievement among females who have taken part in spatial skill development interventions demonstrating improved performance and increased retention (Sorby 2001; Sorby et al. 2018). This is reflected in recent research which examines the *affective* impact of successful spatial skills interventions. Participants, particularly female participants, who increase spatial skills also demonstrate reduced spatial anxiety

(Ramirez et al. 2012), mathematics anxiety (Ma and Cartwright 2003), fear of mathematics (Ashcraft and Kirk 2001) and stereotype threat (McGlone and Aronson 2006). The majority of interventions aimed to address spatial skill deficiency tend to focus on university level students already enrolled in STEM programs. While this approach has been effective in terms of women who have already selected STEM program, it fails to address the gender imbalance and general lack of students entering these disciplines.

By addressing the lack of formal spatial skills development opportunities in a typical pre-college classroom, an intervention designed to develop these skills in middle school could potentially lead to increased STEM performance, reduced gender imbalance within STEM environments, and positively influence students' affect for STEM pathways. However, when considering a teacher-led intervention, it is essential to consider teacher perceptions of effectiveness. Studies have shown that teacher perceptions regarding the quality and effectiveness of an intervention can influence fidelity and ultimately impact (Donnell and Gettinger 2015). Understanding variance in teacher perceptions and reactions to new practices is critical for successful large-scale implementation (Stuart et al. 2011). This has also been recognised at policy level—Datnow and Castellano (2000) stress that teacher attitudes are an essential component of successful implementation of interventions. As such, teacher perceptions are presented as a key variable in the effectiveness of any classroom-based intervention and warrant examination.

Spatial skills and existing curriculum

The spatial skills development program that is examined within this paper has been designed in a modular fashion so that it can be incorporated into a wide range of existing curricula. The initial deployment examined in this study takes place in 7th grade mathematics classrooms in the US and as such aligns with principles taken from the National Council of Teachers of Mathematics (NCTM 2016). These principles and standards refer to developing visualization skills through hands-on experiences with a variety of physical resources but also through the use of technology. The program provides physical resources in order to facilitate a wide range of pedagogical strategies and also includes specially designed software which aids in differentiation and independent problem solving (Gerson et al. 2001). The standards reference an ability to interpret 2D information and transform it to a 3D representation, but also represent 3D objects using 2D systems. The exercises within each module reflect this need for deep conceptual learning that could be undermined if the lack of variety of activities resulted in procedural approaches to problem solving. This allows for development of a high level of mastery and conceptual understanding. There are many parallels between areas outlined by the NCTM (NCTM 2016) and areas of national underperformance as outlined by PISA (OECD 2016).

In implementing spatial reasoning within middle school mathematics classrooms, teachers have been hampered by limited professional development opportunities related to how to develop spatial thinking and a lack of materials that are available for including this instruction in their everyday teaching (Moore-Russo et al. 2013). The materials described in detail in this article have been shown to improve students' spatial reasoning skills and are suitable for inclusion in a middle school mathematics syllabus (Sorby 2009; Rafaelli et al. 2006). The materials have been pilot-tested in several middle school classrooms and are the focus of a current Goal 3 (Efficacy and Replication) research project from the Institute for Education Sciences through the U. S. Department of Education. While previous deployments of the program support wider adoption, it is critical that the perspectives of teachers implementing the program are examined if the program is to be effective at a larger scale (Charalambous and Philippou 2010; Handal and Herrington 2003). The curricular materials used in the program are currently available for a nominal cost through higheredservices.org.

Structure of the spatial skills development program

The program outlined here has been developed in response to the growing need to target the development of spatial skills in a middle school setting. The modular nature of the program reflects an overall design that seeks to be flexible in order to meet the requirements of an often crowded curricula while addressing the various pressing concerns of educators, researchers, and policy makers. The program consists of 10 modules. In previous pilot studies using these materials in middle school classrooms (Rafaelli et al. 2006; Sorby and Veurink 2019), teachers were allowed to flexibly adapt materials and offer them at times that were of their choosing and some modules were omitted from instruction all together. Positive outcomes in terms of spatial skills development and transfer to mathematics achievement were observed in these pilot studies. The modules have been designed so that they can be adapted to meet the requirements of existing scheduling structures. Each module focuses on a particular aspect of spatial reasoning that has been empirically linked to overall spatial skill development (Buckley et al. 2018). While efforts have been made to increase the flexibility of the program by developing it in a modular fashion, there are some modules that must be covered in a linear manner in order to develop essential prerequisite skills. The various individual models and essential paths are outlined in Fig. 1.

Support resources

Each module is supported with a variety of resources including specialised software, video tutorials, PowerPoint slides, a teacher guide book and a student workbook. In addition, physical modelling materials are also recommended for use in teaching the curriculum. Manipulatives include Snap Cubes, honeycomb party favours that are used by the student to demonstrate the concept of solids of revolution, K'Nex pieces to create 3-D axes for object rotation, and paper patterns for nets that students can cut out and fold to create 3-D objects. A comprehensive set of resources provides opportunities for teachers to adopt a wide variety of pedagogical approaches suitable to their individual classroom and teaching style. These resources have been developed with the help of practicing middle school teachers and have been refined through multiple development cycles.

Each module presents several different activity types with various difficulty levels presented to allow for differentiation. The different types of activity within each module require different approaches ensuring a more complete development of the skill targeted by the module. For example, within module *4-Orthographic Drawings* activities require students to interpret multiple 2D views and select the correct 3D view (see Fig. 2).

As the difficulty increases, students are required to interpret 2D views and then construct a 3D solution. Conversely students are later required to interpret 3D views and construct multiple 2D views that adequately convey all necessary information about the object (see Fig. 3).

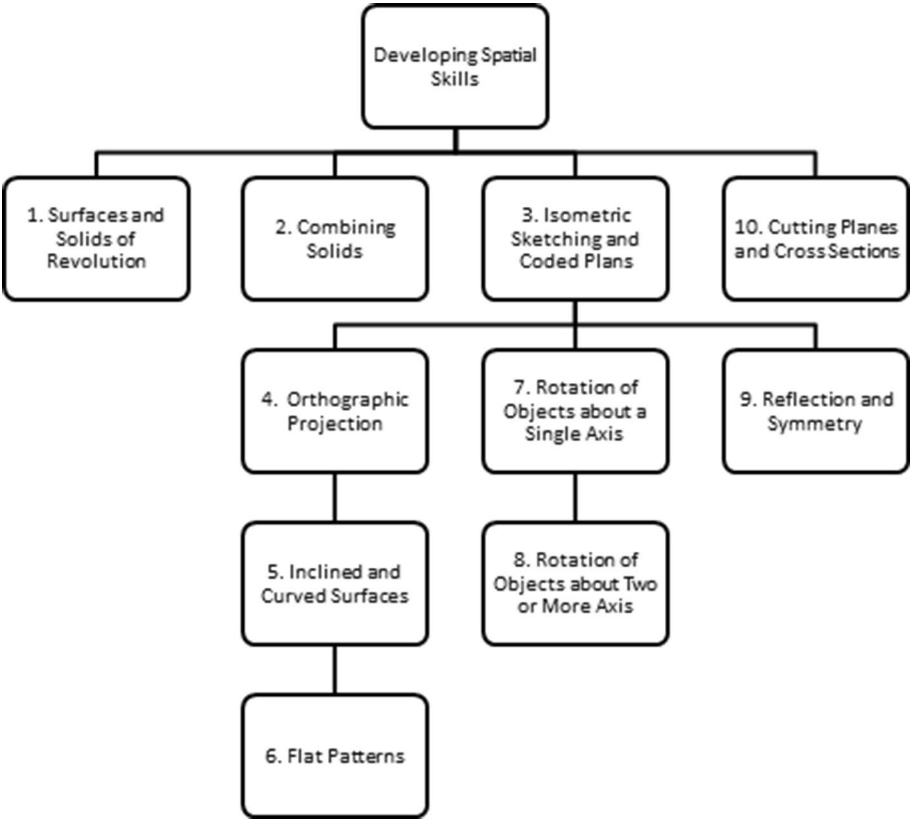


Fig. 1 Program structure

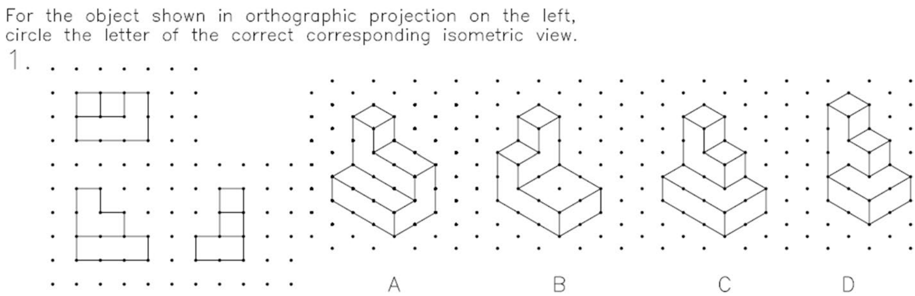


Fig. 2 2D to 3D visualization and selection task

Transformation from 2 to 3D, and later from 3 to 2D, provides an excellent opportunity for formative assessment. In this manner, a teacher can ascertain whether a student is demonstrating a conceptually sound understanding of the topic, or whether they are using rote steps to simply complete the exercise. This is representative of all module designs which aim to provide consistent opportunities for formative assessments and comprehensively

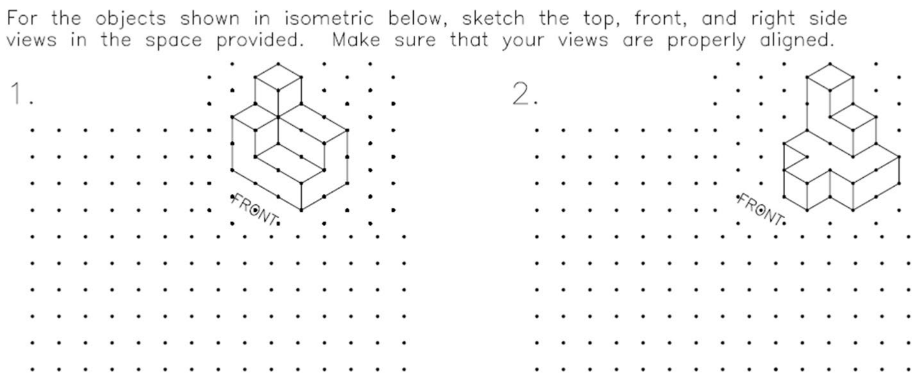


Fig. 3 3D to 2D Representation task

address the prescribed skill. It should be noted that the modules were designed in a manner that encourages teachers to employ their own chosen pedagogical strategies in order to reach, and enhance, the learning goals of each module.

Example module

The following is presented as an example of the implementation of just one module in the curriculum—Surfaces and Solids of Revolution. Implementation of the remaining nine modules would follow a similar pattern. The recommended coverage for each module begins with a mini-lecture on the topic [Access to PowerPoint slides for the mini-lecture for each module can be found at: https://www.higheredservices.org/spatial-course-mini-lectures/].

For module 1, the mini-lecture starts with definitions of Surfaces and Solids of Revolution and how they differ from one another. Basically, a Surface of Revolution is like a thin ribbon in space—it has no volume, only surface area. A Solid of Revolution is a solid object with both a volume and a surface area. Figure 4 illustrates the difference between the two types of geometric entities.

Next students learn that a different surface/solid is obtained depending on which axis a person chooses to rotate the 2-D shape about. Figure 5 shows a 2-D shape that has been revolved about one axis and then a different axis, resulting in two distinctly different objects. Figure 5 illustrates this concept. Students then learn that a shape does not need to be revolved by a full 360-degree angle. The shape can be revolved 90, 180, or 270° and a different object will result each time.

The next principal to be covered is that a hollow object results if the shape being revolved is located a certain distance away from the axis of revolution as illustrated in Fig. 6.

Finally, students are instructed to visualize revolutions by first reflecting the 2-D shape across the axis of revolution and then connecting the corners of the shape with circles (Fig. 7).

After the students learn the basics about the topic for a given module, they spend time working with the software, either individually or in pairs. A sample of the software module is found at: https://www.higheredservices.org/HESpB5KsQWQJ/Module_1/modul

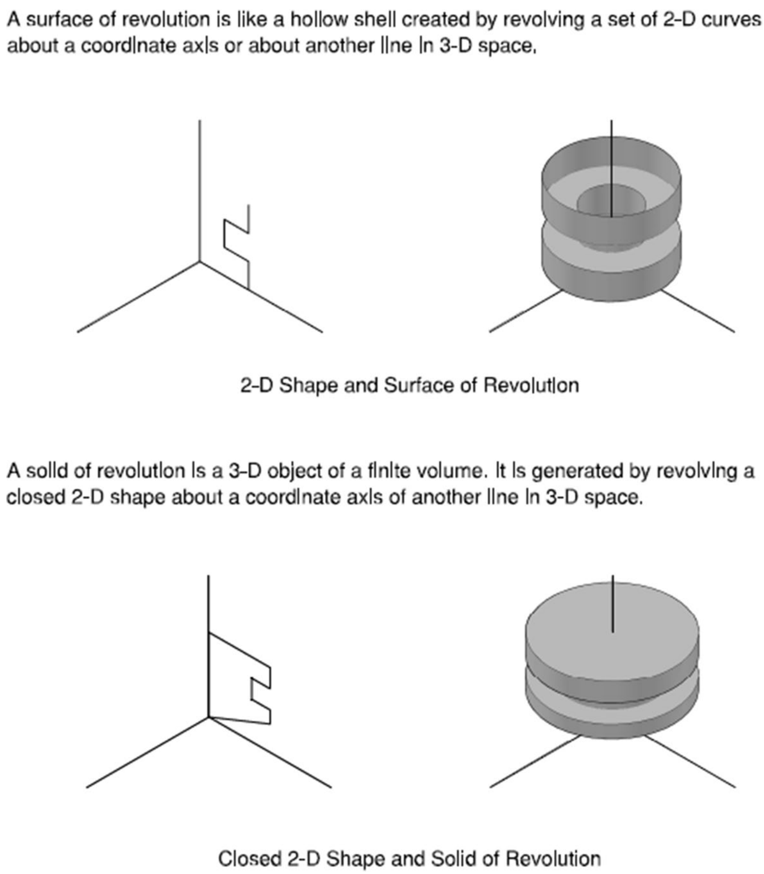


Fig. 4 Surfaces and solids of revolution

e_1_theme_1.html. The software begins with background material similar to that illustrated in the PowerPoint mini-lecture and reinforces topics for the students with colourful animations designed to illustrate key points. After they have completed the software, students are assigned various pages from the workbook. Appendix A includes sample pages from the workbook illustrating the different types of problems found in the Surfaces and Solids of Revolution module.

Evidence of impact

The Spatial Skills Development Program was previously used in a pilot study in partnership with middle school students and teachers. The results shown in Fig. 8 were obtained with 8th grade students enrolled in an Integrated Technology course who completed the curriculum as part of the required course (Rafaelli et al. 2006). These students demonstrated a considerable improvement in several tests of spatial cognition, including those in Mental Rotation, Cutting Planes, Folding Patterns and Isometric Interpretation.

The resulting solid or surface of revolution will vary depending on the chosen axis of revolution.

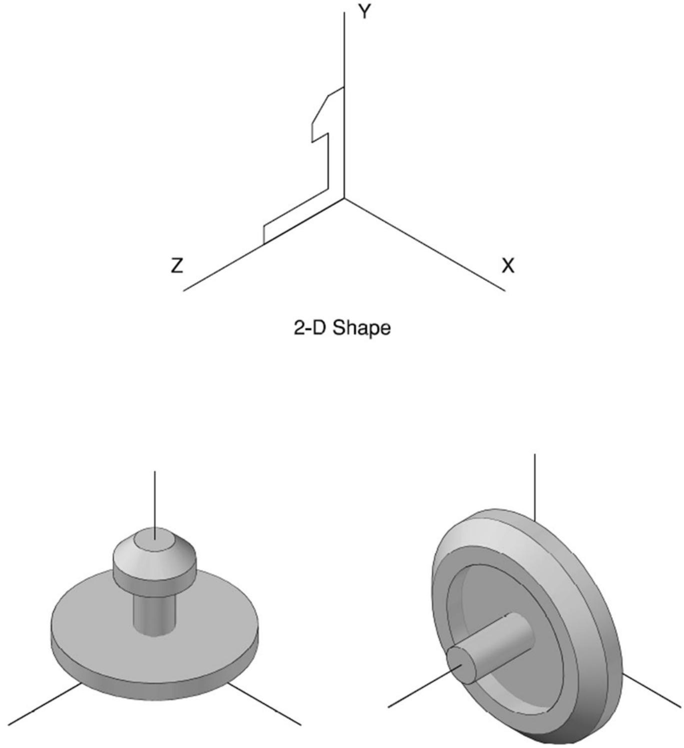


Fig. 5 Axis dependent revolution

If the axis of revolution is not located on the 2-D shape itself but some distance, x, away from it, then a solid of revolution with a cylindrical hole of diameter 2x will be created from it.

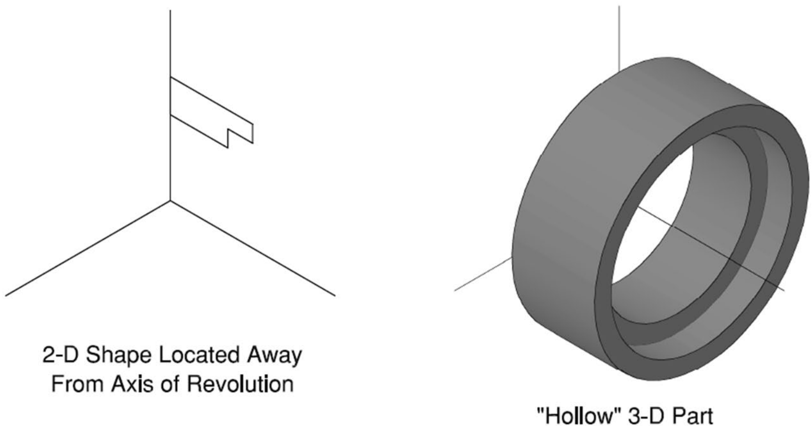


Fig. 6 Hollow 3D part

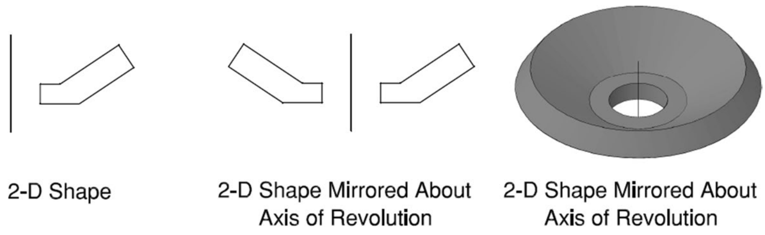
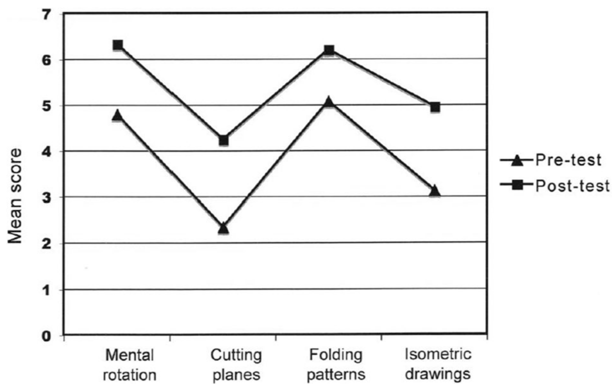


Fig. 7 Visualizing a revolution

Fig. 8 Middle school improvement rates (Rafaelli et al. 2006)



The use of the program with university students demonstrated similar improvement rates through numerous studies (Sorby 2001). Sorby et al. (2018) presents data from a 5-year application of the program with over 3000 participants suggesting significantly increased spatial skills and highlights links to broader STEM success. In a middle school pilot study (Sorby and Veurink 2019), positive outcomes were obtained in terms of spatial skills development as well as mathematics achievement. In addition, as mentioned previously, the program outlined here is currently deployed in a large-scale middle school-based study funded by the Institute for Education Sciences of the U.S. Department of Education; preliminary results suggest the program is suitable and effective in a middle school setting. However, the perspectives and values of teachers implementing this specific program remain unclear as teachers' values regarding curriculum adoption have been found to be critical to initial effectiveness and development (Kirk and MacDonald 2001), the data presented here begin to answer these questions. With the effectiveness of the program previously established, the primary aim of the current study is to examine teacher perceptions regarding the design and delivery of the program.

Methods

In order to examine teacher perceptions, relating to the effectiveness and usability of the program, fidelity data was gathered at the end of each module. The program was initially delivered throughout the academic year 2016–17 after the completion of a training workshop attended by participating teachers. In total 13 teachers completed at least

80% of the program as part of their regular classroom teaching during the academic year following the training workshop and were deemed eligible for inclusion in the current study. The program was delivered in 13 separate middle schools in the Midwest of the United States of America to 7th grade students. Fidelity logs tracked completion of modules by teachers and included self-reported time spent on each activity and resources used within lessons. The focus of the current study is the qualitative answers provided in response to questions focusing on teacher perceptions of module effectiveness and teacher perceptions of student affect and engagement for each module. In order to analyse this data, Braun and Clarke's (2006) 6-step framework was employed. Review and coding were completed by the lead author of this paper. The first phase of analysis required a comprehensive review of all data in order to familiarise the researcher with the data set and create initial notes; the second phase coded responses. A review of all generated codes was completed during phase three in order to ensure consistency and to avoid overlap. Phase four resulted in the identification of themes within which these codes resided. This phase also examined links between themes. Phase 5 generated definitions for each theme in order to differentiate between each and to aid clarity in final reporting. Finally, phase 6 resulted in the report which outlines links between themes and forms the basis of this study (See Figs. 9, 10).

Trustworthiness was addressed in line with Nowell et al. (2017). Specifically, credibility, dependability and reflexivity informed the design and execution of the study. Credibility was enhanced through the use of peer debriefing (Lincoln and Guba 1986). Dependability was enhanced through rigorous record keeping with each of the 6 stages clearly documented and made accessible for peer review in line with Tobin and Begley (2004). Reflexivity was considered throughout the analysis and was again addressed through peer debriefing (Tobin and Begley 2004).

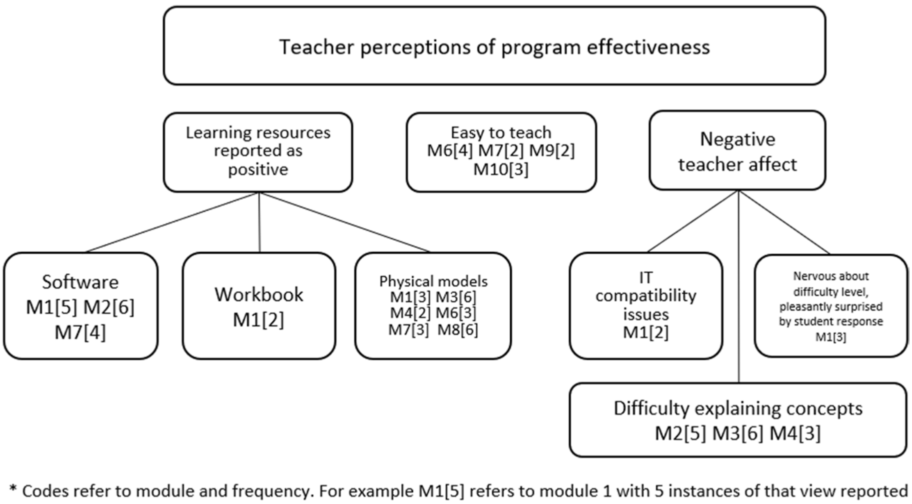


Fig. 9 Thematic map of teacher perceptions of program effectiveness

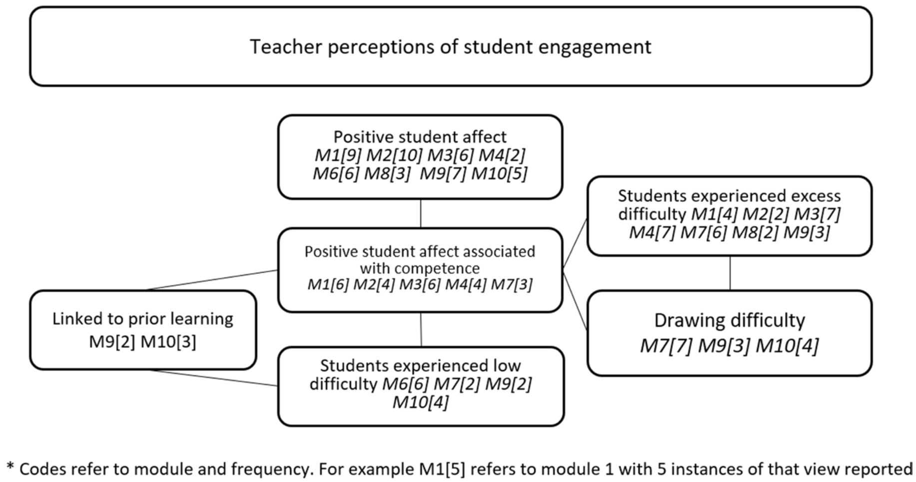


Fig. 10 Thematic map of teacher perceptions of student affect and engagement

Findings

The following section outlines teacher perceptions of module effectiveness and student engagement. Directly quoted material will employ a code to identify the individual teacher and the relevant module. For example, *T3/M8* refers to Teacher 3 who just completed delivery of Module 8: Rotation of Objects About 2 or More Axis. Appendix B includes a table outlining common teacher perceptions grouped per module in order to examine frequency and identify common themes related to module design. Thematic maps are employed within this section in order to show the relationships between these themes.

Teacher perceptions of program effectiveness tended to focus on the value of the supplied resources for each module and the relative difficulty in teaching each module (See Fig. 9).

Learning resources were frequently positively reported by teachers. The physical resources (snap cubes) are repeatedly cited as essential and very beneficial. Teachers frequently reported that the cube models were useful as a medium for demonstrations but also as an aid for pupils to use independently, facilitating a wide range of pedagogical approaches.

> T1/M3: The students enjoyed using the snap cubes to help them with visualization. This seemed to make the process much easier for most students. Many students struggled with the drawing aspect of the module.

The effectiveness of the cube resource was reported more frequently in modules that were identified as having a high difficulty. This is seen in module 3 where pupils are introduced to isometric sketching.

> T6/M3: Many of [th]em really struggled with the isometric drawing. They said having the snap cubes was very helpful, but some even with the cubes had a hard time drawing the figures in isometric view.

Software was also positively and frequently reported, especially in relation to module 1, 2 & 7. Descriptions focused on the usefulness of the software for introducing new concepts and the positive student affect associated with its use. Additional development of software could prove beneficial, potential benefit could be gained by focusing software support on modules identified as excessively difficult by teachers (Module 1, 3 & 4).

> T1/M1: The software was helpful in describing revolutions
> T5/M1: They all really liked the software. They also found the 3D party supplies helpful when visual[is]ing the revolutions, going from a 2D shape to the 3D solid.

Comparatively infrequent negative teacher affect was centred on initial technical difficulties and difficulty explaining new concepts to students. A common link was observed between teachers who expressed difficulty explaining concepts and identifying modules as excessively difficult for pupils. This suggests that low teacher self-efficacy to teach certain module-specific concepts could be potentially linked to perceptions of excessive student difficulty. The impact of difficulty on self-efficacy has been linked to performance and engagement (Power et al. 2019) and highlights the need to calibrate difficulty in order to achieve the positive outcomes associated with high self-efficacy. This, in turn, highlights the importance of teacher professional development events and how comfortable teachers are with the material prior to initial delivery. Opportunities for further examination of these factors should focus on teacher spatial skills after going through the training workshop or examine longitudinally teacher perceptions as they deliver the program multiple times and thus becoming more familiar with the concepts from the curriculum.

Teachers' perception of student affect was broadly positive and repeatedly linked to student competence (Modules with high student affect: 1, 2, 3, 6, 9 & 10; low/negative student affect: 4, 7, 8) (See Fig. 10).

Modules that were deemed 'difficult' by teachers demonstrated lower frequency of perceived student positive affect and low frequency negative affect (4, 7, & 8). Modules that addressed concepts linked to areas of prior learning were reported as easier to teach with associated positive student affect (9, 10). Teachers who reported difficulty explaining key concepts were less likely to link positive student affect to ability. Instead they tended to report excessive difficulty when asked for student perspectives. The role that teacher ability and knowledge plays in the delivery of the modules is worthy of further research.

Conclusions

The need to develop spatial skills in order to increase achievement in STEM learning environments has been firmly established (Stieff and Uttal 2015; Wai et al. 2009). However, teachers have been slow to implement practices aimed at developing spatial skills, in part due to a lack of available resources and associated professional development opportunities (Moore-Russo et al. 2013). This has resulted in a fragmented approach to a system wide problem. Some students engage in activities such as building with Legos™ or playing certain 3-D computer games and naturally acquire spatial skills. However, opportunities to engage in these extracurricular activities is limited in lower socioeconomic groups (Wilbur and Roscigno 2016). As spatial thinking has been shown to be important to success in most STEM fields, a lack of access to such developmental activities further disadvantages those who are already less likely to enter, or succeed, in STEM pathways. A disproportionate number of the students who have weak spatial skills are women or are from low SES groups—the same students who are underrepresented in STEM and who could benefit most from pursuit of a high-paying STEM career. Poorly developed spatial skills act as a barrier to STEM success for these students and influence decisions related to future areas of study and career paths (Wai et al. 2009). Therefor a formalised inclusion of spatial skill development activities within existing curricula is required if those who are most in need of these opportunities are to benefit.

The curricular materials described in this paper represent a viable method for developing spatial skills at the middle school level. The materials have been shown to be effective in improving spatial skills of students in a wide variety of educational settings, including at the university, community college, high school and middle school levels (Sorby 2001, 2009; Hungwe et al. 2007; Gerson et al. 2001). However implementation of new curriculum requires active consultation with teachers in order to support initial delivery and development for improved future iterations (Handal and Herrington 2003; Charalambous and Philippou 2010). By incorporating data based on teacher perspectives, the current study elevates teacher voice beyond the typical local level of implementation while exploring inevitable variances in fidelity (Kirk and MacDonald 2001).

The value of tailored professional development opportunities is vital in this regard as it provides an opportunity to establish a dialogue and assess teacher needs. Future iterations of the professional development for this program should focus on areas identified by teachers as difficult to teach or where they perceived their students to be engaging with activities that were excessively difficult (See Figs. 9, 10). This has the potential to develop conceptual understanding as well as teacher self-efficacy. Similarly, further development of resources should be focused on these perceived high difficulty modules. Future potential research could examine teacher spatial ability and self-efficacy to teach spatial topics in order to provide greater insight into the factors affecting program delivery and effectiveness.

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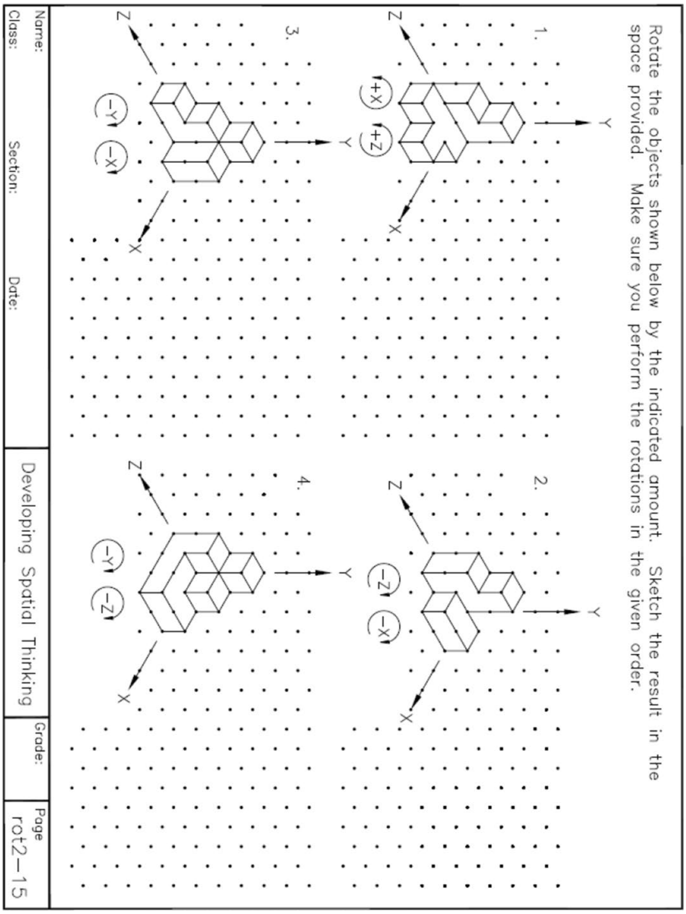
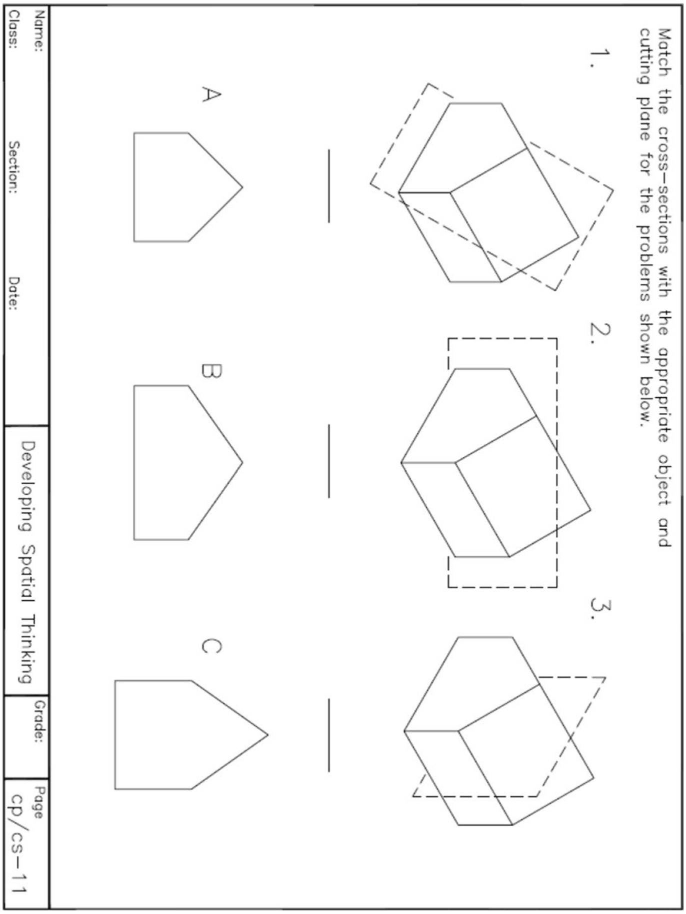
Appendix A

Module 8 Workbook Sample.



Module 10 Workbook Sample.



Appendix B

Module	Numbers within this column identify individual teacher's perspectives
1	Learning resources reported as positive: (Physical models 2, 5, 13; Software 1, 2, 3, 4, 5; Work-book 2, 5,)
	Negative Teacher Affect: (IT compatibility issues 4, 8; Nervous about difficulty level, pleasantly surprised by student response 2, 5, 6)
	Positive student affect: (1, 2, 3, 4, 5, 7, 8, 9, 11)
	Positive student affect associated with competence (1, 5, 8, 9, 10, 11, 13)
	Multiple choice student difficulty (9, 11, 3, 12)

Module	Numbers within this column identify individual teacher's perspectives
2	Learning resources reported as positive (Software 1, 2, 3, 4, 5, 13)
	Difficulty explaining concepts (2, 3, 4, 7, 13)
	Small group instruction effective (2, 3)
	Positive student affect (1, 3, 5, 6, 7, 8, 9, 10, 12, 13)
	Positive student affect associated with competence (4, 6, 9, 12)
	Students experienced excess difficulty 2, 4
3	Learning resources reported as positive: (Physical models 2, 3, 4, 5, 8, 12)
	Difficulty explaining concepts (2, 4, 5, 6, 10, 13)
	Small group instruction effective 6, 8, 13
	Positive student affect 4, 7, 9, 10, 11, 13
	Positive student affect associated with competence 2, 3, 4, 6, 11, 13
	Students experienced excess difficulty 1, 2, 3, 5, 6, 7, 8,
4	Learning resources reported as positive: (Physical models 2, 3)
	Difficulty explaining concepts 6, 8, 10,
	Positive student affect 1, 11
	Positive student affect associated with competence 2, 5, 6, 13
	Negative student affect 4, 6, 9, 10
	Students experienced excess difficulty 4, 6, 7, 8, 9, 10
6	Learning resources reported as positive: (Physical models 3, 4, 13)
	Easy to teach 6, 8, 9, 10
	Workbook issue (p. 5 + 6) 11, 12
	Positive student affect 1, 4, 5, 6, 7, 10
	Students experienced low difficulty 3, 5, 6, 7, 8, 10
7	Learning resources reported as positive: (Physical models 1, 2, 3; Software 5, 8, 9, 10)
	Small group/ individual instruction effective 12, 13
	Easy to teach 5, 6
	Positive student affect 1, 9, 11
	Students experienced low difficulty 4, 6
	Students experienced excess difficulty 1, 2, 3, 9, 10, 12
	Drawing difficulty 1, 5, 6, 9, 10, 11, 12
8	Learning resources reported as positive: Physical models 1, 2, 3, 5, 6, 13
	Positive student affect 1, 11,12
	Students experienced excess difficulty 5, 6
9	Difficulty explaining concepts 9, 10
	Positive student affect 3, 4, 5, 9, 10, 12, 13
	Linked to prior learning 5, 12,
	Students experienced low difficulty 4, 5
	Students experienced excess difficulty 9, 10, 13
	Drawing difficulty 9, 10, 13

Module	Numbers within this column identify individual teacher's perspectives
10	Easy to teach 2, 6, 13
	Positive student affect 1, 2, 9, 10, 12
	Linked to prior learning 9, 10, 12
	Students experienced low difficulty 2, 6, 10, 12

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