This study investigates kindergarten children’s identifications of examples and nonexamples of triangles, pentagons, and circles and their self-efficacy related to these tasks. The participants of this study included children who had been abused and neglected. When comparing the group of abused and neglected children with other children, results indicated that both groups of kindergarten children had high self-efficacy beliefs which were not significantly related to knowledge. Significant differences in knowledge were found between the two groups.

Early knowledge of mathematics is often seen as a predictor of later school success (Jimerson, Egel, & Teo, 1999). Abused and neglected children\(^2\) are especially at risk, as these children lag behind their peers in cognitive development (Gowen, 1993). During the elementary school years, the mathematics achievement scores of abused and neglected students are significantly lower than their peers, even when controlling for socioeconomic status (Kendall-Tackett & Eckenrode, 1996). One of the key mathematical domains during the preschool years mentioned by many national guidelines is geometry. During these years, children are developing and refining their spatial and geometric thinking. The first aim of this study is to investigate the geometrical knowledge of kindergarten children, including abused and neglected kindergarten children. Are differences in geometrical knowledge already noticeable in kindergarten?

Abuse and neglect during the preschool years can have a significant, as well as lasting impact on an individual's self-perception (Waldinger, Toth, & Gerber, 2001). One aspect of self-perception related to the promotion of knowledge is self-efficacy (Bandura, 1986). Bandura (1986) defined self-efficacy as "people's judgments of their capabilities to organize and execute a course of action required to attain designated types of performances" (p. 391) and claimed that, "...beliefs of personal efficacy make an important contribution to the acquisition of the knowledge structures on which skills are founded" (Bandura, 1997, p. 35). Primary caregivers, as they provide feedback of children's performances, play a significant role in developing children's self-efficacy (Bandura, 1993). Thus, abusive parents may contribute to negative self-efficacy. On the other hand, an inflated self-efficacy belief may result as a form of
self-protection in the face of parental abuse and neglect. In such cases, a high self-efficacy gives the child a false sense of self. The second aim of this study is to investigate kindergarten children’s geometric self-efficacy beliefs, that is, beliefs related to performing geometrical tasks. Is there a difference between the geometry related self-efficacy of abused and neglected children and other children?

When investigating children’s knowledge it is important to consider both real achievement and perceived achievement in tandem. One study of elementary school children found that maltreated children, more so than nonmaltreated children, tend to overestimate their level of competence, particularly for arithmetic (Kinard, 2000). The third aim of this study is to investigate the relationship between children’s geometric knowledge and self-efficacy beliefs. We investigate this relationship among kindergarten children, including abused and neglected kindergarten children.

**Theoretical background**

Two main issues are at the heart of this study: young children’s geometric knowledge and young children’s self-efficacy beliefs. This section begins by describing previous studies related to young children’s geometric knowledge and then reviews studies related to mathematics self-efficacy.

Young children learn about and develop concepts, including geometrical concepts, before they begin kindergarten. At this age, young children begin to perceive attributes but need guidance in order to assess which attributes are critical for identifying a figure and which are not (van Hiele, 1958). For example, studies have found that when a triangle is not oriented with a horizontal base, children may not identify it as a triangle (e.g. Burger & Shaughnessy, 1986). Children may also accept curved sides, either concave or convex, when identifying triangles (Clements, Swaminathan, Hannibal, & Sarama, 1999). Within the domain of geometry, the Early Years Foundation Stage Statutory Framework in England (2008) and the mandatory Israel National Preschool Mathematics Curriculum (2008) specifically require that by the end of kindergarten children use mathematical language to describe two-dimensional figures. This study focuses on identifying triangles, pentagons, and circles.

Few studies have investigated preschool children's self-efficacy. This may be due to children's difficulty in differentiating between what is real and what they desire to be real (Stipek, Roberts, & Sanborn, 1984). Research finding are mixed. Some studies have found that young children may have overly high self-efficacy beliefs (Stipek, Roberts, & Sanborn, 1984) while others have found that young children are able to understand the process of self-evaluation and may fairly judge their own competence (Anderson & Adams, 1985). "Mathematics self-efficacy…is a situational or problem-specific assessment of an individual’s confidence in her or his ability to successfully perform or accomplish a particular task or problem" (Hackett & Betz, 1989, p. 262). Research related to self-efficacy and mathematics has shown that regardless of mathematical ability, students with a higher self-efficacy tend to expend more effort...
on mathematics tasks than students with lower self-efficacy (Collins, 1982). Such students are willing to rework problems, discarding faulty strategies in favor of trying new ones, and in general display a more positive attitude towards mathematics than students' with a lower self-efficacy. Studies have also shown that students' self-efficacy beliefs predict mathematics performance (Bandura, 1986; Pajares, 1996) and do so to a greater degree than mathematics anxiety (Pajares & Miller, 1995). Among first and second graders, academic self-efficacy was found to be related to mathematics achievement (Liew, McTigue, Barrois, & Hughes, 2008). It is important to note that self-efficacy beliefs may be domain specific or general. Most studies related to mathematics self-efficacy measured a very general belief in mathematics self-efficacy which did not necessarily relate to specific mathematics topics (i.e. Usher, 2009). This study will focus on the child's self-efficacy while engaging in geometrical tasks and will investigate the relationship between kindergarten’s children’s geometric knowledge and their geometric self-efficacy.

**METHODODOLOGY**

The participants of this study included 141 kindergarten children, ages 5-6 years old, living in low socio-economic neighbourhoods. All of the children were scheduled to enter first grade during the following school year. Of the 141 children, 69 children were labelled as abused and neglected by the social welfare department of their municipality. All of the children attended municipal kindergartens in their local neighborhood in the morning. While most children go home after school is over, the 69 abused and neglected children were bussed after school to day-care centres run by their municipality where they received hot meals and enrichment.

The research took place in the last three months of the school year. A structured interview was developed for this study interweaving questions related to geometric self-efficacy with questions related to geometric knowledge. Children who were identified by the social welfare department of the city as being abused and neglected were interviewed individually in a quiet corner of the day-care center which they attended in the afternoons. The other children were interviewed individually in a quiet corner of their kindergartens in the morning.

The focus of this study was on identifying and reasoning with triangles, pentagons, and circles and associated self-efficacy beliefs. The interview began with the following self-efficacy questions: If I show you a picture of a shape, will you be able to tell me if the shape is a triangle? Are you very sure or only a little bit sure? These self-efficacy related questions were based on the *Pictorial Scale of Perceived Competence and Social Acceptance for Young Children* (Harter & Pike, 1984). In that study, children were show pictures of two children engaging in some task, one successful and one not successful. The interviewer asked the child to point to the child he or she identified with. After the child pointed to the appropriate picture, the child was asked if he or she was a lot like the child in the picture or a little bit like the child in the picture. Thus, a four point scale was created. Likewise, in the current study, the first two questions, taken together, created a scale of 1-4 describing...
children’s belief in their ability to identify triangles. For example, if a child answered “yes” to the first question and “a little bit” to the second question, his self-efficacy was graded at 3. If he answered “no” to the first question and “very sure” to the second question, his self-efficacy was graded at 1.

Children were then presented one at a time with four figures, each figure drawn on a separate card, and asked, “Is this a triangle”? Why? The entire set of questions, including the first two self-efficacy related questions, was then repeated for a pentagon and a circle with a different set of figures presented for each shape. Figure 1 displays the figures presented for each set of questions. Figures were presented in the order shown in each row.

<table>
<thead>
<tr>
<th>Is this a…</th>
<th>Intuitive example</th>
<th>Non-intuitive example</th>
<th>Non-intuitive non-examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>triangle?</td>
<td>Equilateral triangle</td>
<td>Scalene triangle</td>
<td>Rounded-corner “triangle” Pizza</td>
</tr>
<tr>
<td>pentagon?</td>
<td>Regular pentagon</td>
<td>Concave pentagon</td>
<td>Curved-sides “pentagon” Hexagon</td>
</tr>
<tr>
<td>circle?</td>
<td>Circle</td>
<td>Spiral</td>
<td>Decagon</td>
</tr>
</tbody>
</table>

**Figure 1: The set of figures presented in this study**

In choosing the figures, both mathematical and psycho-didactical dimensions were considered. When considering triangles, the equilateral triangle may be considered a prototypical triangle and thus intuitively recognized as a triangle, accepted immediately without the feeling that justification is required (Hershkowitz, 1990; Tsamir, Tirosh, & Levenson, 2008a). The scalene triangle may be considered a non-intuitive example because of its “skinniness”. Whereas a circle may be considered an intuitive non-example of a triangle, the pizza-like “triangle” may be considered a non-intuitive nonexample because of visual similarity to a prototypical triangle (Tsamir, Tirosh, & Levenson, 2008a). Similarly, the regular pentagon was thought to be easily recognized by children who had been introduced to pentagons whereas studies have shown that even among children who had been introduced to pentagons, the concave pentagon is more difficult to identify (Tsamir, Tirosh, & Levenson, 2008b). Triangles and pentagons may vary in the degree of their angles providing a wide variety of examples. In contrast, the circle’s symmetry limits the variability of its characteristic features. Thus, only one example of a circle was given. The nonexamples of each shape were also chosen in order to negate different critical attributes. Due to the young age of the children, we chose to limit the amount of
figures presented to each child and thus did not include in this study intuitive nonexamples. Finally, we hypothesized that, in general, the triangle and circle would be figures known to the children from their surroundings whereas the pentagon is a figure less known but part of the preschool mathematics curriculum.

RESULTS

This section begins by describing children’s self-efficacy beliefs related to identifying the different shapes. It then describes the results related to children’s actual identification of the figures. Finally, it analyzes the relationship between self-efficacy and knowledge.

Self-efficacy beliefs

Recall that a scale of 1-4 was used to grade children’s self-efficacy, 4 being very high and 1 being very low. Results, presented in Table 1, indicated that, in general, the children had a high self-efficacy related to identifying the different shapes. In addition, no significant difference between the self-efficacy of the two groups of children was found for any of the shapes.

<table>
<thead>
<tr>
<th>Children</th>
<th>Abused and neglected children</th>
<th>Other children</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Triangle</td>
<td>3.7</td>
<td>.62</td>
</tr>
<tr>
<td>Pentagon</td>
<td>3.1</td>
<td>1.1</td>
</tr>
<tr>
<td>Circle</td>
<td>3.7</td>
<td>.75</td>
</tr>
</tbody>
</table>

Table 1: Children’s geometric self-efficacy per shape per group

Cronbach’s alpha was used to investigate internal consistency between the self-efficacy scores for each shape per group of children. A weak internal consistency was found in both groups, $\alpha=.50$ for the group of abused and neglected children and $\alpha=.34$ for the other children. These results indicate that, for these children, self-efficacy may be task or shape specific. This is consistent with previous self-efficacy studies which claimed that mathematics self-efficacy may be problem-specific (Hackett & Betz, 1989). On the other hand, when considering that the self-efficacy questions all related to identifying shapes mentioned in the preschool curriculum, we allowed that a general geometric self-efficacy grade may still be calculated for each group. Results indicated no significant difference between the geometric self-efficacy of the abused and neglected children ($M=3.7$, $SD=.43$) and the geometric self-efficacy of the other children ($M=3.5$, $SD=0.61$).

Geometric knowledge

We begin by describing children’s identifications of the individual figures presented to them. Due to limited space, this paper does not analyze the children’s explanations which accompanied identifications but provides sample illustrations where relevant. Results, summarized in Table 2 indicated that all of the children correctly identified
the equilateral triangle. This coincides with studies which have found that the equilateral triangle with a horizontal base may be considered a prototypical triangle and is thus intuitively identified as such (e.g. Tsamir, Tirosh, & Levenson, 2008a).

<table>
<thead>
<tr>
<th>Figure name</th>
<th>Abused and neglected children</th>
<th>Other children</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equilateral triangle</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Scalene triangle</td>
<td>20</td>
<td>35</td>
</tr>
<tr>
<td>Rounded-corner “triangle”</td>
<td>19</td>
<td>22</td>
</tr>
<tr>
<td>Pizza</td>
<td>46</td>
<td>56</td>
</tr>
<tr>
<td>Regular pentagon</td>
<td>71</td>
<td>71</td>
</tr>
<tr>
<td>Concave pentagon</td>
<td>29</td>
<td>24</td>
</tr>
<tr>
<td>Curved-sides “pentagon”</td>
<td>57</td>
<td>70</td>
</tr>
<tr>
<td>Hexagon</td>
<td>26</td>
<td>32</td>
</tr>
<tr>
<td>Circle</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Spiral</td>
<td>51</td>
<td>61</td>
</tr>
<tr>
<td>Decagon</td>
<td>83</td>
<td>85</td>
</tr>
</tbody>
</table>

Table 2: Frequencies (in %) of correct identifications per figure per group

The rounded-corner “triangle” was the most frequently misidentified figure. As one child claimed, “It has the shape of a triangle”. Interestingly, the equilateral pentagon was identified correctly by less than three-quarters of the children in both groups, though learning to identify pentagons is part of the kindergarten curriculum. As expected, few children in both groups identified correctly the concave pentagon. One child explained, “It looks like a bridge and has only four points.” Regarding the circle, although all of the children correctly identified the circle, approximately half of the children incorrectly claimed that the spiral was a circle. Perhaps, the children focused on the roundness of the spiral and the absence of sides. One child claimed it was a circle and added “it continues to roll.” Finally, although few children correctly identified the scalene triangle, when comparing the groups of children, this was the only figure for which a significant difference was found \( \chi^2(1, N=138)=4.33, p<.05 \).

After reviewing the results of children’s responses to the individual figures, we grouped together the figures according to the shape they were intended to investigate. For each shape, triangles, pentagons, and circles, the mean score was configured resulting in a grade for each child ranging from 0-100% for each shape. Results, presented in Table 3, indicated that abused and neglected children had a significantly lower triangle grade than other children, \( p<.05 \). No significant differences were found between the two groups of children for the other shapes. Finally, averaging all 11 figures and creating a general geometric knowledge grade, we noted that the
neglected and abused children scored significantly lower ($M=.57, SD=.11$) than the other children ($M=.62, SD=.14$), $t(117)=241, p<.05$.

<table>
<thead>
<tr>
<th>Children</th>
<th>Abused and neglected children</th>
<th>Other children</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M$</td>
<td>SD</td>
</tr>
<tr>
<td>Triangle</td>
<td>.46</td>
<td>.20</td>
</tr>
<tr>
<td>Pentagon</td>
<td>.46</td>
<td>.18</td>
</tr>
<tr>
<td>circle</td>
<td>.78</td>
<td>.24</td>
</tr>
</tbody>
</table>

Table 3: Children’s geometric knowledge per shape per group

Relating geometric knowledge and geometric self-efficacy

The third aim of the study was to investigate if children’s geometric knowledge was related to their geometric self-efficacy. Nonparametric correlations were configured for each geometric shape per group of students. Results for both groups of children indicated that no significant relationship was found between children’s ability to identify triangles, pentagons, and circles and their respective self-efficacy beliefs. Finally, when considering general geometric knowledge and general geometric self-efficacy, no significant relationships were found in either group.

SUMMARY AND DISCUSSION

This paper describes an investigation of geometric knowledge and geometric self-efficacy among kindergarten children, including children who were abused and neglected. We begin by discussing similarities in self-efficacy and then similarities in knowledge. We then discuss differences, which for this group, arose when comparing geometric knowledge.

When asked to assess their abilities to identify triangles, pentagons, and circles, children in both groups reported a high self-efficacy, believing greatly in their ability to identify each of the mentioned shapes. There are several possible reasons for this response. First, it could be that children have a tendency to reply in a positive manner or to the high end of any question or scale posed to them. Thus, asked if they can or cannot do something, they respond almost automatically in the positive. Perhaps a naïve belief in one’s own capabilities is indicative of all children who are young. While these, and possibly other reasons, may explain the high self-efficacy rating children exhibited, it remains that for the participants of this study, there were no significant differences between the self-efficacy of abused and neglected children and other children. In addition, children’s high self-efficacy did not correlate with their knowledge. As mentioned in the background, young children may find it difficult to differentiate between what is real and what they desire to be real (Stipek, Roberts, & Sanborn, 1984). And yet, among first and second graders, academic self-efficacy was found to be related to mathematics achievement (Liew, McTique, Barrois, & Hughes, 2008). Perhaps, between kindergarten and first grade, there is a leap in the development of children’s sense of self. Perhaps differences between the two groups
of children regarding geometric related self-efficacy, and possibly other academic related self-efficacy, may come to the fore at a later age.

Regarding children’s identifications of geometric shapes, if we focus on the first example of each shape presented to the children, the equilateral triangle, the equilateral pentagon, and the circle, we note that the frequencies of correct identifications were exactly the same for each group of children. That is, figures which are symmetrical and possibly prototypical of their shape in general, may be easily identified by all kindergarten children regardless of their home backgrounds. In addition, there were no significant differences between the two groups of children in their general knowledge of pentagons and circles. Regarding pentagons, this finding may not be surprising. The pentagon is less common in children’s everyday experiences and is usually first introduced in kindergarten. On the other hand, knowledge of circles was also similar between the two groups. It was thought that knowledge which might stem from the child’s everyday experiences might produce different results for the different groups.

When looking at the differences between the two groups, less correct identifications were noted among the abused and neglected children than among the other children for the non-intuitive scalene triangle, as well as for each of the nonexamples of triangles, and a significant difference between the two groups of children was found in their general knowledge of triangles. Finally, when the results of the other shapes were also taken into consideration, abused and neglected children exhibited significantly less knowledge than other children. These findings indicate that even before children begin first grade, differences are detectable between the two groups of children. Knowledge of geometric shapes most often begins before formal presentation in school. As such, these differences may possibly stem from the home environment.

Abused and neglected children learn in the same kindergartens as other children. Thus, in order to plan lessons and interventions, it is important to note both the similarities and differences among these children. A high self-efficacy which is not realistic is an issue common to both groups of children and needs to be addressed. In addition, the non-intuitive examples of triangles and pentagons were incorrectly identified by most of the children in both groups. Thus, it is important to actively promote this knowledge among all kindergarten children. And yet, differences do exist. Equity is not only about giving a fair chance to children from different socio-economic backgrounds or minority students. It is about providing “high expectations and strong support for all students” (NCTM, 2000, p. 12). Children who have been abused and neglected have special needs. Schmid (2007), in his report on children at risk in Israel, suggested that identification of risk factors in early childhood may prevent or minimize problems which develop later on. This study is a first step in considering the mathematics educational needs of children at risk. Additional research is needed to address possible interventions which take into consideration
both similarities and differences in knowledge, self-efficacy, and possibly affective issues when promoting mathematics for all children, including children at risk.

REFERENCES


