Elementary School Students' Math Skills, Spatial Perceptions and Evaluations of the Quality of the Built Environment

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ABSTRACT
Quality of the built environment poses a vital problem for developing countries. While this issue has multi-facets and involves many parties, we want to concentrate on the education and the educational environments. This paper discusses a research study carried out in the investigation of the relationship between the perception of the quality of the built environment, spatial perception, geometric thought and math performance of Turkish children. The study was part of a project aimed at developing children's awareness for the physical environment. As the responses of children from different physical environments were examined, information on children's perceptions and attitudes towards the built environment was obtained. The hypothesized relationship between affective and cognitive characteristics related with the built environment was observed.
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Introduction

The built environment that has been shaped over the course of history creates the setting for our activities. From birth onwards people perform various activities in the spaces created, feel their existence and meaning in life, experience their feelings and culture embedded in space. Architecture is an integral part of human life and quality of the built environment is a major concern for people. This issue needs specific attention in a developing country like Turkey because various factors such as speculation, economical conditions, lack of education and consequently indifference has had an accelerating negative effect on the built environment especially after 1950s with the industrialization and its influences. The outcomes may range from functional, health and security requirements to the lack of aesthetic quality.

The Turkish Republic was founded on the ruins of an empire and was constructed primarily in accordance with western ideals. Starting from 1950s the effects of industrialization took control over the built environment. Over the years, the inadequacy of the infrastructure, internal migrations due to industrialization and the sacrifice of local culture to "modern" ideals have had serious consequences for the built environment (Tekeli, 1984). The unplanned urban development, the loss of the historic urban fabric and the deterioration of the built environment were both the causes and the consequences of the factors described above. Among those, public indifference to the environment and its effects is our concern in this paper.

Human and environment relationship covers issues in a wider perspective. Among them, indifference to the environment has been investigated (Gifford, 1976) and various terms were coined. "Environmental numbness" is marked if the users seldom exhibit any attitude in reaction to disagreeable conditions. "Environmental awareness", on the other hand is the active perception of the physical environment. Perceiving the features of the environment, the user can decide how to operate in that environment and adapt to the space to consent to an agreement between the user and the environment (Sommer, 1972). A clear tendency for students to accept without alteration a rather uncomfortable classroom arrangement has been observed (Gifford, 1976). Environmental comfort on the other hand should be an outcome of a combination of urban elements, architectural design and user behavior (Bernardi & Kowaltowski, 2006) and is not the concern of this paper.

Indifference, like all other attitudes, may be transformed into awareness and care for the environment through environmental education. The effectiveness of programs integrating design and architecture into education indicates that environmental awareness can be created when students learn to look at and perceive their environment (Wals, 1994). Perception is defined as how people view the world around them and how the world is structured (De Bono 2004), In order to understand and have a say in the world they live in, people need to learn to perceive their environment. The investigation, understanding and evaluation of the built environment in order to take appropriate decisions for action for its improvement is very important especially in developing countries where most of the housing construction is made up of self built houses (Labaki & Kowaltowski, 1998). Buildings in developed countries conform to more acceptable standards; hence, environmental education can focus on issues like energy conservation rather than "environmental comfort" pertaining to the design of the building, the activities that take

place in it and its level of physical comfort. It is more vital for the citizens of developing countries to demand for an increase in the quality of the built environment. Educators and design professionals should acquire more effective approaches to inform the public and increase concern for environmental design quality when it is needed. Thus making children conscious about the physical environment is an important step (Kowaltowski et al., 2004).

Examination of children's comprehension of the environment is crucial for research in environmental education (Payne, 1998; Jurin & Hutchinson, 2005). However, the literature on students' understanding of the environment is quite limited and mostly confined to the natural environment. Moreover, research shows that human managed or built landscapes are not seen as environments by the students (Shepardson, 2005). Hence, very little attention has been paid to how children come to understand their own environment through their everyday communications (Wals, 1994). Studies show that students hold common ideas based on their observations, social interactions and language that may enlighten their practice. Observing the attitudes and behaviors of school children, it has been shown that students were unaware of comfort problems and they tolerated substandard physical conditions where they did not feel that they could intervene positively to bring about change in the school environment (Bernardi, 2001 cited in Kowaltowski et al., 2004).

Environmental education aims to develop responsible environmental behavior. In order to realize that goal, students must be provided with opportunities to acquire the knowledge, values, attitudes, commitment, and skills needed to protect and improve the environment. Ballantyne and Packer, (1996) argued that affective dimension has dominated environmental education. They claimed that the teaching of attitudes and values was emphasized at the expense of environmental knowledge. Environmental education could be integrated into the school curricula to endorse constructive learning. It has been claimed that neither a knowledge-based approach nor a values-education approach in isolation would be sufficient to satisfy the objectives of environmental education. Environmental educators should take a more holistic approach to teaching and learning that identifies the interrelatedness of environmental knowledge, attitudes, values, and behaviors to support the development of appropriate environmental conceptions (Ballantyne & Packer, 1996).

It is hypothesized in this study that children's interaction with the physical environment within the scope of the mathematics education can be beneficial both ways. Mathematics may be an effective subject in equipping students with an awareness of the built environment. Studying the built environment may in turn enhance the learning of mathematics. Many examples of environmental education programs integrating architecture and mathematics aimed at increasing children's awareness of the built environment exist (Taylor, 1993; Nordström, 2001; Classen, 2002; Loveland, 2003; AI Architect, 2003; Stylianou & Grzegorczyk, 2005). Mathematics programs may be adjusted to include objectives towards increasing awareness of and sensitivity for the physical environment. The topics in mathematics curricula may be developed to emphasize thinking about and evaluating the quality of the physical environment. This may not only improve students' mathematical skills of but can also make teaching abstract concepts more straightforward. It is worth investigating the aspects of math education related to the perception and evaluation of the built environment. Geometric thought develops visual ability and improves reasoning skills. The physical environment can pose useful, concrete examples for learning geometry. The Geometry Standard of the *Principles and Standards for School Mathematics* (National Council of Teachers of Mathematics [NCTM], 2000) as one of the five content standards suggests that students should study geometry for a purpose by using visualization, spatial reasoning and geometric modeling (Lindquist & Clements, 2001).

In this study, the relationship between children's perceptions and evaluations of the quality of the built environment, their visual perception skills, math achievement and the quality of the environment they are exposed to was considered in the light of the idea that affective based values and attitudes focus should be replaced by the idea that conceptual change has cognitive and affective components that should be studied as a whole (Ballantyne & Packer, 1996). This study was aimed at investigating the relationship between the physical environment and elementary and middle school students' spatial perception skills, their geometric competence developed through mathematics education and their evaluations of and attitudes towards the built environment.

Methods

A questionnaire developed for the assessment of the perception and evaluation of the built environment was administered to elementary and middle school students from different built environments along with a scale for assessing visual perception and another scale for assessing the development of geometric thought. Their math grades were obtained. An investigation was carried out on the relationship between these different characteristics. The characteristics of children living in different built environments were compared.

Sample

The sample group consisted of a total of 998 elementary school students. 47 % of the students were girls and 53 % were boys. The mean age was 13.6 with a standard deviation of 1.6. Three cities in Turkey: namely City A, City B and City C, were selected purposefully, each possessing a distinct character in terms of its demographic and spatial features. From these cities, eight schools were selected conveniently based on ease of access for the researchers with

different geographical and physical environments. Three of the schools were chosen from City B, a central Anatolian town that has restored its traditional architecture and fabric and one of the few towns in which the housing fabric is well preserved. The sample included two schools from City C, a city in southeast Turkey in a less urbanized and developed region of the country. Three schools were chosen from City A. The physical characteristics and environment of the schools in City A were rather different from the environment of the schools in Anatolia. City A, with its long history of cultural activity and its rich architectural heritage is a city that has undergone both transformation and degeneration in its culture, architecture and, consequently, in its built environment. As the largest city in Turkey, City A has been exposed to a great deal of internal migration as a result of which the city's physical environment is in constant transition. Each of the three schools selected from City A differed from the others as regards its demographic as well as its physical environment. One of these schools was a private school in City A, an upper income district. The second, a public school, was located in an area that had undergone a great deal of internal migration. The third was a public school in an upper middle-income neighborhood with students of a lower middle-income group. The physical environments of each school selected differed from the others. Each was expected to provide information concerning the perception level of students of various instances of restored environments, environments in transition and developing environments. Variety in demographic character and physical environment was considered as an important criterion for the choice of school.

Instruments

Three scales were used in the study. Perception of the quality of the built environment was assessed by a questionnaire developed for this study. The level of geometric competence by a geometric thought development scale. Spatial ability was assessed using a spatial perception test.

Perception of the Quality of the Built Environment Questionnaire.

A questionnaire for investigating the elementary school students' levels of awareness of the built environment was developed. It was made up of three parts.

Development of the Scale

The first part of the scale consisted of open ended questions related to the children's descriptions of their physical environments, such as the form and color of the school buildings. In the second part there were questions pertaining to their perceptions and evaluations of the built environment. The children were asked to rate certain elements of the environment on a scale from one to four; higher scores indicating perceptions of better quality.

The last group of questions provided data on how the students felt about the built environments in terms of their concern and feelings of responsibility. The items were developed to assess different characteristics, not necessarily forming a single construct. Each of the 12 questions indicating evaluation of and attitude towards the built environment were added up to obtain a single score for each characteristic, where "true" got three points, "I don't know" got two points and "false" got one point.

The last part of the questionnaire consisted of 12 questions indicating students' perceptions and attitudes towards the built environment. The students were asked to indicate if they agreed, or disagreed with the given statements. A third choice could be "I don't know". In order to quantify the data obtained from this questionnaire, a participant obtained 3 points if he/she agreed with the given item, two points if marked "I don't know" and got one point if disagreed.

The questionnaire was in accordance with the six categories identified by Loughland, et al. (2002). They identified six categories for primary and secondary students' understanding of an environment, the first three reflecting the environment as an object and the last three as reflecting a relationship between people and the environment (Shepardson, 2005).

Psychometric Quality of the Scale

A pilot study was carried out to clarify the quality of the scale after the suitability of the items was discussed with five experts for obtaining evidence of construct validity. Three of the experts were math educators and two were instructors from a faculty of architecture. The questionnaire was administered to a total of 404 elementary school students in the pilot study. 209 of these students were female and 195 were male.

The findings from the pilot study were evaluated to access the validity of the instruments. The open ended questions were considered first, followed by an examination of the other questions. As the open-ended items were examined, it was observed that the students' descriptions and evaluations of the physical environment would be informative for future research. A comparison of the evaluations of students from the different schools produced considerable results. Students attending the school close to the upper income district of City A evaluated their school rating as 2.6 out of 4 with a standard deviation of 0.83. Students attending the school at a lower income neighborhood evaluated their school as 2.38 with a standard deviation of 0.94. Statistically, this constituted a significant difference ($t=2.1$, $p<0.5$) with an effect size of .23. Comparison of the views concerning the neighborhoods revealed a greater difference between the students of the two schools. Students attending the school close to the high socio-economic neighborhood with a better planned environment evaluated the environment of the school as 3.09 out of 4 with a standard deviation of .77. Students attending the school in the lower income neighborhood evaluated the environment of the school at 2.39 with a standard deviation of 0.96. Statistically, this was a more significant difference ($t=6.54$ $p<.01$) with quite a high effect size of .73. These results were interpreted as showing that the students' evaluations of their environments

were in accordance with the quality of the environment. This result was considered as an indicator of the construct-related validity for the second part of the instrument.

The items at the last part were developed to assess several different constructs. Hence, the internal consistency as a whole was not high. Therefore, for the psychometric characteristics, it was examined in parts.

A principal component factor analysis with an orthogonal rotation was run to reveal the conceptual structure of the last part of the questionnaire. 5 factors explaining 56 % of the variance emerged.

Each factor was named as following:

1. Helplessness/ Indifference: The three items in this factor had factor loadings of .74, .57 and .56. A sample item was: "We cannot do anything for the improvement of the environment in our neighborhood."

2. Identification: The three items in this factor had factor loadings of .76 and .65 and .39. A sample item was: "We would feel bad when we have visitors if our neighborhood is filthy and messy."

3. Attachment: The two items had factor loadings of .78 and .74. A sample item was: "The owners of a neighborhood are the people who are living there."

4. Power to change: The two items had factor loadings of .75 each. A sample item was: "The authorities will build us a park if we ask for it."

5. Accountability: The two items had factor loadings of .55 and .73. A sample item was: "When someone builds a new house it should be approved by the people living in the neighborhood."

The findings from the factor analysis of the pilot study were accepted as evidence for the construct validity of this part of the questionnaire. Consequently, it was decided that these items could be utilized in further research for a larger group of students.

Geometric Thought Development Scale

The scale was prepared in the light of the Van Hiele theory of the development of geometric thought (Usiskin, 1982). According to this model, students learn geometry in five stages. In the first stage students perceive the geometric forms as a whole, in the second stage the students can classify the forms according to their characteristics, at higher levels the students can produce logical deductions and at the final stage they can make rigorous proofs like real mathematicians (Fuys, 1985). The Turkish form of the scale based on the Van Hiele model was made up of 25 questions (Duatepe, 2004). Although the original form of the test assesses the students' Van Hiele levels, in this study the scale was used only to give a score to each student based on the number of questions he/she could answer.

Spatial Perception

Siccar Point Preview Test' was given to the students to assess their levels of spatial perception (Karaman, 2000). This test included questions where similar forms were selected from a group of drawings.

Procedure

Information was obtained concerning the students' socio-economic conditions, living environments, and mathematics grades together with the physical and environmental conditions of their schools. Data were then collected from 952 children relating to their perception of the quality of the built environment questionnaire, geometric thought development scale and Siccar Point Preview test.

Results

The first step was the investigation of the responses to the open ended items in the questionnaire relating to the students' perceptions and evaluations of the physical environment. The students' comments of their school buildings were taken into consideration. Students described their school buildings basically in crude geometric forms as "square" or "rectangular". Only a few students referred to the materials, such as "wooden construction". It was observed that the responses related to color and forms were primitive and sometimes contradictory, like other studies in which the students' ideas tended to describe rather than explain their environments (Shepardson, 2005).

In the next step the students' evaluations of their environments were considered. When asked to evaluate the school buildings, 9 % of the students marked that they found their buildings " substandard", 40 % found them "mediocre", 33 % thought that they were "good", 19 % thought that they were "very good". Students' evaluations on the neighborhoods of their schools were similar. 6% thought that the neighborhoods of their schools were "substandard," 19% "mediocre," 43 % "good," and 31% "very good." This information was valuable in that data have not been accumulated that evaluate environmental comfort knowledge among the general population in developing countries (Kowaltowski et al., 2004).

After the descriptions the students rated their environments on a scale from one to four. The students' descriptions and evaluations of the physical environment of their neighborhoods were a little bit more positive than their evaluations of the school buildings.

The students' ratings of the quality of their environments were compared for children going to school in different environments since it was observed that the students from different settings gave different answers to these questions. Examples of the ratings of children of their environments were listed in descending order in Table 1. Children living and going to school in well preserved well planned environments rated their environments more positively. In order to check if these findings had statistical significance, an analysis of variance and the post-hoc Scheffe test were run on the scores for different schools. The corresponding F value was found to be 11.8 ($p<.01$) indicating statistical significance for the difference of ratings. Findings revealed that students at the public school located in an area that had received a large number of internal migrants rated their neighborhood very low when compared to the ratings of children from the other schools. This

neighborhood was characterized by unplanned development and squatter settlements.

In evaluating their neighborhoods, students were mainly concerned with such elements as trees, gardens, green area, pollution, view and orderliness. These elements varied depending on the neighborhoods in which the schools were located. Students whose schools were located in the better planned districts were mainly concerned with green areas and the attractiveness of the environment, while they also mentioned their proximity to the prosperous neighborhoods of City A. Students in the unplanned area complained of the unclean environment and the existence of squatters. They praised the efforts to care for the plant life in the environment. Students at City B, a well-preserved historic district, mentioned the preservation of the natural environment and concern for the conservation of the historic buildings. Students in City C mentioned gardens, proximity to the city center and unpolluted environment as positive qualities of their environment.

When evaluating the aesthetic quality of the environment, 64% of all the students believed that there were unattractive buildings in their environment. As a solution to the problem of what action to take concerning aesthetically displeasing buildings 20% of the students proposed to paint them another color, 25% of the students proposed rehabilitation, and 20% of the students proposed demolition and the construction of new buildings.

In response to questions relating to where they lived 19% of the students said that their families were not satisfied with the environment they lived in. 25% of these had made complaints to the authorities, 13% of the students did not know where to file a complaint, while 62% of the students believed that nothing would change even if they filed a complaint. In response to the question as to who should be responsible for building activity, 35% of the students said that contractors should be responsible, 12% of the students said that civil engineers should be responsible, 20% of the students said that architects should be responsible while the rest mentioned the municipality, the state, professors and craftsmen.

The results of the questions relating to their concerns and feelings of responsibility for the environment were as follows: 15% of the students said that they were not interested, 22% of the students believed that the buildings in their environment were beautiful, 39% of the students desired a more organized environment while 24% of the students said that they would like to have attractive buildings in their environment. In City B, the well preserved historic town, only 9% of the students said that they were not interested in the environment. This was the lowest percentage for this question.

The students who mentioned having shown the greatest concern and care for the environment, came from higher socio-economic neighborhoods. Their parents had a higher level of education. The exceptions were the students from City B. Although the education levels of the families were not very high in that district, the students in this well preserved historic environment had more concern and care for the environment and gave greater importance to the conservation of the historic and natural environment than any of the other groups.

The correlation coefficients were calculated between the scores on spatial visualization, geometry test and math grades. The correlation coefficient between spatial visualization scores and geometry competence was calculated to be .37 ($p<.01$). The correlation coefficient between spatial visualization scores and math grades was calculated to be .24 ($p<.01$).

A relationship was observed between the education of the family and students levels of spatial perception ($r=.38$, $p<.01$), geometrical knowledge ($r=.41$, $p<.01$), and math grades ($r=.16$, $p<.01$).

Analysis of variance results comparing the scores of students from different districts revealed that the students who showed a superior level of spatial perception and mathematics came from the group from the districts of higher socio-economic levels with educated parents, mostly from City A. Following this group were the students from City B, the city with the preserved historical environment. These findings were thought to be important because they revealed the relationship between visual perception and cognitive skills on the one hand and quality of the environment on the other. Although students from City B had parents with limited education, the architectural and spatial quality of the environment they lived in seemed to have a relationship with the development of their cognitive skills.

In the next part, the attitudes of the students towards the built environment were investigated through the perception of the quality of the built environment questionnaire. In Table 2 the students' who either agreed or disagreed were taken into consideration those who responded as "I don't know" were disregarded.

After each item was analyzed separately the scores on the subscales were considered. The correlation coefficients between the different subscales of the final part of the perception of the quality of the built environment questionnaire and the students' levels of spatial ability, geometry competence and math grades were calculated. Three subscales correlated with cognitive variables. The subscale concerning "Helplessness/ Indifference" correlated negatively with spatial ability ($r=-.24$, $p<.01$), geometry competence ($r=-.17$, $p<.01$) and math grades ($r=-.10$, $p<.01$). This factor involved items like: "we can not do anything to improve our neighborhood" and "we are not concerned if trees are cut down at our neighborhood". There was also a positive correlation between the math grades and the second factor concerning "Identification" ($r=.10$, $p<.01$). The correlation coefficients between the third factor "Attachment" where a sample item would be "The owners of a neighborhood are the people who

are living there" and geometry competence (r=.14, p<.01) and spatial ability (r=.10, p<.05) were positive.

The scores on cognitive characteristics related with math, like spatial ability, geometry competence and math grades had a positive relationship with positive attributes like identification for and attachment to the built environment but negative relationship with the negative attribute of feeling helpless in changing the environment.

Since a relationship was hinted between the items of the attitude questionnaire and spatial ability, geometry competence, and mathematics grades, an item in the questionnaire was investigated separately. Regarding the item "We cannot do anything to improve the quality of our neighborhood" 21% of the students said "no, they would not be concerned" and 65% of the students said "yes, they would be concerned." For further analysis of the same idea, these two groups were compared on their scores of spatial ability, geometry competence, and mathematics grades. The group that showed concern scored significantly higher levels of math grades, spatial perception and geometry competence.

Discussion

This research study aimed at an investigation of elementary school students' perceptions, evaluations of and attitudes towards the built environment as well as their relationships with the students' spatial perceptions, and performance in math and geometry,. In a wider perspective, it aimed at obtaining information to create a basis for environmental education for preventing the degeneration of the physical environment.

Valuable information was obtained on the students' ideas about the built environment. The students' perceptions of their environments were in accordance with the quality of the environment. Their rather primitive descriptions and fairly realistic evaluations were revealing in contributing to the scarce body of knowledge on the built environment in developing countries. We know from other studies that constructions even when they have high architectural quality rarely result in user's liking. The level of contentment can depend upon the user's environmental awareness and perception. (Kowaltowski et al., 2004). It was also noteworthy that students could make an objective evaluation of their physical environment, which showed the students' awareness of that environment. The role of the built environment in the education of youngsters is vital in developing their awareness of the environment. This would eventually open the way for the development of livable environments.

The students' ideas about the human- environment interaction were also noteworthy. The students' perceptions and attitudes about people's affiliation to and responsibility toward the built environment were obtained. It has been marked that the children's views could be grouped under headings like feelings of helplessness when faced with environmental problems, power to change the environment, identification and attachment to the built environment and responsibility and accountability for one's actions. The relationship between these characteristics and the children's cognitive characteristics provided hints about how the attitudes and behaviors could be changed by improving cognitive skills through education.

Another point that was of value was the relationship between cognitive development and the characteristics of the built environment. Findings revealed that the built environment the students lived in seemed to have a relationship with their cognitive development. The children living in high quality environments where the people's socioeconomic standards were high showed better performance on cognitive skills. This result could be explained by the relationship between the socioeconomic status and cognitive skills. A more interesting finding was the better scores of students' at City B a small town where the socioeconomic standards were fairly low but the environment was architecturally and historically well preserved. The results of the study showed that apart from the socioeconomic conditions a relationship with spatial perception, geometric thinking ability, success in mathematics and attitude towards the environment was apparent. Hence, the relationship between the quality of the environment and cognitive characteristics that could be improved in schools emphasized the importance of the quality of the educational environments. Clearly further research is needed to find out the appropriate school environment each age group requires. Improvement of the school environment or built environment in general is an ongoing issue that also requires the reevaluation of environmental education.

Table 1. Students' Ratings of the Quality of their Environment

School	Mean	Standard Deviation	N
City B-1	3.49	.72	70
City A-1	3.43	.72	204
City B-2	3.36	.75	141
City B-3	3.31	.79	77
City A-2	3.28	.80	79
City C-2	3.09	.99	133
City C-1	2.99	.97	144
City A-3	2.78	1.01	104
Total	3.22	.88	952

Table 2. Percentage of Responses for Each Questionnaire Item

Item	Agree	Disagree
Our neighborhood belongs to the people who live there	50.8 %	17.3 %
Our neighborhood belongs to the state	27.6 %	41.3 %
If someone wants to build a new house, he should ask for the approval of the people living in the neighborhood	43.8 %	40.6 %
We are not concerned if the trees are cut down in our neighborhood	23.1 %	72.2 %
They will build us a park if we demand it from the local authorities	36.9 %	29.1 %
People are free to build a house of any kind and shape if they have enough money	40.6 %	45.1 %
We cannot do anything for improving our neighborhood	22.1 %	64.8 %
Only local authorities can do something for improving our neighborhood	26.7 %	56.9 %
It is all right to throw litter on the floor, since the streets are dirty anyway.	5.7 %	90.9 %
We would feel bad if our neighborhood is unclean and disorderly when we have visitors	64.2 %	21.1 %
Our neighborhood is designed for our comfort	33.3 %	40.9 %

References

AIArchitect. (2003), Three approaches for introducing architecture to young people. Retrieved September 24, 2007, from http://www.architectureweek.com /2003/0813/culture.html.

Ballantyne, R. R. & Packer, J. M. (1996). Teaching and learning in environmental education: Developing environmental conceptions. *Journal of Environmental Education*, *27*(2), 25-33.

Bernardi, N. & Kowaltowski, D. C. C. K. (2006). Environmental comfort in school buildings: A case study of awareness and participation of users. *Environment and Behavior, 38*(2), 155-172.

Classen, M. (2002). Applying Math to Real Life. School Libraries in Canada, Academic Research Library, 22(1), p. 30.

De Bono, E. (2004). Thinking course: Powerful tools to transform your thinking. London: BBC Books.

Duatepe, A. (2004). The Effects of Drama Based Instruction on Seventh Grade students' Geometry Achievement, Van Hiele Geometric Thinking Levels, Attitude Toward Mathematics and Geometry. Unpublished PhD dissertation, Middle East Technical University, Istanbul, Turkey.

Fuys, D. (1985). Van Hiele levels of thinking in geometry. *Education and Urban Society*, *17*(4), 447-462.

Gifford, R. (1976). Environmental numbness in the classroom. *The Journal of Experimental Education*, *44*(3), 4-7.

Jurin, R. R., & Hutchinson, S. (2005). Worldviews in transition: Using ecological autobiographies to explore students' worldviews. *Environmental Education Research, 11*(5), 485-501.

Karaman, T. (2000). *The Relationship between gender, spatial visualization, spatial orientation, flexibility of closure abilities and the performances related to plane geometry subject of sixth grade students*. Unpublished master's thesis, Bogazici University, Istanbul, Turkey.

Kowaltowski, D. C. C. K., Labaki, L. C., Pina, S. A. M. G., Borges Filho, F., & Bernardi, N. (2004). Teaching children about aspects of comfort in the built environment. *The Journal of Environmental Education, 36*(1), 19-31.

Labaki, L. C., & Kowaltowski, D. C. C. K. (1998). Bioclimatic and vernacular design in urban settlements of Brazil. *Building and Environment, 33*(1), 63-77.

Lindquist, M. M., & Clements, D. H. (2001). Geometry must be vital. *Teaching Children Mathematics, 7*(7), 409-415.

Loughland, T., Reid, A., & Petocz, P. (2002). Young people's conceptions of environment: A phenomenographic analysis. *Environmental Education Research*, *8* (2), 187-197.

Loveland, E. (2003) Achieving academic goals, through place-based learning: Students in five states show how to do it. *Rural Roots*, *4*(1), 6-11.

National Council of Teachers of Mathematics. (2000). *Principles and Standards for School Mathematics*. Reston, VA: NCTM. Retrieved September 24, 2007, from http://standards.nctm.org/

Nordström, M. (Ed.), (2001). *The city at their fingertips-current projects with children and young people in Sweden*. The Swedish Urban Environment Council Publications.

Payne, P. (1998). Children's conceptions of nature. *Australian Journal of Environmental Education, 14*, 19-26.

Shepardson, D. P. (2005). Student ideas: What is an environment? *The Journal of Environmental Education, 36*(4) 49-59.

Shepardson, D. P. (2005). Student ideas: What is an environment? *The Journal of Environmental Education*, *36*(6), 49-58.

Sommer, R. (1972). *Design awareness*. San Francisco: Rinehart.

Stylianou, D. A. & Grzegorczyk, I. (2005). Symmetry in mathematics and art: Exploration of an art venue for the learning of mathematics. *PRIMUS, XV (1)*, 30-44.

Taylor, A. (1993). How schools are redesigning their space. *Educational Leadership*, *51*(1), 36-41.

Tekeli, I. (1984). The social context of development of architecture in Turkey. In R. Holod, A.Evin (Eds.), *Modern Turkish Architecture*. (p.26). Philadelphia, PA: University of Pennsylvania Press.

Usiskin, Z. (1982). *Van Hiele Levels and Achievement in Secondary School Geometry, CDASSG Project*. University of Chicago Press.

Wals, A. E. J. (1994). Nobody planted it, it just grew! Young adolescents' perceptions and experiences of nature in the context of urban environmental education. *Children's Environments, 11*(3), 1-27. Retrieved Feb2 2008 from http://www.colorado.edu/journals/cye/.

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