# THE EFFECT OF PUZZLE PROTOTYPES ON CHILDREN'S SCIENCE ATTITUDES

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**Abstract**— This study aimed to investigate the effect of puzzle prototypes on fifth and seventh graders' attitudes towards science education. The study group involved a total number of 108 children including fifth (control: 24, experiment: 24) and seventh (control: 30, experiment: 30) graders attending to a randomly selected elementary school amongst the ones located in neighborhoods of Ankara/Turkey characterized by families in middle socio-economic status. In this study, "General Information Form" to collect information about parents and children and "Science Attitude Scale" to find out children's attitudes towards science were used. While analyzing the data, independent samples t-test was used to identify the mean differences between control and experiment group children's pretest scores. In order to investigate the effect of puzzle prototypes implementation on children's attitudes towards Science, two-way ANOVA for repeated measures on one factor was used. As a result, it was found out that puzzle prototypes implementation had a positive effect on fifth and seventh graders' attitudes towards science according to the pretest and posttest mean scores of both the control and experiment group children ($\eta 2=0.330$, $\eta 2=0.417$, $p<.05$). In the light of the findings, it can be suggested that Turkish Ministry of National Education should extend the use of puzzle prototypes which leads to fun and learning at the same time congruent to the existing curriculum.

**Index Terms—** Puzzle Prototypes, Science Subject, Science Attitude.

## I. INTRODUCTION

Science education aims to define the physical and biological world, understand the nature and natural facts, clarify, control and predict the phenomena. It seeks cause and effect relationship on the natural events and tries to predict these events. This process requires high level cognitive skills which develop primarily through science education. Science education is an important subject which helps children explore the physical surroundings, utilize the nature in an efficient way and develop scientific thinking skills [1]. In this respect, it serves as a subject through which children can easily establish connections between daily life and natural facts because most of the tools, devices and mechanical systems used daily are elements of the attainments and literature of Science subject. In addition, Science helps children become a science literate as well as gaining relevant skills [2]. Scientific literacy is an evolving combination of the science-related attitudes, critical thinking abilities, skills and knowledge. In such a way, students develop inquiry, problem solving and decision making abilities to become life-long learners and to maintain a sense of wonder about the world around them [1]-[3]. As a result, children understand science and the nature of scientific knowledge solve the problems according to the principles, concepts, laws and theories of science through the use of scientific methods.

It is not sufficient for children to gain only the knowledge, concepts and skills in Science lesson; indeed, they should gain the scientific attitude and values as well. It is a widespread knowledge that attitude is the key factor in actualizing meaningful learning in science. Thus, the intended positive scientific attitudes and values are likely to affect their future learning of science concepts [4]-[5]. As a result of misinformation, children find science difficult and complex to comprehend which leads to failure in Science related academic success [6]. References [7]-[8] assert that the gained positive attitudes during early years affect the possibility of children to study science and carry out scientific research. On the other hand, [9], [10]-[11] suggest that there is a positive correlation between positive attitudes towards science and science related academic success. Attitude is defined as a predisposition or a tendency to respond positively or negatively towards a certain idea, object, person, or situation whereby it influences an individual's choice of action, and responses to challenges, incentives and rewards [12].

Since children's attitudes are shaped in early years, elementary science education plays an important role in developing positive attitude towards science [13], [5]-[14].

During elementary years, children who mastered solving some cognition-related problems need concrete objects. In this phase, as relative thinking is developed, children like to tackle problems from different perspectives, generalize, make deductive, inductive reasoning and play mind games. The puzzles, in this respect, provide an effective joyful academic learning environment for children. Teachers should design and facilitate effective and interactive learning environments and provide appropriate educational materials in order to raise children who have positive attitude towards Science as well as

possessing necessary scientific skills [15]. According to the research, visual descriptions, instructional technologies and educational materials all play a key role in learning [16], [17], [18]-[19]. Instructional materials and visual media attract the attention of the learners, motivate, enliven the interest, embody the topic, make the learners react emotionally, simplify the complex topics, make it easy to understand by arranging the knowledge and show the relationships among the concepts.

Instructional materials are crucial in that they are visual, entertaining, attractive and stimulate attentiveness [20]. Puzzles which are considered as instructional materials promote children's motor, cognitive, language and social-emotional development and are used for various age groups. Apart from supporting learning through playing, puzzles also contribute to children's mental skills such as perception, remembering, analyzing, exploring, comparison, forming relations, detecting the similarities and differences, observing the details, making visual differentiation, envisioning, problem solving, critical thinking, analyzing, forming whole-part relationship, concentration and observation [21], [22], [23]-[24]. Children explore every object with its use and functions as they play. Such a learning is an advance in knowledge in mind. On the other hand, through this process language development is also fostered since children use the newly learned vocabulary items. While playing, children uninterruptedly think, perceive, comprehend and symbolize all which are abstract mental activities. Such a mental activity promotes the cognitive abilities such as perception, interpretation, evaluation and decision-making. Cognitive development and other developmental domains are intertwined; i.e. they cannot be separated from each other while each of them supports the other. Furthermore, some other skills such as queuing, sharing, helping together with fine motor development and language development are also supported through play [25], [26]-[27]. Puzzles provide the chance to try over and over again which leads to the development of schemas. Reference [28] asserts that puzzles provide new experiences through problem solving and motivation through a joyful way of learning. Apparently, use of puzzles as instructional materials are likely to affect children's attitudes towards Science. Considering this issue, this study aimed to investigate the effect of puzzle prototypes on fifth and seventh graders' attitudes towards science education.

## II. MATERIALS AND METHOD

The study complies with the principles of pretest – posttest experimental design with control group. In this design the dependent variable is fifth and seventh graders' "attitudes towards Science" whereas the independent variable is "puzzle prototypes implementation" of which effect was investigated [29]. The study group involved children including fifth and seventh graders attending to a randomly selected elementary school amongst the ones located in neighborhoods of Ankara/Turkey characterized by families in middle socio-economic status. Two classes from each grade were randomly selected among the fifth and seventh grades in the randomly selected school. Therefore, the study group was comprised of total number of 108 children including fifth (control: 24, experiment: 24) and seventh (control: 30, experiment: 30) graders.

In this study, "General Information Form" to collect information about parents and children and "Science Attitude Scale" which was developed by [30] to find out children's attitudes towards Science were used. Science Attitude Scale included both positive and negative 15 items. The scale is of a five point Likert scale consisting statements as follows: "totally agree", "agree", "neutral", "disagree" and "totally disagree". During the data input, reverse coding was used before calculating the score, i.e., the positive items were coded from 5 to 1 while the negative ones were coded from 1 to 5. The lower scores meant lower levels of attitudes and vice versa. The reliability coefficient of Science Attitude Scale was found out to be .83. Both of the data collection tools were filled up by the study group children on their own.

A total number of 20 instructional plans (for each group 10) which include puzzle prototypes and play activities were prepared. The developmentally appropriate plans were congruent to the normal curricula and can be integrated easily. The games were designed according to the children's interests and needs and daily experiences and ordered from simple to complex by taking cognitive processing skills such as matching, relating, grouping and ordering. Puzzle prototypes and games were prepared in parallel with the elementary Science curriculum and curricular manuals. Within the educational program there were gradually level based designed games and puzzle prototypes prepared according to the units such as sense organs, balanced diet, food groups, vitamins, digestion system, urinary system, endocrine glands, habitats, places for animals, food of animal origin, saving the nature and formation of rain. In addition, the program includes puzzle prototypes intended for story making and telling. Prior to the implementation of puzzle prototypes, "Science Attitude Scale" was administered to the children in the study group from both groups as a pretest. Then, the experiment group children were given an instruction of 20 puzzle prototypes which could be integrated into the curriculum for two days a week, one hour daily for a period of five weeks. After the puzzle prototypes implementation, "Science Attitude Scale" was re-administered as a posttest.

In the analysis of the data collected through "Science Attitude Scale", descriptive statistics such as frequency distribution and arithmetical mean together

with parametrical statistics were used to test the hypothesis since the groups were found out to be homogeneous [31]. In order to identify the difference between the control and the experiment group children's pretest and posttest scores, independent samples t-test was used while investigating the effect of puzzle prototypes implementation on children's attitudes towards Science, the difference between pretest and posttest scores were identified through two-way ANOVA for repeated measures on one factor.

## III. FINDINGS AND DISCUSSION

The findings from the study which aimed to investigate puzzle prototypes on the fifth and seventh graders' attitudes towards Science were presented as tables and discussed.

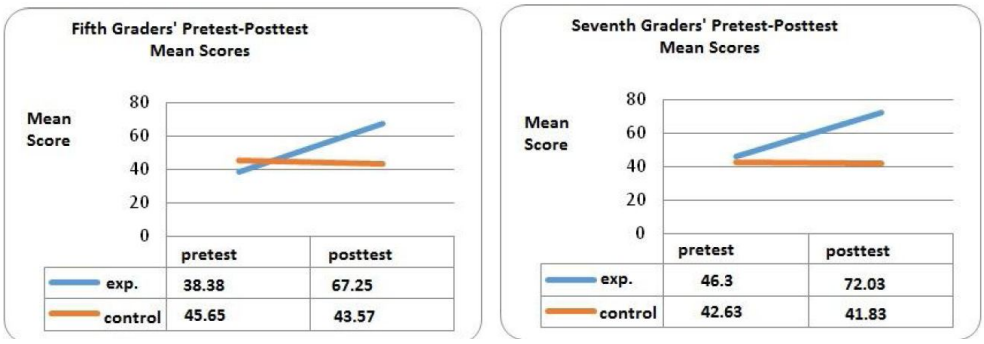



**Figure 1. Fifth and seventh graders' pretest – posttest mean scores from Science Attitude Scale**

According to Figure 1, fifth graders who were in the experiment group scored 38.38 before the treatment whereas the mean score from Science Attitude Scale increased to 67.25 (gain score=28.87). In contrast, the control group members' pretest mean score was 45.65 while the posttest mean score was 43.57 (gain score=-2.08). Likewise, seventh graders who were in the experiment group scored 46.30 before the treatment whereas the mean score from Science Attitude Scale increased to 72.03 (gain score=25.73). In contrast, the control group members' pretest mean score was 42.63 while the posttest mean score was 41.83 (gain score= 0.8).

**Table 1.** ANOVA results of the fifth graders' pretest - posttest mean scores from Science Attitude Scale

| VARIANCE | KT | sd | KO | F | p | $\eta^2$ |
|---|---|---|---|---|---|---|
| Between-groups | 8545.660 | 46 | | | | |
| Group (Experiment/Control) | 1580.891 | 1 | 1580.891 | 10.214 | .003* | .185 |
| Error | 6964.769 | 45 | 154.773 | | | |
| In-group | 21259.690 | 47 | | | | |
| Measurement (Pretest-Posttest) | 4213.987 | 1 | 4213.987 | 16.611 | .000* | .270 |
| **Group*Measurement** | **5629.477** | **1** | **5629.477** | **22.190** | **.000*** | **.330** |
| Error | 11416.226 | 45 | 253.694 | | | |
| Total | 29805.350 | 93 | | | | |

*p<.05

**Table 2.** ANOVA results of the seventh graders' pretest - posttest mean scores from Science Attitude Scale

| VARIANCE | KT | sd | KO | F | P | $\eta^2$ |
|---|---|---|---|---|---|---|
| Between-groups | 14951.200 | 59 | | | | |
| Group (Experiment/Control) | 8602.133 | 1 | 8602.133 | 78.582 | .000* | .575 |
| Error | 6349.067 | 58 | 109.467 | | | |
| In-group | 17323.999 | 60 | | | | |
| Measurement (Pretest-Posttest) | 4662.533 | 1 | 4662.533 | 36.637 | .000* | .387 |
| **Group*Measurement** | **5280.133** | **1** | **5280.133** | **41.489** | **.000*** | **.417** |
| Error | 7381.333 | 58 | 127.264 | | | |
| Total | 32275.199 | 119 | | | | |

*p<.05

Table 1 presents that group x measurement common effect is significant in terms of the improvement in experiment group children's attitudes towards Science [$F_{(1, 45)}$=22.190, p<.05, $\eta^2$=0.330]. According to this finding, there is 33% difference between the gain scores of the control and experiment group in favor of the experiment group in terms of attitude towards Science. Therefore, depending on the games inherent in puzzle prototypes implementations it was found out that the experiment group children gained higher in comparison with the control group in terms of the difference between the mean pretest scores and posttest scores.

Table 2 presents that group x measurement common effect is significant in terms of the improvement in experiment group children's attitudes towards Science [$F_{(1, 58)}$=41.489, p<.05, $\eta^2$=0.417]. According to this finding, there is 41.7% difference between the gain scores of the control and experiment group in favor of the experiment group in terms of attitude towards Science. That is, depending on the games inherent in puzzle prototypes implementations it was found out that the experiment group children gained higher in comparison with the control group in terms of the difference between the mean pretest scores and posttest scores.

Students' attitudes towards Science develop at early ages. As a result of misinformation, children find science difficult and complex to comprehend which leads to failure in science related academic success. For this reason, introduction to Science is rather important so that the students love and develop positive attitudes towards Science [32]. Reference [33] investigated the relationship between achievement in Science and affective characteristics, namely attitudes, perceptions and interests. As a result, they found out that there was a significant

relationship with a large effect size. As a gain of Science subjects, children are supposed to acquire the skills and mental process necessary for solving science-related problems they encounter in daily life instead of memorizing science facts [34]. Therefore, science teaching should be effective and active so as to develop positive attitude towards Science. The reason is that children initially love Science, participate actively, learn by doing, explore, observe, examine, make experiments and finally reach the knowledge on their own in an effective Science lesson [35]. This is only possible when appropriate educational materials are provided during this process. One of these materials is surely the puzzles.

Reference [36] suggested that grade level, having a private room at home, achievement level, the frequency of using laboratory at school were significantly effectual on sixth, seventh and eight graders' attitude towards Science. In this sense, puzzle prototype implementations which allow children to learn by doing are likely to develop positive attitude towards Science such as making experiments at laboratory settings.

Reference [37] carried out a research to study the effects of such factors as home characteristics, student characteristics, teaching and learning variables and school factors on the attitude towards science courses; and revealed that these variables have a contribution of 70% to students' adoption of positive attitudes towards science. The contribution rates of the abovementioned factors are as follows: home characteristics 1%, student characteristics 16%, school characteristics 11%, learning and teaching variables 41%. These results show that the teaching methodology used by the teacher is the most important factor which determine students' adoption of positive attitudes towards science. In addition, [38] emphasized the role of learning at play settings and educational materials for permanent learning. It is acknowledged that establishing a positive learning environment is crucial in reaching educational goals. On the other hand, multi-sensory learning environment also contributes to the permanence of learning. In order to address more than one sensory organ teachers should provide more visual and auditory materials. Especially, utilizing new technology in the classrooms enrich the quality of learning [39]. Moreover, teaching using game technique motivates the learners and establishes an entertaining and efficient learning environment [40].

Reference [41] studied sixth graders' academic achievement in Science subject, specifically "Solar System and the Planets" and indicated there was a significant difference between the achievements of the experimental group who used educational game-based learning method and the achievement of the control group who used traditional learning method in favor of the experimental group. Likewise, [42] reported the positive effect of puzzle prototypes on fifth graders' Social Studies subject achievement while [43] reported similar findings for second graders' Introduction to Science subject. In the light of such findings in the relevant literature, puzzle prototypes can be thought of as affecting the positive attitude of fifth and seventh graders towards Science.

## V. SUGGESTIONS

As a result of this study, which aimed to investigate the effect of puzzle prototypes on fifth and seventh graders' attitudes towards Science, it was found out that puzzle prototypes have effect upon children's attitudes.

Based upon the findings derived from this study, some suggestions may be given as follows:

- Pre-service training sessions should be available to prospective teachers regarding the use of puzzle prototypes.
- Researchers can carry out further research on different age groups and various other subjects.
- Puzzles for other subjects should be designed for use at public schools affiliated to Turkish Ministry of National Education and the use of puzzles should be extended country-wide.

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