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Analyzing and Enhancing Geometric Transformation Skills of Elementary Education pre-Service Teachers within an International Context

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Abstract. The purpose of this study was to investigate the pre-service classroom teachers' spatial skills in Turkey and compare them with their American counterparts in terms of their prior and after intervention spatial skills measured by a standardized test (Differential Apptitude Test-Space Relations). Intervention over 6 weeks (approximately 15 minutes each session) consisted of structured geometric transformation activities using an interactive computer program Mathemagic™. Pre-test results showed that the Turkish pre-service elementary teachers fell way behind their American counterparts. However, they learned significantly more from the same intervention than did the Americans and they had almost the same post test mean score. We concluded that Turkish pre-service teachers can improve their spatial skills given the appropriate computerized learning environment.

Keywords: geometric transformations, spatial visualization, cross cultural comparisons, computer programs

INTRODUCTION

Recent international studies (e.g., Third International Mathematics and Science Study [TIMSS], 1999; Programme for International Student Assessment [PISA], 2003) show that the Turkish students fell well behind their international counterparts in mathematics and science. In some of the domains of mathematics such as geometry this difference was even more dramatic. Of the 38 countries that participated in TIMSS-99, Turkey ranked 31st in mathematics and 33rd in geometry. Furthermore, among the 8th graders, Turkey ranked 34th in mathematics and 36th in geometry out of 40 countries that participated.

These consistently low scores of Turkish students might be due to the fact that their teachers themselves have low spatial ability and low interest in teaching geometry. In addition, pre-service elementary school teachers, uniquely poised to influence children's learning, may be less skilled spatially than pre-service teachers of mathematics and science (Lord & Holland, 1997). Manipulatives are plentiful in the elementary schools, but spatially unskilled elementary teachers overlook learning opportunities since they cannot teach what they themselves do not know (Franke, et al., 1998). Therefore we investigated the pre-service classroom teachers' spatial skills in Turkey and compared them with their American counterparts in terms of their prior and after intervention spatial skills measured by the standardized Differential Aptitude Test -Space Relations (DAT).

METHODS

Participants

The research population consisted of undergraduate elementary education majors enrolled in 6 sections of a required mathematics methods course that also addresses topics of informal geometry. Four course sections were in the US and two course sections were in Turkey. Sixty-eight American students participated, while 35 Turkish students completed the study. The American students were comprised of 65 females and 4 males, while among the Turkish students there were 28 females and 7 males. The different genders were approximately evenly distributed between control and experimental groups.

Materials

The study made use of a standardized test of spatial visualization (the spatial portion of the Differential Aptitude Test, Space Relations Subset (DAT, authored by Bennett, Seashore, & Wesman, 1947) as pretest and posttest instruments. The DAT is a 25 minute timed test to complete as many of 60 as the time permits. The DAT was used because a) it is a standardized test of spatial visualization, and b) the items in the DAT (surface development, imagining flattened patterns folded up into three-dimensional shapes) does not in any direct way relate to the experimental activities, mentally visualizing geometric transformations of two dimensional shapes.

The Mathemagic™ computer program developed and used by Lamb et al. (2002) in their studies of spatial "misperceivers," served as the experimental environment. Mathemagic™ is well-suited for learning to visualize transformations in 2D plane because a) rotations, for example, are in multiples of 90 degrees, conforming to Newell & Simon's (1972) theory of a problem space, a finite set of transition rules to map from one discrete state to another, including a starting state and goal states; b) the software has a motivating game with "show" mode where the user sees animation of transformation and "no show" mode where the user sees only the final image. The "show" and "no show" modes of the game provide excellent means of designing spatial weaning exercises on geometric transformations.

Procedure

The pretest was administered to all students participated in mathematics methods course in both countries, Turkey and USA, during early class sessions in the Fall semester 2006. The experimental groups, utilizing computers, participated in transformational geometry visualization exercises, once a week for six weeks for approximately 15 to 20 minutes each session. Participants worked through structured exercises using the Mathemagic™ program and drawing exercises. The exercises made extensive use of the game mode in the Mathemagic™, making extensive use of the "show" and "no show" modes, to implement "spatial weaning." The exercises consistently presented activities first with full visual support ("show mode"), followed by activities with less visual support ("no show" modes).

Participants also worked through (diagnostic assessments/formative evaluations) work sheets, including diagnostic drawing items where they had to draw how they thought a transformed object would look and essay questions aimed at evaluating their conceptual understanding ("Does the order of transformations matter?"). Finally, eight weeks later, the research participants in both countries were post-tested with the exact same version of the DAT.

In both the United States and Turkey, there were two groups, one experimental group with the exercises in geometric transformations described above in addition to the course requirements and one control group who did nothing more than the course requirements.

RESULTS

We first present the pre-test results to make the overall picture of the initial state clearer. Pretest revealed two important findings. First, as seen from Table 1, the US students scored significantly better on DAT than did the Turkish students (t=3.018, n=103, p<0.003).

Table 1. Pretest results of pre-service elementary teachers by country

COUNTRY	N	PRETEST MEAN	SD	MEAN DIFF.
Turkey	35	30.74	8.35	4.96*
USA	68	35.71	7.66	

p<0.01

Second, however, note that both the highest and the lowest achievers were also from Turkey. The highest score a Turkish student received was 57 out of 60 maximum. While the highest score a US student received was 55. The lowest score a Turkish student received was 16, while the lowest score a US student received was 18. The wide distribution of Turkish students' scores is also evident in Table 1, which shows that the standard deviation for Turkish students is larger.

As depicted in Table 2, the posttest scores of the students from the two countries are very close. The difference did not approach statistical significance.

Table 2. Posttest results of pre-service elementary teachers by country

COUNTRY	N	POSTTEST MEAN	SD	MEAN DIFF.
Turkey	35	38.49	9.06	1.57
USA	68	36.91	10.61	

When it comes to the gained scores (see Table 3), Turkish students gained statistically significantly more with the intervention than did their American counterparts (t=4.86, n=103, p<0.000).

Table 3. Gained score of pre-service elementary teachers by country

COUNTRY	N	GAINED SCORE MEAN	SD	MEAN DIFF.
Turkey	35	7.74	4.43	6.54***
USA	68	1.21	9.21	

p<0.001

Since the Turkish students had relatively lower scores on the pretest than did the US students but gained more with the intervention, we suspect that lower achievers in both countries might have gained more than did the higher achievers. We tested this hypothesis.

Table 4. Low versus high achievers gained scores on DAT

LEVEL OF ACHIEVEMENT	N	GAINED SCORE MEAN	SD	MEAN DIFF.
Low achievers	31	6.03	8.0	4.16**
High achievers	73	1.88	9.2	

$p<0.01$

Table 4 shows that low achievers gained statistically significantly more from the intervention than did the high achievers ($t=2.314$, $n=104$, $p<0.024$).

DISCUSSION and CONCLUSION

This current study was utilized a pretest-posttest experimental design with control group. Compared were the pre-service classroom teachers' spatial skills as measured by a standardized test. On the first issue, as to whether the Turkish pre-service classroom teachers differ significantly from their American counterparts in term of their spatial skills as measured by a standardized test the results revealed such significant difference. The Turkish students were spread wider than that of the Americans.

After the intervention, although the Turkish students improved statistically significantly more than the US students, the post-test average among the Turkish students was almost identical to the post-test average among the US students. So, even though the Turkish students improved much more, they really only caught up to the US students. Perhaps the activities helped students at the low end more than they helped students at the high end (Smith, 1998). It may not be the country that makes the difference; but rather that lower-ability students benefited more from our activities than higher-ability students.

Why the Turkish students scored significantly lower than the Americans on pretest is open to speculation. Perhaps, they were less familiar with tests such as the DAT. Perhaps, they use interactive electronic and other visual media less than Americans. Similar results are reported in the current literature (Olkun, Altun, & Smith, 2005) that Turkish students are less exposed to computers than do their American counterparts.

In any case, the results have three important implications: First, they suggest that spatial can be enhanced through relevant learning activities such as geometric transformations. Secondly, the results suggest that relevant activities may also affect far transfer and some generalization of spatial skill, i.e., the interventions were not specifically related to the DAT spatial visualization test used for the pre and posttests. Thirdly, the cross cultural differences may be alleviated through relevant interventions especially for participants who started out weaker in spatial visualization skills.

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Theme: Technology in teacher education