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A QUALITATIVE EXPLORATION OF INDIAN SCHOOL STUDENTS' PERCEIVED SPATIAL ABILITY

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Abstract:
The present phenomenological study investigates the lived experiences of Indian school students, in attempting to answer the question: "What is it like for a student to experience the spatial ability phenomenon in learning school science?" The study included 12 interviewees and 12 focus group participants at Jamia Senior Secondary School run under Jamia Millia Islamia administration. Data sources included interview transcripts; think aloud transcripts, focus group transcripts, researcher journal entries, performance data, observation data, and spatial ability test (MRT) data. This paper provides the holistic, structural description of the spatial phenomenon that emerged from the descriptions of the participants' experience, as well as an expository on invariant themes that were elicited from the data. Educational implications are also discussed.

Keywords: spatial ability, lived experiences, childhood experiences

1. Introduction

Engagement with the representation of the carbon compounds at the school level is when I happen to learn the concept of spatial ability. A curiosity sparked in me as I began teaching Chemistry, which begged me to ask: which interventions would improve the spatial ability of students? To inquire, reviewing literature associated with spatial ability and other domains provided results and methodologies which seemed unselective. Further inquiry clubbed with my teaching experience, I learned that spatial ability although manifested at different levels, evident by students' performance, is harder to conceptualize and measure.

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Definitions of spatial ability continue to be unmet with consensus among the scholars and researchers, despite the research of the said field can be traced as far back as 1920s (Sorby, Leopold, & Gorska, 1999). Alternatively, spatial ability can be proposed as a collective of specific skills (Voyer, Voyer, & Bryden, 1995). Attempts have been made by theorists of numerous schools – art, engineering, education, math, and cognitive psychology etc. – to precisely define the concept in question. In order to do so, they have proposed combinations of the concepts 'spatial' and 'visual' with 'skill,' 'perception,' 'relations,' 'imagery,' 'cognition,' 'ability', 'reasoning,' 'orientation,' and 'rotations.'

In the Theory of Multiple Intelligences, Gardner (1983), put forth that people utilize seven autonomous intellectual facilities. One among them, relevant to the discussion of visual-spatial ability, is the 'spatial intelligence.' It is defined as the ability for one to perceive, transform, and recreate spatial and visual information.

Linn and Peterson ran a meta-analysis study of process-oriented, factor analytic, and correlational studies conducted between 1974 and 1984. Through it, they concluded that in a general sense, spatial ability can be understood as the procedural skill of representing, transforming, generating, and recalling symbolic, nonlinguistic information. It is accompanied by the tasks of mental rotation and spatial perception and visualization. Here, spatial visualization consists of complex manipulation of spatially occurring information. Spatial perception denotes the ability to connect spatial relationship to oneself, despite information of distractive nature. Lastly, mental rotation consists of quickly rotating two or three-dimensional objects accurately. Analysis of the relationship between diverse spatial representations, rather than matching of representations, occurs through these tasks. Furthermore, another set of tasks called 'dynamic spatial reasoning tasks' consists of relative velocity and judgment tasks.

As a root of success, spatial ability is not only accredited in the field of sciences, but also in mathematics, technology, art, medical field, engineering, architecture, and design (Hegarty, M., 2007; Hegarty, Cohen, C., M., Keehner, M., Montello, D. R., & Lippa, Y, 2007). This emphasizes the critical necessity for interventions to enhance the students' spatial ability.

Research discussing the root of spatial ability has also been given importance i.e., whether it is innately existent or assimilated by means of experiences (El Koussy, 1935). Theorists such as Piaget and Inhelder (1971) and Thurstone (1938) strongly incline to the approach that it is innate. Studies also have discovered that it can be learned and developed with the help of apt training and motivation activities (Kang & Mohler, 2010; Lohman, 1993; Sorby, 1999). However, there appears to be disagreement on how spatial ability is affected by training and activities (Kang & Mohler, 2010; Lohman, 1993; Sorby, 1999). For example, some may struggle with spatial activates despite receiving specific intervention. Differences in performance have also been found in different age groups, ethnicities, and genders (Peters, Lehmann, Takahira, Takeuchi, & Jordan, 2006; Silverman, Choi, & Peters, 2007).

The reason for the above variances maybe owing to the fact that several studies have produced training models to improve an individual's spatial ability (Mohler,

2008). Researchers have not considered an individual's orientation and experiences as contributing factors to their spatial ability, until recently (Ibid.). Exercising a qualitative technique, spatial ability of Indian school students was studied from their own perspective. As a result, it provided a unique information associated with childhood experiences, which may have influenced their spatial ability.

2. Significance

Quantitative approach has dominated as a tool for measurement for the unique nature of spatial ability. This has resulted in less research questioning and inquiring the reasons behind successes or failures of some individuals in tasks relating to spatial performance. This difference can be culturally derived as suggested by some studies (Silverman, Choi, & Peters, 2007; Tang, et al., 2006; Wang & Lin, 2005). In fact, adopting a qualitative approach is primary in understanding how they are culturally derived. For example, studying environmental factors, participant's background, and experiences would help to investigate the concept (Demetrious, Kui, Spanoudis, Christou, Kyriakides, & Platsidou, 2005; Silverman, Choi, & Peters, 2007; Wang & Lin, 2005).

3. Purpose

The present research proposes to elicit, describe, and analyze the background, experiences, and perspectives of school students with different levels of spatial ability through answering the question: "*What was it for a student to experience the spatial ability phenomenon in learning school sciences?"*

Similar question, as that proposed in Mohler's study, is posed in the present study in the context of Indian school students. The study examines in students' perspectives with regards to spatial ability caused through diverse childhood and life experiences including upbringing and academic experiences.

4. Methodology

As emphasized so far, the present research employs a qualitative research methodology through interviews, observations, and focus-group discussion. The study is based on the phenomenological perspective that examines a participant's perceived meaning of a concept that is shaped by their experiences. Its key focus is "*to explore how human beings make sense of experience and transform experience into consciousness, both individually and as shared meaning"* (Patton, 2002, p. 104).

Students enrolled in Class X of the Jamia Senior Secondary School, Jamia Millia Islamia, were selected for the study. Although NCERT syllabus forms the basic guideline, knowledge is also imparted in Islamist, Hindu ethics, elementary Urdu, computer, physical education, and music besides mathematics, natural sciences, and social sciences. Languages such as Hindi, Urdu, and English are also taught in the curriculum. Differences in socio-economic background of the students exist, including

students from urban, semi-urban, and rural localities, and low and middle-income families. Sample from the present population was selected as they were on course to conclude their school sciences education.

Unique and extreme cases of spatial ability phenomenon in individuals can be studied through qualitative study as evident by Mohler (2008) and Patton (2002)'s works. Working on the same lines, school students (n = 57) were tested with Vandenberg Mental Rotation Test (MRT) (1971) used for in-class activity. This test has the test-retest reliability of .83 (Vandenberg and Kuse, 1978). Upon scoring (M = 8.51, SD = 4.31), two groups namely High Spatial Participants (HSP) and Low Spatial Participants (LSP) were created based on their MRT scores among the volunteered students.

For a single case qualitative study, the minimum number of participants required differs. For example, Mohler (2008) interviewed twelve students, however, they may also range from three to ten participants in order to comprehend the experiences and background (Creswell, 1998). Therefore, to meet higher end of minimum participants, twelve participants – six from each group: HSP and LSP – were selected for in-depth interviews. Among the six, there were three male and three female participants.

4.1 Data Collection

In-depth personal interviews were the key source of data along with various other sources for the triangulation purpose. Each participant was interviewed thrice and each interview lasted for 90 minutes. First of the three interviews worked on drawing on the individual's experiences and background in affecting their spatial ability.

Questionnaires were administered to assess their personal background, which included acquiring details such as gender, age, family income, parental occupation, parental involvement in studies, and student's involvement in parents' occupations. Similarly, personal experiences were also assessed, such as hobbies, academic experiences, childhood experiences, and favorites (books, subjects, teachers, etc.). Following this, participants engaged individually in the 90-minute interviews. One of the obstacles was the language barrier, owing to which some interviews were therefore conducted in local languages such as Hindi or Urdu. The transcribed material was translated into English for data explicitation. The interviews were divided into subsections as suggested by Mohler. First interview designed to examine background and experiences affecting one's perspective of one's own spatial ability and reflections of participants on their spatial ability as it developed. All interviews were audio-recorded.

4.2 Data Analysis

Coding procedures proposed by Giorgi (1985 & 1997) were followed: procedural steps of bracketing, intuiting, and describing was used in the present study. Here, the first eliminates assumptions and takes in notice overall textual description. Intuiting requires the production of meaning units that are then utilized in summarizing the

textual description. Lastly, describing involves structuralizing the description of meaning units (Giorgi, 1985).

The predetermined coding system was followed during transcribing to discover and identify students' background and experiences affecting their spatial ability. Patterns and identifications made during analysis were explored and further used a tool to improve rereading the data. Therefore, several layers of analysis were conducted upon the acquired data.

5. Invariant Themes

Five themes, encompassing the participant's perspective on spatial ability development, were drawn based on the data gathered from the interviews. Themes such as childhood toys, games and sports experiences, feelings and parental involvement, and favorite subject in school were some of the comparable themes with that of Mohler (2008). The next sections discuss the themes and the findings in them.

5.1 Childhood Toys

In the first group – high spatial ability (HSP), all the six participants reported their engagement with building block toys, puzzle toys, tinker toys, and physical toys, however, only three did from the low spatial ability (LSP) group. In fact, the LSP group indicated rarely playing with those particular toys. On the contrary, the LSP group preferred playing with friends or non-engaging toys. This is consistent with the literature (Brosnan, 1998). Mohler (2008) also found that both HSP and LSP groups played or had access to Legos.

Only one LSP but four HSPs preferred playing chess and games on mobile or computers. Countless studies have found that spatial ability could be effectively polished by using animated visuals and/or through physical activities (Alderton, 1989; Lohman, 1993).

5.2 Spots and Outdoor Games Experiences

There is little research done concerning visualization phenomenon applied to the sports. Although studies examining a connection between spatial ability and sports performance are present (Glasmer & Turner, 1995; Lord & Garrison, 1998; Lunneborg, 1982), but they fail to emphasize on the visualization as a way to improve sports performance. In fact, many participants entail experiences of visualization as real, vivid, and necessary as an applied effort in other subject matters.

Four participants accepted the use of visualization to improve sports performance. To add to that, two of the HFGs reported the same. Three HSPs reported having used visualization in cricket while two did in *kancha* and *gulli-danda*, and one in badminton.

5.3 Favorite School Subjects

Several studies support that in comparison to students with low spatial ability, high spatial ability ones perform significantly better in mathematics and sciences. In the

present study, all the HSPs reported mathematics as their favorite subject and their strength in these two. On the contrary, LSPs inclined towards language subjects, which are Hindi, Urdu, and English. They further reported finding mathematics as relatively hard. Science was favorited among all six but one LSPs. The findings are consistent with Mohler's high and low spatial ability participants.

5.4 Parental Involvement

A study (Wang & Lin, 2005) found parental involvement as one of the factors affecting a school student's success in mathematics and spatial ability. Parents are responsible for maintaining a more structured time frame after formal schooling. Their further create higher expectation that the children have to meet. These lead on to affect a school student's higher achievement (Ibid.).

Unsurprisingly indeed, it was found parental involvement was high in the HSPs. Upon further analysis of their background, one of the following two cases were to be present in each of HSPs. Either parental occupation included engineer, architect, teacher, and accountant (i.e. white-collar workers) or the parents were farmers, carpenters, tailors (i.e. blue-collar workers), but the participants showed involvement in their parent's occupation. In the present research, this new theme emerged in comparison to Mohler (2008). Looking at the former case, opportunities for learning is increased due to the good financial position.

5.5 Feelings

Nearly every participant in Mohler's (2008) study showed some form of frustration, intimidation, and confusion during a spatial task. He further proposed that these limit the participant's spatial ability. For example, a large number of school students indicated low-confidence about their spatial ability. Only one of the HSPs reported having the strong spatial ability. Even when the Vandenberg Mental Rotation Test was being administered, participants reported being frustrated and intimidated. And, on the contrary, the same was not reported while solving mathematical and scientific problems, regardless of the fact whether spatial skills were involved (eg: problems based on drawing and imagination from their science textbook in second interview).

Since the school, students invest more time and effort in learning school subjects, could have factored into the increased performance in mathematical and scientific tasks. In fact, none of the participants attempted similar items of MRT in a formal or school context before the participation in present study. The idea of taking responsibility for academic success and failure to oneself is prevalent among the Indian school students. Therefore, when one undervalues their skills, they are driven to perform better through extra effort and time. This perspective may motivate students to achieve higher performance instead of hindering their progress. Evidently, when the participants were intimated and frustrated with the spatial problems, they may use the feelings as a motivation tool to perform better. This is also supported by the findings of Wang and Lin (2005).

6. Conclusions and Educational Implications

Work on improving the spatial ability of students is ever growing with several intervention models being developed and tested. This is not to assume, however, that these interventions work universally and uniformly. With the population facing difficulty in spatial ability leading to stunted adult career progression, the necessity of spatial ability to perform a task has only increased (Maccoby & Jacklin, 1974; McGee, 1979). The present research aimed to examine school students' background and experience along with how these affect their perceived spatial ability in learning school sciences.

The findings from the present research would assist educators in understanding perceived roles of the childhood experiences, academic or school experience, personal background and hobbies in inculcating and improving spatial ability among school students.

It was found in the present research that both high and low spatial participants were having access to building blocks and toys which delivered hands-on activities during their childhood. Furthermore, LSPs preferred playing with fellow peers over hands-on activities. Another interesting finding is that even female participants had access to puzzle games and building blocks as toys. For example, one of the HSP said:

> *"Yes, I played with them. I think everyone had one when they were little. Challenges, puzzles, Umm… but it was interesting, time-consuming, engaging and addictive…. building. Build all sort of things and then um. Break."*

Gender differences were expected in spatial ability as male students were accustomed to these types of toys and female students were not. While toys such as building blocks and puzzle games enhance spatial ability, but generally females are only restricted to kitchen sets and stuffed dolls. It is speculated therefore that since all the female HSPs come from urban educated background, they have grown up using toys of regardless of a child's gender.

Studies have shown that musical experience in childhood help in developing spatial ability (Mohler, 2008). Since many participants did not have musical experiences, they failed to associate it as a factor which may have affected their spatial ability. This proposition is supported because most of the participants had little or no musical experience. In fact, they reported investing time to improve their skills in sciences and mathematics instead of engaging extracurricular activities.

As an additional support, parents engage themselves with the child in their after-school studious activities. For example, most participants indicated having engaged in studying with a tutor, coaching classes, or parents. These efforts put forth by parents improve children's performance in science and mathematics. HSPs' parents were more involved in their studies, it can be proposed, since parents are engaged in either blue-collar work but continue to assist in study by providing motivation and pressure or

white collar workers who may be educated and/or have grasp the importance of formal education.

Due to the correlation found between spatial ability and science and mathematics, it was expected that high spatial school participants report mathematics as a favorite subject. Contrary to them, the low spatial school participants report mathematics as a difficult subject. Highlighting the prevalence of mathematics as a favorite subject among the HSPs, one of the participants' words shall be looked at:

> *"Mathematics has multiple parts, I really liked geometry, but not numbers...I liked theories, problems, lines and drawings in geometry."*

Low-confidence was prevalent among the participants when they were asked their outlook on their own spatial ability. This was evident by their frustration, intimidation, and confusion. Some studies, however, indicate these feelings may, in fact, be beneficial for students' performance. For instance, when school students uncover or come across weakness, they tend to invest extra time and effort to overcome the weakness. With that said, a longitudinal study should provide interesting findings, where the research might see if the feelings subside.

The findings of the present study provide helpful information for educators and parents. They may develop models based on the findings to improve the spatial ability of their students and children. Students' perspective on spatial ability may be formed by their childhood experiences. The present study, therefore, found that early intervention is the primary for the successful development of spatial ability. Primarily, spatial ability phenomenon of an individual needs to be emphasized and understood. Secondarily, stakeholders such as parents and educators need to provide access to a variety of toys, engage in children's learning, and encourage participation in sports and outdoor games.

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