

Correlates of Science Concept Acquisition: Foundations for Better Doctors, Engineers, and Scientists

Sarah Shahed,¹ Madiha Rauf Hashmi,² Ali Madeeh Hashmi³

Abstract

Background: School prepare students for successful professional careers. Evidence indicates that the quality of science education in schools is deteriorating and students may not be developing the conceptual understanding of science required for success in later life. This may be one of the causes of dearth of research scientists in the country.

Objective: The present study was conducted to study science concept acquisition and related variables in secondary school students in Punjab Province.

Method: A survey was conducted involving a purposive sample of 720 male and female students of class 9 in both science and humanities groups in public sector schools in six districts of Punjab covering the central,

southern and northern region of the province. The Science Concept Acquisition Test and a self – constructed questionnaire were used for data collection.

Results: The findings of this study revealed that variables like class size, teaching methodology, academic group and city were important in the performance of students in science. The study also yielded gender differences in test scores.

Conclusion: It is suggested that the school authorities and all stakeholders need to take steps to improve the quality and learning outcome of science education in Pakistan.

Keywords: Concept Acquisition , Rote Memorization, Gender, Teaching methodology, academic group.

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Shahed S.¹

Department of Gender and Development Studies
Lahore College for Women University

Hashmi M.R.²

Department of Gender and Development Studies
Lahore College for Women University

Hashmi A.M.³

Department of Psychiatry and Behavioral Sciences
King Edward Medical University/ Mayo Hospital, Lahore

Introduction

Attempts have been made in recent years to improve the quality of science education in Pakistan. It is important that the learners are able to apply the learnt concepts of science in daily and professional life which empowers learners to form conclusions and generalizations based upon the information accumulated with the passage of time.¹ However many students unfortunately have a very poor foundation in science literacy and therefore may remain unable to apply the formally studied concepts in their practical life. This represented a significant rate of science pupils dropping science subjects in the later year because conceptual understanding had not been obtained.²

In Pakistani school settings, particularly state funded schools, the emphasis of learning is on retention and rote memory. Thus students do enough to get through the next test but do not necessarily grasp the information.^{3,4} According to the census, the proportion of enrollment in science to enrollment in humanities,

aggregate at 9th grade is 2:1 in Pakistan⁵ which reflects that our educational framework is still unable to attract of people towards science subjects. In an attempt to understand the theoretical understanding of conceptual knowledge in pupils, educator and social research specialists have found out variables which help in successfully imparting the practical and conceptual knowledge among students. The role of many factors has been discussed and considered critical to promote scientific conceptual learning in students by many researchers which are; sex, the school environment, student factors, teacher factors, nature of subject, Government policies, and so on.⁶⁻⁹ Besides this, class size and teaching methodology were also explored^{10,11} as important elements of student achievement in school, particularly in sciences.

Numerous researchers have found huge contrasts between male and female students in science accomplishment and uncovered a noteworthy gender impact favoring boys in science accomplishment.¹²⁻¹⁵ Other researchers reported conceivable clarifications for why females perform lower than males in science by highlighting differences, in educational assistance, parental support, inspiration, registration aspect, and practical experience.¹⁶⁻¹⁸

Class size is of vital importance in students also matters. As the number of students in school increases, class size also increases which creates problems for teachers in giving attention to each student. Studies indicate that class size can impact students' emotions, academic accomplishment, school quality and educational standard¹⁹ and lower scholastic accomplishment.²⁰ Another study found there was no huge distinction in the post – test accomplishment scores between large classes and small classes.²¹ UNESCO reported 34 as a normal class size in states associated with World Education Indicator program (WEI) and 24 in member countries of Organization for Economic Development and Cooperation.²² Concerning teaching methodology, academic literature proposes that abstract understanding of science can be obtained if right instructional strategy is used. Researches have discovered that students grasp the concept well when they have a chance to use scientific facilities and instruments practically.²³⁻²⁶

A wide range of variables can thus influence the academic achievement of students and it is important to distinguish those which might impact science concept acquisition among students. This study attempted to examine young school students' grasp over general science concepts and whether it changes in the pre-

sence of personal and school related factors such as gender, academic group, instructional technique, class size, city and marks obtained in class 8th.

Objectives of the Study

The main objectives of the present study were to:

- Assess the students' concepts of science being imparted in Government schools.
- Investigate the contributing school related variables of learning conceptual science in schools.
- Explore gender differences in the acquisition of science concepts.
- Provide a set of recommendations for improvement in science teaching methodologies, science curriculum and science teacher education programs in Pakistan in the light of the findings of the present study.

Method

This descriptive study was conducted by using the survey method. This research was designed by using quantitative research method to investigate gender difference and possible related influential variables regarding science concepts acquisition in secondary public schools' students. The total sample size of this study was 720 enrolled student both girls and boys of class 9th (360 female and 360 male students) from six districts of Punjab (Lahore, Gujrat, Rawalpindi, Jhelum, Multan and Bahawalpur) covering the northern, southern and central region of the province. Students were selected by using purposive sampling from 14 public secondary schools (7 girls secondary schools and 7 boys secondary schools) in six districts. From selected government schools a class of 60 male students and 60 female students each (30 from science and 30 from Arts/Humanities group) were selected. Only those secondary schools were selected where boys and girls enrolled in arts and science groups were easily accessible. The Science Concepts Acquisition Test (SC-AT)²⁷ was used to measure the science achievement among students. It is a 40 – item multiple choice objective test covering the items related to basic science concepts. The scoring was done with the help of key, so that number of correct answers yield students' score. A separate proforma was used for getting information regarding school related variables and demographics. Oneway Analysis of Variances (ANOVA), Post

Hoc Tukey's HSD, t-test and correlation were used to test the hypotheses of the study. All tests were measured by using SPSS.

Results

360 female and 360 male students with mean age 15.13 were participated in this study. Equal number of

female and male students enrolled in science and arts groups were selected. Mean score of the SCAT recorded in this study was 22.39. Additionally 55.8% students experienced lecture method as a teaching strategy used in their science classes whereas 44.2% students experienced lecture with practical methods in their schools.

Table 1: Independent sample t-test measuring the difference in SCAT scores of the students(n=60).

Factor		Mean	SD	t	p
Gender	Female	21.93	5.29		
	Male	22.87	5.88	-2.259	.024*
Academic Group	Arts/Humanities	20.97	6.03		
	Science	23.83	4.74	7.065	.000**
Teaching Methodology	Lecture	21.85	5.66		
	Lecture with Practical	23.08	5.47	-2.93	.003**

* p < .05 **p < .01

Table 2: Independent sample t-test measuring the difference in test score of the students of different cities.

Factor		Mean	SD	t	p
Lahore	Female	20.70	4.89	.84	ns
	Male	19.90	5.47		
	Total	20.3			
Gujrat	Female	20.51	3.46	-6.29	.000*
	Male	24.53	3.51		
	Total	22.52			
Rawalpindi	Female	20.88	5.32	-4.02	.000*
	Male	24.65	4.92		
	Total	22.77			
Pind Dadan Khan	Female	23.83	3.83	-.53	ns
	Male	24.23	4.28		
	Total	24.03			
Multan	Female	22.91	7.41	3.86	.000*
	Male	17.96	6.58		
	Total	20.44			
Bahawalpur	Female	22.71	5.13	-3.25	.001*
	Male	25.93	5.58		
	Total	24.32			

* p < .05 **p < .01

The result showed that there was a significant difference in Science Concept Acquisition Test scores of male and female students of class 9. The mean score indicated that male students scored better in SCAT test and the difference between the two groups was significant. Additionally, the mean of science group students was found to be significantly greater than the humanities group. The analysis about using different teaching methodologies shows that the student taught by lecture plus practical method scored significantly higher than the student taught by lecture only method.

The results indicated that students of Bahawalpur and Pind Dadan Khan secured the highest average score on SCAT. There was a significant difference in the Science Concept Acquisition scores of male and female students belonging to different districts of Punjab except Lahore and Pind Dadan Khan. The mean score indicated that male students of Gujrat, Rawalpindi and Bahawalpur

scored better in SCAT test, whereas female students of Multan city scored higher in the SCAT than boys.

Table 3: Analysis of Variance of Test Scores of students across six districts.

Variable and Score	SS	df	MS	F	P
Between Groups	1772.225354	4	442.13		.000
Within Groups	20854.37	714	31.09		29.20
Total	22626.59	719			

* F value significant at $p < .05$

The students' scores across six districts were further analyzed through ANOVA. The result reflected significant differences in students' SCAT scores belonging to six districts of Punjab, $F(5,714) = 12.13$, $p < .05$. This was further analyzed in the post hoc Tukey's HSD comparison. The SCAT scores of students indicate that the students belonging to Rawalpindi ($M = 22.76$, $SD = 5.44$), Gujrat ($M = 22.52$, $SD = 4.02$), Pind Dadan Khan ($M = 24.03$, $SD = 4.05$) and Bahawalpur ($M = 24.32$, $SD = 5.58$) scored better than the students of Lahore ($M = 20.30$, $SD = 5.18$). Additionally, students of Rawalpindi ($M = 22.26$, $SD = 5.44$), Gujrat ($M = 22.52$, $SD = 4.02$), Pind Dadan Khan ($M = 24.03$, $SD = 4.05$) and Bahawalpur ($M = 24.32$, $SD = 5.58$) scored better than the students of Multan ($M = 20.44$, $SD = 7.41$).

Table 4: Analysis of Variance of Test Scores of students across class sizes.

Variable and Score	SS	df	MS	F	P
Between Groups	337.045	2	168.52	5.421	.005
Within Groups	22289.45	717	31.09		
Total	22626.59	719			

* F value significant at $p < .05$

The SCAT scores of students differed significantly across their class sizes in public schools $F(2,717) = 5.421$, $p < .05$. This was further analyzed in the post hoc Tukey's HSD comparison. The results indicated that the students' group whose class size was less than 30 ($M = 23.88$, $SD = .6.31$) scored significantly higher on SCAT than the group of students with class size 30

($M = 21.24$, $SD = 5.54$) and the group of students with more than 30 class size ($M = 22.35$, $SD = 5.44$). Other comparisons between groups did not yield any statistical differences at $p < .05$.

The Pearson correlation between total score and science marks gained in annual examination was calculated. The analysis yielded a relationship between the students' science subjects marks gained in annual examination of class 8th with the SCAT test scores of students in this study.

Discussion

The findings revealed the gender differences in SCAT scores. Moreover, the overall performance of male students was found to be better than that of females which is consistent with numerous other studies.^{12,14,15} The possible explanation of this difference as also mentioned by other researchers can be the differences in teachers' and parental support, motivation, enrollment patterns, and practical experience.^{16-18,28-30} Our study also highlighted gender differences in test scores of students belonging to six districts of Punjab. The result indicated that male students of Gujrat, Rawalpindi and Bahawalpur scored better in SCAT test, whereas girl students of Multan city scored higher in the SCAT than boys. Moreover, our finding revealed that students of Gujrat, Rawalpindi, Pind Dadan Khan and Bahawalpur performed better in SCAT than students of Lahore and Multan. An explanation of these results might be the differences in facilities available in schools and different teachings methodologies practiced in schools by teachers. Furthermore, individual difference in attitude towards science can be a crucial which should be further investigated. Students of humanities study Science for their first ten years in school; however, their performance in science is not as good as that of a science student. There is a dearth of research on this subject. It may be due to factors such as students' motivation or attitude. Other possible reasons can be that teachers and parents pay more attention to a child studying science subjects. However, this needs to be further explored.

The finding of this study revealed that students taught with practical and lecture method scored higher in SCAT scores than those taught only by lecture method. Many previous studies support this finding.^{23-26,31} The use of effective teaching methodology has remained a point of critical debate in literature for many years. Many researchers have emphasized practical

methods for effectively gaining science concepts.^{32,33} In our study, we verified that students in public schools taught with practical demonstrations along with conventional methods gain greater understanding of concepts.

Our findings suggest that there are significant differences in the test scores of students across different class sizes. The results further indicated that students in a smaller sized class, less than thirty, scored higher than students in a class size of thirty and more than thirty students per class. This is consistent with prior literature findings.^{34,35} Most public schools have large sized classes. However, students who had the opportunity to study in smaller classes were found to perform better since they get time to discuss their academic issues with their teachers and teachers can provide more time for discussion and practical work.²⁰

Controlling class size can thus have a significant effect on learning and achievement in science.

Another significant finding of the present study was the positive correlation between the test scores of students with marks obtained in the science subject in their final examination of class 8th. SCAT scores can be good indicators of students' performance in exams and can be utilized for future research.

Conclusion

It is imperative to have an understanding of the factors that promote and hamper students' conceptual understanding of science taught in schools. This study concentrated on some of the variables related to schools that influence the students' performance in SCAT scores and found many of them to be significantly related with science concept acquisition.

Future Implication

Teachers need to educate their students so that they improve their academic performance as well as to be able to apply the acquired concepts in later life. Our study reported that smaller class size, less than 30, can improve the understanding of students regarding scientific concepts. Our schools need to make this a priority. The authorities can also help by formulating policies regarding maximum class size. Teachers in public schools should incorporate the use of practical demonstrations in order to develop better understanding of different scientific concepts in students. The government can play its role by arranging trainings and refresher

courses for teachers to equip with new teaching techniques and ensuring the provision of all necessary instruments for practical work in public schools. Science curricula need to be revised and updated to make them practical and interesting for students.

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