Journal of Science Education
Volume: III, Issue I, 2021, 29-48

Relationship of Teachers' Conceptual Knowledge of Biology with Students' Achievement at Secondary Level

Tallat Umbrin*

Abstract

The research investigated the relationship of teachers' conceptual knowledge of Biology with students' achievement. The study was aimed at finding out the status of conceptual knowledge of teachers, its influence on students' achievement, and its relationship with students' achievement. The quantitative approach was used, or this research and a co-relational method was used to find relationships. The population of the study comprised of secondary-level biology teachers and their students of 10th grade. The sample of this study consisted of Biology teachers and their students. Multi-stage sampling was done. It was made sure that sampling from girls and boys high/higher secondary schools of each cluster (Markaz) would not be less than fifty percent. The previous result of students of grade 9th was obtained from the Board of Intermediate and Secondary Education, Rawalpindi. A test comprised of multiple-choice items was developed and administered to biology teachers. Data were analyzed; by using percentages, averages, regression, graphs, and t-tests. Results revealed that there was a significant relationship of teacher conceptual knowledge of biology on students' achievement. Teachers with higher conceptual knowledge tend to have students with greater achievement. It was also found that there was no significant difference in conceptual knowledge of male and female teachers. Research further showed that there was no gender effect on students' achievement in biology. It was recommended that teachers' conceptual knowledge may be updated. The research was carried out at the secondary school level. This kind of research may be conducted at a higher secondary school level as well.

Keywords: conceptual knowledge, Biology teaching and learning, achievement

* Corresponding Author: SST (Science)/Headmistress, GGES Chak Kharak, Tehsil & District Chakwal.
Email: dilavezabrash@gmail.com

Introduction

In science, acquisition and categorization of the information is dependent on conceptual knowledge. Conceptual knowledge is the comprehension of main ideas and their connection with each other. Conceptual knowledge represents the knowledge that is needed for successful interaction with our surroundings. Conceptual knowledge includes the cognitive processes that make it easier to interact with environment (Hahn & Ramscar, 2001). Conceptual knowledge is not rote memorization, instead its learning involves thinking and intellectual activity. There are two categories that come under the heading of teacher knowledge. One of them is overall pedagogical knowledge and the second one is subject knowledge. Subject knowledge includes Knowledge of truth and reality, processes, concepts and their affinity, knowledge of principles and their application. A teacher's conceptual knowledge is concerned with definition or relation of concepts of some field of inquiry.

Students' achievements can be determined by looking at their grades or assessment. Most countries have standardized tests; aligned with country standards. Students' growth can be assessed by their achievement. It shows their success and problems too. The best way of making a judgment about students' knowledge is assessing the students' achievement (Organization for Economic Co-operation and Development (OECD), 2010; and National Research Council (NRC), 2012). In order to enhance the students' competency in science; knowledge of scientific concepts and linkage among these concepts based on main science-related concepts is necessary (National Research Council, 2012). Student's achievement indicates how well a student has learned the subject matter within particular period of time. Instructional standards are provided to teachers for each grade. Standards are "to-do" which guides teachers during instructions. Focusing on instructional standards helps in enhancing teachers' instructions. As a result, students' achievement also increases (Carter, 2018).

Students' achievement is one of the important factors under consideration while assessing the teachers' effectiveness. Lipping (1999) reported that teachers' conceptual knowledge helps the students in learning of the ideas on which their problem-solving abilities and future learning depends. Conceptual knowledge is a connected web of knowledge; a network in which the linking relationships are as prominent as the discrete bits of information. Research by Carnoy and Arends (2012) revealed that teachers' knowledge positively influences pupils' learning. According to the National Commission on Teaching and America's Future

(1996) teachers' know-how subject and subject-related skills have an impact on students' achievement. Effective teaching results in better students' achievement. Ineffective teaching results in students' lower achievement results (Hanushek and Rivkin, 2004). Teachers' conceptual knowledge of the subject helps the teachers to engage students (Shepard et al., 2005). Teachers must have knowledge of the subject and psychology of their students (Hiebert, Carpenter, Fennema, Fuson &, Murray, 1997).

Statement of Problem

Presently, biology is being taught by teachers with different academic backgrounds. Some biology teachers have not studied science/biology at their degree level. Some of them have science degrees which are school subjects. Some have higher degrees but not in biology. Teachers differ in their biological conceptual knowledge. Hence, the researcher decided to study the relationship of teachers' conceptual knowledge with students' achievement.

Objectives

1. To find out the status of conceptual knowledge of biology teachers.
2. To find out the relationship of teachers' conceptual knowledge with students' achievements.

Review of Related Literature

Saeed and Khalid (2002) reported that the proficiency of teachers is regarded as their knowledge, natural abilities, expertise, and character. Hargreaves (2000) found that students' respect for the teachers and their performance is related with teachers' attitudes and interest in the teaching-learning process. Haider, Qasim, and Ameen (2015) reported that competence is a combination of knowledge, natural ability, and mental condition requisite for job performance. The capability of teachers includes practicable potential and skilled power to gain and retain knowledge. To serve in an educational setting in a productive way these characteristics are pre-requisite for teachers. Sali-Ot (2011) conducted research on teachers' proficiencies and found that instructors possess great proficiencies in content knowledge.

Johnson and Johnson (2010) reported that a conventional learning environment does not support pupils in gaining the concepts, as mastery in practical work and attitude are the need of the hour to face the global

challenges. According to Iqbal, Azam and Rana (2009); Faiz, (2011), there is a deficiency in knowledge of science-related subject matter and teaching methods. Research show that science teaching in Pakistan is nothing but the mere telling of facts. Focus is laid on reading and verbal explanation. No focus is laid on learning by doing to demonstrate concepts.

According to Paul and Kremer (2006) teachers' knowledge is positively associated with pupils' learning. A teacher must have multi-dimensional personalities including the traits of knowledge, skills of motivation, and self-controlling skills (Baumert and Kunter, 2013). According to Rice (2003) teachers must have first-hand knowledge of the subject. Insufficient knowledge of the subject results in ineffective teaching. As a result, students show less motivation in learning.

Ehindero and Ajibade (2000) found that students' learning is associated with their appreciation of teachers' subject-related knowledge. Aboderin (2001) found that mastery of a major subject is pre-requisite for effective teaching. Eggen and Kauchak (2001) found that the best teacher possesses subject knowledge, knowledge of education-related terms, and knowledge of teaching methods. Kimani, Cheboswony, Kodero, and Misigo (2009) reported that insufficient conceptual knowledge of teachers is correlated with students' learning. As a result, students lose their interest in learning (Adekunle, 2006).

According to National Professional Standards for Teachers in Pakistan (2009), teacher education is important for better educational outcomes. The effectiveness of a teacher is correlated with students' achievement. No clear indications are available that which aspect of teacher impacts the intended outcomes most (Rockoff & Johnah, 2004; Rivkin, Steven, Hanushek, John, and Kain, 2005; Aaronson, Barrow, and Sander, 2007).Mezieobi, Fubara and Mezieobi (2008) stated that the competence of teachers in subject matter is a pre-requisite for learning process.

A teacher must have professional competence. Academic and pedagogical competencies both come under the heading of professional competence. The first one is related to his/her knowledge of the subject. The second one is related to teaching methods (Akpan, Essien and Obot, 2008). According to Rena (2000) the learners' learning depends upon enhanced knowledge of the subject matter. Teachers' grip on subject matter enhances learners' interest in the learning process. This results in the achievement of set objectives. He further reported high association between both. Wamala and Seruwagi (2012) studied "the influence of teacher competence on the academic achievement of sixth-grade students in Uganda" (p.84). Findings suggested the enhancement of learners'

learning is dependent on teacher competence. The results revealed a highly positive association between both.

Igwe (1990) concluded that teachers' qualification has no relationship with students' achievement. Adeniji (1999) reported that teachers' qualification has less influence on students' achievement. "teacher is a reformer and a human engineer. He works as a farmer. He transfers knowledge to students" (Ahmad, 2005, p. 74). Akram and Zepeda (2013) investigated the influence of teachers' aspects on pupils' learning. The focus was on English and mathematics subjects. Teachers' effectiveness factors such as knowledge of the subject, pedagogical aspects, evaluation, educational settings, and interaction with pupils were taken into consideration. Research findings showed that all the factors were associated with students' learning.

Mirza and Iqbal (2014) found that collaborative teaching positively influences pupils' achievement. Mehmood and Rehman (2011) conducted the research entitled "effective use of teaching methodologies at secondary level in Pakistan" and found a positive relationship between the pedagogical practices and pupils' learning. Khalid, Yasmin, and Azeem (2011) conducted research entitled "impact of teacher's background and behavior on students learning". They found no difference in male and female teachers' teaching attributes. Further, they reported that no significant difference was found among the teachers of cities and villages. There was no significant difference among teachers on the basis of qualification. Shah (2009) found that teachers' behavior influences pupil achievements.

Khan, M., Muhammad, Ahmed, Saeed, and Khan, S. A. (2012) conducted research at the secondary level, for physics students. They concluded that activity-based teaching positively influences the pupils' achievement. Akhter (2013) conducted her study at the university of education, Lahore. She found that effective teaching is dependent on the selection of suitable pedagogical practices in the science and evaluation systems. She further reported that only a few teachers, specifically young ones, and most females know to use inquiry-based teaching in science, in accordance with the curriculum.

Athar and Jamal (2017) reported that the 'pedagogical practices' are the key factor of teachers' effectiveness in the attainment of intended learning outcomes. Khan, A., Khan, S., and Khan, M. (2017) found that teachers' positive attitude, calm personality, informed knowledge, managerial and interactive skills positively influence the teaching and learning process. According to Kausar, Kiyani, and Suleman, (2017) classroom environment significantly influences the learning of pupils. Rashid and Zaman (2018) conducted research on teachers' behavior. They

found that explanatory and speaking skills show a high association with students' learning.

Research conducted by Farooq and Shahzadi (2006) revealed that in-service training of teachers is positively related to students' achievement. It was also found that the gender of students has no role in mathematics learning. Abid, Hussain, Mahmood, Saeed, and Shoaib (2017) found that elementary school teachers possess an average level of subject knowledge. The study further showed that there was no influence of gender on teachers' subject knowledge. The classroom is the place where the fate of a nation is decided. Progress of the country is in hands of youth and the youth is dependent on educational institutes. Teachers' personality traits, the know-how of the subject, and verbal and non-verbal expressions all can add to students' achievement (Khan et al., 2016).

According to Iqbal, Azam and Rana (2009); Faiz, (2011), there is a deficiency in knowledge of science-related subject matter and teaching methods. Research shows that science teaching in Pakistan is nothing but the mere telling of facts. Focus is laid on reading and verbal explanation. No focus is laid on learning by doing to demonstrate concepts. Factual knowledge is not the single indicator of students' achievement. Assessment of inter-linked knowledge of main concepts of a discipline is also very important (Bransford, Brown, and Cocking, 2000).

Hypothesis

H_0: Conceptual knowledge of biology teachers has no relationship with students' achievement.

Methodology

Prior to data collection, an application for permission was submitted to District Education Officer (Secondary). Afterward, a formal letter requesting permission to collect data was sent to the heads of concerned schools. The tool and a simple instruction sheet were delivered to the headmistresses and headmasters of public secondary schools.

Research Design

The quantitative approach along with the co-relational research design was implied in this research. A correlational study is related to the study of the existence of relationships, opinions of people, and prevailing conditions. It mainly focuses on present conditions. It may check the influence of past

events by relating to the present situation (Best and James, 2006). A simple definition of correlation is the relationship between two variables. The main purpose of co-relational research is to find out the variables related to each other. It is concerned with searching for variables that are inter-connected and tells that change in one variable provides an idea that what change will be seen in the other variable (Co-relational Research, Definition, Purpose and Examples, 2013).

Population

There were a total of two hundred and twenty-nine (229) government high/higher secondary schools for boys and girls in district Chakwal. Out of those two hundred and twenty-nine (229) schools, one hundred twelve (112) were government girls high/higher secondary schools and one hundred seventeen (117) were government boys high/higher secondary schools.

There were one hundred and thirteen (113) government high/higher secondary schools for boys and girls in tehsil Chakwal. Out of those one hundred and thirteen (113) schools, fifty-eight (58) were government boys high/higher secondary schools and fifty-five (55) were government girls high/higher secondary schools.

Sample

Multi-stage sampling was done from tehsil Chakwal. At the first stage, cluster sampling was done and four centers (Markaz) from tehsil Chakwal were selected. Afterward, stratified sampling and simple random sampling were done. There were eighty high/higher secondary schools in which biology was being taught. Out of eighty schools, three schools (two girls and one boy school) were included in pilot testing, which was not part of actual research. Six teachers and six hundred seven students were included in pilot testing. A simple random sampling procedure was opted to select sample schools. It was made sure that samples from each center would not be less than fifty percent. There were fifty-five schools (including thirty girls and twenty-five boys schools) that were included in actual research through simple random sampling from each center.

Research Instrument

A test comprising of thirty-nine multiple test items was developed for teachers of biology. Tool to assess teachers' conceptual knowledge of

biology was administered at the high school level. Students' result of 9th grade was obtained from the official record of schools as students' achievement.

Researcher developed the test by following these steps:

i. Purpose of the test
ii. Content selection
iii. Development of test items
iv. Item review
v. Piloting
vi. Item analysis and revision of items
vii. Validity of test
viii. Reliability of test
ix. Item difficulty
x. Item discrimination

The main focus of the test was the assessment of teachers' conceptual knowledge of biology. In order to check face validity, the researcher requested the experts to refine the items in format and language to make the test simple. Considering the usability of the test; the time allocated was mentioned, language used was simple and easily understandable; clear instruction was provided. The content of the test was checked by biology teachers and experts.

The content validity of the test was also established by experts. They critically analyzed the content of the items and suggested minor modifications which were applied. Reliability of the test was checked by using test retest technique. For this purpose, conceptual knowledge based test was administered to six teachers who were not included in sample. The same test was re-administered among the same teachers after a week. Pearson's product-moment correlation was applied to the data collected. The Pearson's coefficient was found 0.84 which confirmed the reliability of the test.

Data Collection

Data were collected by personal visits. The test was administered to biology teachers (who taught the 9th-grade students of biology) and the result of 9th-grade students was collected from the official record of respective schools.

Data Analysis

Data were analyzed with the help of percentages, averages, regression, and t-test by using Statistical Package for Social Sciences (SPSS).

Table 1.
Teachers' Conceptual Knowledge of Biology (Average) Versus Students' Achievement of Biology (Average)

Descriptive Statistics

Variables	Mean	Standard Deviation	N
Students' achievement (Dependent variable)	57.793	15.064	55
Teachers' conceptual knowledge (Independent variable)	68.582	10.778	55

Table 1 shows the average of teachers' conceptual knowledge and average of students' achievement. The graphical representation of male and female teachers' conceptual knowledge and students' achievement may help to understand the relationship between both variables. The relationship of teachers' conceptual knowledge and students' achievement is presented below in the figure 1.

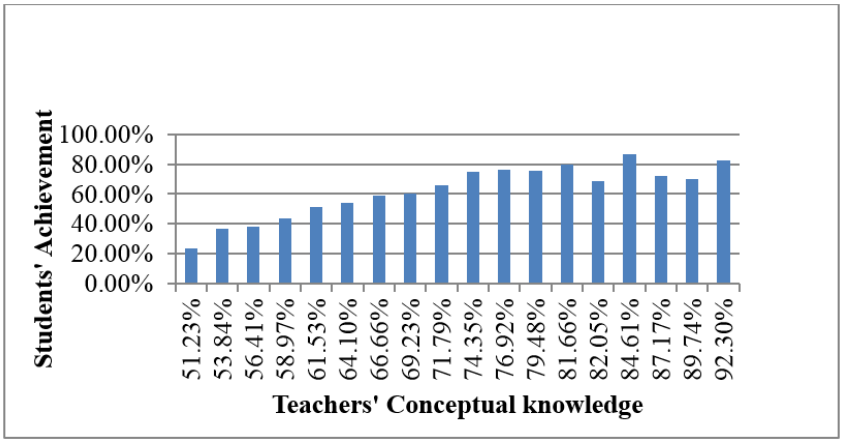

Figure 1. Graphical representation of the relationship of male and female teachers' conceptual knowledge with students' achievement.

Figure 1 shows the average of male and female teachers' conceptual knowledge and average students' achievement in biology. Overall, an increase in teachers' conceptual knowledge shows an increase in students' achievement. The scattered graph may further help to understand the relationship more accurately.

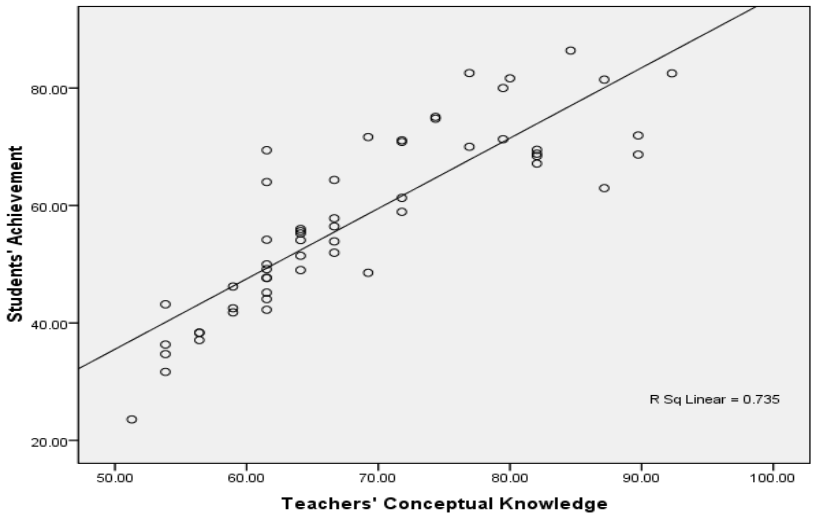

Figure 2. Scattered graph of teachers' conceptual knowledge and students' achievement

Figure 2 shows the relationship between teachers' conceptual knowledge and students' achievement. The data look linearly and positively related. Students' achievement shows an increase with the increase in teachers' conceptual knowledge. Regression may further elaborate the influence of teachers' conceptual knowledge on students' achievement.

Table 2.
Simple Linear Regression for Teachers' Conceptual Knowledge and Students' Achievement
Model Summary

Model	R	R Square	Adjusted R Square	Durbin-Watson
1	.858[a]	.735	.730	2.104

a. Predictors: (Constant), Teachers' conceptual knowledge

b. Dependent Variable: Students' achievement

Table 2 describes the simple linear regression between teachers' conceptual knowledge and students' achievement. It depicts that the Pearson correlation R-value is 0.858 which indicates a highly positive and strong relationship between both variables. R square expresses the variance (in percentage) in the dependent variable by the independent variable. The square value indicates how much of the total variation in the dependent variable (students' achievement) can be explained by the independent variable (teachers' conceptual knowledge). R square value is 0.735. It shows that 73.5% of the variance observed in students' achievement is due to teachers' conceptual knowledge.

Table 3.
ANOVA as a Part of Linear Model of Regression
ANOVA

Model	Sum of Squares	Difference	Mean Square	F	Significance
1 Regression	9011.651	1	9011.651	147.249	.000[a]
Residual	3243.609	53	61.200		
Total	12255.260	54			

a. Predictor: (Constant), Teachers' conceptual knowledge

b. Dependent Variable: Students achievement

Table 3 depicts ANOVA values. ANOVA is another way of looking at our regression model. It is used to check that model with one independent variable works better than simply using the mean. The table shows significance value p is .000 indicates a statistically significant relationship between the independent variable and dependent variable.

Table 4.
Coefficients Showing the Relationship Between Teachers' Conceptual Knowledge and Students' Achievement
Coefficients

Model	Un-standardized coefficients B	Standardized coefficients Beta	t	Significance
1 (Constant)	-24.405		-3.560	.001
Teachers' conceptual knowledge	1.199	.858	12.135	.000

a. Dependent Variable: Students' achievement

In table 4 the un-standardized coefficient shows the value 1.19 that is with a positive sign. It indicates that the dependent variable (students'

achievement) increases with the increase in the independent variable (teachers' conceptual knowledge). It describes that for every one-unit increase in teachers' conceptual knowledge, students' achievement increases by 1.199 points. The significance value is .000 is less than the level of significance $\alpha = 0.05$.

Discussion

The major objective of the research was to find out the relationship of teachers' conceptual knowledge on students' achievement. Data analysis revealed the great influence of teachers' conceptual knowledge of biology on students' achievement. Research findings supported the findings of previous research. Metzler and Woessmann (2010) reported that impact of teacher subject knowledge on student achievement is statistically significant. Previous research show that teacher knowledge is the only factor which is consistently associated with student achievement. The findings suggested that policymakers and educational administrators should take into account the teachers' subject knowledge. The research findings supported the previous research work in the United States, conducted by Hanushek (1971); Summers, Anita, Barbara, and Wolfe (1977); Murnane, Barbara and Phillips (1981). Hanushek (1997) find that teacher performance scores have positive impact on pupil learning.

Eide, Eric, Goldhaber, and Brewer (2004) reported that teachers' effectiveness is based on teachers' academic performance. "Out of teacher attributes such as teaching experience, salary and test scores only teachers' knowledge measured by test scores has consistently been found to be associated with students' achievement" (Hanushek, Steven and Rivkin 2006, p.1064).

The report of the National Commission on teaching and America's future (1996) suggested that teachers' knowledge and skill influence students' learning. The influence of teaching on student achievement is greater as compared to student ethnicity, family income, class size and school type. (Yusuf and Dada, 2016).

Another research found that a highly effective teacher enhances the students' achievement even when other students have similar achievement levels (Sanders and Rivers, 1996). Unanma, Abugu, Dike and Umeobike (2013) reported a positive association of teachers' academic qualifications with students' achievement in chemistry. According to Richardson (2008) significant relationship is found between teacher qualifications and student achievement. The findings suggested that students taught by mathematics teachers with five or more years of experience perform better in their

mathematics test. He further concluded that students of a teacher having secondary mathematics certification, showed high achievement on the mathematical test than teachers having different certification.

According to Ogbannaya (2009), all mathematics teachers having a degree with a specialization in mathematics and having experience, influence students' achievement positively. Akinfe, Olofinniyi and Fashiku (2012) conducted research entitled: "Teachers' Quality as Correlates of Students Academic Performance in Biology in Senior Secondary Schools in Ondo State, Nigeria." The research showed that teachers' professional qualification plays an important role to enhance students' academic achievement in biology. They further added that teaching methods and teaching experience significantly influence students' academic achievement. Raw (2003) reported that experienced teachers play important role in enhancing pupils learning. Employing qualified teachers in schools enhances the quality of education. The quality of teachers helps in improving students' achievement in mathematics (Abe and Adu, 2013).

Bilesanmi (1999) reported that in mathematics, teachers' experience significantly and positively influences students' achievement. Okuruwa (1999) found that teachers' degrees with specialization in relevant subjects influence students' achievement positively in science. Teachers as agents for the amplification of educational policies have an influence on students' achievement (Afe, 2001). Wayne and Young (2003) found that higher qualifications of teachers result in better students' achievement.

Conclusion

There exist a significant and positive relationship between teachers' conceptual knowledge and students' achievement. Thus, null hypothesis H_{01} "conceptual knowledge of biology teachers has no relationship with students' achievement" was rejected. It is concluded that there exists a relationship between teachers' conceptual knowledge of biology with students' achievement.

Recommendations

1. The research may be replicated with a large sample of teachers and students of both gender in government and private schools for generalization of results.
2. This research was carried out at the secondary school level. This kind of research may be conducted at a higher secondary level as well.

References

Aaronson, D., Barrow, L., & Sander, W. (2007). Teachers and student achievement in the Chicago public high schools. Journal of Labor Economics, 25 (1), 95–135.

Abe, T.O., & Adu, E. I. (2013). Influence of qualification on development and assessment of computer programmed instructional package on energy concept in upper basic technology in Ekiti state. Journal of Science and Technology, 3(6), 611-618.

Abid, N., Hussain, T., Mahmood, T., Saeed, A., & Shoaib, A. (2017). Subject matter knowledge competence: An empirical evidence of elementary school teachers. Bulletin of Education and Research, 39 (1), 245-250.

Aboderin, A. O. (2001). Planning for effective teaching. In Uche, S. C. & Enukoha, O. I. (Eds). Professional skills for effective teaching. Lagos. Rehoboth Favors. pp. 42-52.

Adekunle, A.B. (2006). Influence of teachers` factors on students` academic performance in accounting. Un-published B.Ed Project. Olabisi Onabanjo university, Ago- Iwoye.

Adeniji, I. A. (1999). A path analytic study of some teachers' characteristics and teacher job performance in secondary schools in Ogun state, Nigeria, University of Ibadan.

Afe, J. O. (2001). Reflections on becoming a teacher and challenges of teacher education. Inaugural lecture series 64. University of Benin, Benin city.

Ahmad, G. P. (2005). A model of in-service training for university teachers. Gomal university. Journal of Research, 21, 74-7.

Akhter, N. (2013). An investigation of Pakistani university teacher-educators' and Student-teachers' perceptions of the role and importance of inquiry-based pedagogy in their professional learning experiences in initial teacher education. School of education, college of social sciences, university of Glasgow.

Akinfe, E., Olofinniyi, O. E., & Fashiku, C. O. (2012). Teachers' quality as correlates of students' academic performance in biology in senior secondary schools in Ondo state, Nigeria. Journal of Education Research, 1 (6),108-114.

Akpan, O. E., Essien, E. E., & Obot, M. M. I. (2008). Teachers' level of mastery of subject matter and students' academic achievement in social studies in Cross River state. West African Journal of Educational Research. 11 (2), 11-17.

Akram, M., & Zepeda, S. J. (2013). Correlating teacher self-assessment score with students' achievement in English and mathematics. Pakistan Journal of Education, 30 (2).13-32.

Athar, M. R., & Jamal, N. (2017). Academic achievement of students associated with professional education of teacher. Journal of Research and Reflections in Education, 11 (2),94-99.

Baumert, J., & Kunter, M. (2013). The coactive model of teachers' professional competence. In Kunter, M., Baumert, J., Blum,W., Klusmann, U., Krauss, S., & Neubrand, M. (Eds.), Cognitive activation in the mathematics classroom and professional competence of teachers (pp. 25–48). New York. Springer.

Bilesanmi, J. B. (1999). A causal model of teacher's characteristics and Students' achievement in some ecological concepts, University of Ibadan.

Bransford, J. D., Brown, A. L., & Cocking, R. R. (2000). How people learn: Brain, mind experience and school. Washington DC: National Academy Press.

Carnoy, M., & Arends, F. (2012). Explaining mathematics achievement gains in Botswana and South Africa, Prospects, 42(4), 453-468.

Carter, V. (2018). What is student achievement? Retrieved from, https://study.com/academy/lesson/student-achievement-definition-factors-research.html

Eggen, P., & Kauchak, D. (2001). Educational psychology: Windows on classrooms. New Jersey prentice hall, Inc.

Ehindero, O. J. & Ajibade, Y. A. (2000). What our student says about how we teach. Ife Journal of Educational Studies, 7 (1), 1-9.

Eide, Eric, Goldhaber, D., & Brewer, D. (2004). The teacher labour market and teacher quality. Oxford review of economic policy, 20 (2), 230–244.

Faiz, F. A. (2011). Problems and prospects of science education at secondary level in Pakistan. Islamabad (Unpublished Dissertation). Retrieved from, http://prr.hec.gov.pk/

Farooq, M. S., & Shahzadi, N. (2006). Effect of teachers' professional education on students' achievement in Mathematics. Bulletin of Education and Research, 28 (1),47-55.

Hahn, U., & Ramscar, M. (2001). Introduction. Similarity and categorization. In Hahn, U., & Ramscar, M. (Eds.). Similarity and categorization, pp.1-11. New York, Oxford University Press.

Haider, Z., Hameed, Q., & Ameen, S. (2015). Applying standardized rubrics for assessing the instructional competence of elementary school teachers in Pakistan. Advances in social sciences Research Journal, 2(3), 39- 50.

Hanushek, E. A. (1971). Teacher characteristics and gains in student achievement: Estimation using microdata. American economic review, 61 (2), 280–288.

Hanushek, E. A. (1997). Assessing the effects of school resources on student performance: An update educational evaluation and policy analysis, 19 (2), 141–16.

Hanushek, E. A., & Rivkin, S. G. (2004). How to improve the supply of high-quality teachers. In D. Ravitch (Eds.), Brooking Pares on education policy, pp 7-44. Washington DC: Brookings Institution Press.

Hanushek, E. A., Steven, G., & Rivkin (2006). Teacher quality. In Eric A. Hanushek, Finis, & Welch (eds.). Handbook of the economics of education, 2, pp. 1051–1078. Amsterdam: North-Holland.

Hargreaves, A. (2000). Mixed emotions: Teachers' perceptions of their interactions with students. Teach. Teacher Education, 16 (8), 811-826.

Hiebert, J., Carpenter, T. P., Fennema, E., Fuson, K., & Murray, H. (1997). Making sense: Teaching and learning mathematics with understanding. Heinemann, 361 Hanover Street, Portsmouth, NH 03801-3912.

Igwe, D. O. (1990). Science teacher qualification and student's performance in secondary schools in Kano State. Journal of Science Teachers Association Nigeria, 26 (2), 24-51.

Iqbal, H. M., Azam, S., & Rana, R. A. (2009). Secondary school science teachers' views about the nature of science. Bulletin of Education and Research, 31(2), 29-44.

Johnson, D. W., & Johnson, R. T. (2010). An educational psychology success story: Social interdependence theory and cooperative learning. Educational Researcher, 38(5), 365-379.

Kausar, A., Kiyani1, A. I., & Suleman, Q. (2017). Effect of classroom environment on the academic achievement of secondary school students in the subject of Pakistan Studies at secondary level in Rawalpindi district, Pakistan. Journal of Education and Practice, 8 (24),56-63.

Khalid, A., Yasmin, S., & Azeem, M. (2011). Impact of teacher's background and behavior on students learning. International Journal of Human Resource Studies, 1 (2),60.

Khan, A., Khan, S., & Khan, M. (2017). Teaching Professionalism and Students Academic Achievements. Research on Humanities and Social Sciences, 7 (7),47-52.

Khan, A., Khan, S., Khan, S. Z., & Khan, M. (2016). Impact of teacher personality on the academics of the students. Journal of Physical Education Research, 3 (2I), 74-79.

Khan, M., Muhammad, N., Ahmed, M., Saeed, F., & Khan, S. A. (2012). Impact of activity-based teaching on students' academic achievements in physics at the secondary level. Academic Research International, 3 (1),146.

Kimani, G., Cheboswony, M., Kodero, H. M., & Misigo, B. L. (2009). The self-concept and academic performance of institutionalized and non-institutionalized HIV/AIDS orphaned children in Kisumu municipality. Educational Research and Reviews, 4 (3), 106-110.

Lipping, M. (1999). Knowing and teaching elementary mathematics. Mahwah NJ: Erlbaum national council of teachers of mathematics.

Mehmood, T., & Rehman, Z. (2011). Effective use of teaching methodologies at secondary level in Pakistan. Journal of American Science, 7 (2), 313-320.

Metzler, J., & Woessmann, L. (2010). The impact of teacher subject knowledge on student achievement: Evidence from within-teacher within-student variation. Institute for the study of labor. Discussion paper series. Institute of labor economics (IZA), discussion paper no. 4999.

Mezieobi, K., Fubara, V., & Mezieobi, S. (2008). Social studies in Nigeria: Teaching methods, instructional materials and resources. Owerri: Acadapeak Publishers.

Mirza, M. S., & Iqbal, M. Z. (2014). Impact of collaborative teaching on mathematics students' achievement in Pakistan. Journal of Research and Reflections in Education, 8 (1), 13-21. Retrieved from, http://www.ue.edu.pk/jrre

Murnane, Richard, J., Barbara, R., & Phillips (1981). What do effective teachers of inner-city children have in common? Social science research, 10 (1), 83–100.

National commission on teaching and America's future (1996). What teachers know and can do has the most important influence on what students learn.

National Professional Standards for Teachers in Pakistan (2009). Policy and planning wing. Ministry of education, Government of Pakistan, Islamabad.

National Research Council (2012). A framework for K-12 science education: Practices, crosscutting concepts, and core ideas. Washington, DC. National academies press.

Ogbannaya, U. I. (2009). The influence of teachers' background. Professional development and teaching practices on students' achievement in mathematics in Lesotho (Masters dissertation), Pretoria: University of South Africa.

Okuruwa, T. O. (1999). The effect of some teacher's character on pupils' performance in primary science. University of Ibadan, Ibadan.

Organization for Economic Co-operation and Development (2010). Education at a glance 2010: OECD indicators. Retrieved from http://www.oecd.org/edu/skills-beyond school/educationataglance2010oecdindicators.htm

Paul, G., & Kremer, M. (2006). Schools, teachers, and education outcomes in developing countries. In Eric, A. Hanushek, Finis Welch (eds.), Handbook of the economics of education, 2, 945–1017. Amsterdam, North-Holland.

Rashid, M. A., & Zaman, S. (2018). Effects of teacher's behavior on academic performance of students. Department of social sciences, Shaheed Zulfikar Ali Bhutto Institute of Science and Technology (SZABIST), Islamabad, Pakistan. Retrieved from, https://www.researchgate.net/publication/325248514

Raw, V. K. (2003). Quality teaching. New Delhi: APH Publishing Company.

Rena (2000). Who will teach: A case study of teacher education reform. California: Caddo Gap Press.

Rice, J. K. (2003). Teacher quality: Understanding the effectiveness of teacher attributes. Washington, DC: Economic Policy Institute.

Richardson, A. R. (2008). An examination of teacher qualification and student's achievement in mathematics (Masters Thesis), Alabama Auburn University.

Rivkin, Steven, G., Eric, A., Hanushek, John, F., & Kain (2005). Teachers, schools, and academic achievement. Econometrica 73 (2), 417–458.

Rockoff & Jonah, E. (2004). The impact of individual teachers on student achievement: Evidence from panel data. American Economic Review, 94 (2), 247–252.

Saeed, M., & Khalid, M. (2002). Assessing competency of Pakistani primary school teachers in mathematics, science and pedagogy. International Journal of Educational Management,16 (4), 190-195.

Sali-Ot, M. A. (2011). Competencies of instructors: Its correlation to the factors affecting the academic performance of students. Journal of Philippine Association of Institutions for Research, 31 (6), 31-51.

Sanders, W. L., & Rivers, J. C. (1996). Cumulative and residual effects of teachers on future students' academic achievement. Knoxville: University of Tennessee value-added research and assessment center.

Shah, S. S. A. (2009). Impact of teacher's behavior on the academic achievement of university students. Journal of College Teaching & Learning, 6 (1),69-74.

Shepard, L. A., Hammerness, K., Darling-Hammond, L., Rust, F., Snowden, J. B., Gordon, E., Gutierrez, C., & Pacheco, A. (2005). Assessment. Darling Hammond, L., & Bransford, J. (Eds.), Preparing teachers for a changing world: what teachers should learn and be able to do (pp. 275-326). San Francisco, CA: Jossey-Bass.

Summers, Anita, A., Barbara, L., & Wolfe (1977). Do schools make a difference? American Economic Review, 67 (4), 639–652.

Unanma, A. O., Abugu, H. O., Dike, R. C., & Umeobike, U. C. (2013). Relationship between teachers' educational qualifications and student's achievement in chemistry: A case study of Owerri West LGA. Journal of Research and Method in Education, 4 (1),5-10.

Wamala, R., & Seruwagi, G. (2012). Teacher competence and the academic achievement of sixth grade students in Ugenda. Journal of International Education Research, 9 (1), 83-90. http://doi.org/10.19030/jier.v9i1.7503

Wayne, A. J., & Young, P. (2003). Teacher characteristics and student achievement gains: A review. Review of Educational Research, 73 (1), 89-122.

Yusuf, H. O., & Dada, A. A. (2016). Impact of teachers' qualification and experience on the performance of students in colleges of education in Kaduna state, Nigeria. Journal of Quality in Higher Education, 3 (2),52-61.

Citation of this Article:
Umbrin, T. (2021). Relationship of teachers' conceptual knowledge of Biology with students' achievement at the secondary level. *Journal of Science Education, 3*(1), 29-48.