Pakistan Journal of Social Research
ISSN 2710-3129 (P) 2710-3137 (O)
Vol. 4, No. 1, March 2022, pp. 422-428.
www.pjsr.com.pk

CONCEPTUAL DIFFICULTIES OF SECONDARY SCHOOL STUDENTS IN UNDERSTANDING ACID-BASE CHEMISTRY

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ABSTRACT
The dissemination of scientific knowledge has enormous transformative potential. As a result, a nation's progress and growth can't get off the ground without a solid foundation in scientific literacy. From this perspective, the education of science is crucial to cultivating a scientific worldview and boosting students' scientific knowledge. The motivation for this study stems from researchers' previous observations of secondary school students' conceptual difficulties in acid-base chemistry. The study used a descriptive, quantitative research approach to investigate common misconceptions about acid-base chemistry held by high school pupils. A special test instrument labelled as test designed to measure the conceptual difficulties in acid-base chemistry (TCDAB) was developed to measure the conceptual difficulties of secondary school students in Acid-Base chemistry. The Punjab Text Book Board, Lahore, version January 2020, 10th chapter Chemistry Text Book was used as a reference for the creation of the test (TCDAB). A table of the specification was used and was delimited to the first three levels of the cognitive domain of Bloom's taxonomy. TCDAB has been validated by well-known chemists and educators. Test re-tests method was used to determine the reliability and the correlation coefficient (r) was 0.92. The internal consistency of the instrument was also evaluated using SPSS, and the resulting Cronbach alpha coefficient was 0.83. All the students studying chemistry in public secondary school of the district Bahawalnagar of the Punjab, Pakistan were population of this study (Dist. BWN consist of five tehsils which having total 250 schools). To conduct the survey of this study, a sample of 500 students from twenty (20) secondary schools, four (4) secondary schools (2 boys and 2 girls) from each five tehsils was selected by using the convenient sampling technique due to covid-19 in district Bahawalnagar city. The results of the analysis of TCDAB indicated that 60% concept-based items in acid-base chemistry were difficult like Arrhenius concept, Lowry Bronsted concept and Lewis Concepts, amphoteric compounds, conjugate acids and bases, chemical properties of acids and bases, concentration of acid base chemistry, strength of acid base chemistry, Uses of acids and bases, PH scale, and indicators.
Keywords: Acid-base chemistry, conceptual difficulties, table of specification, cognitive domain.

INTRODUCTION
Education in the sciences is important because it gives students a sense of fulfilment in their own lives and the lives of others. One of the greatest benefits of studying science is that it has helped us develop more creative ways of thinking. Learning about science is systematically investigating the physical, social, and natural realms through experiments and observations. All schools provide their pupils with hands-on science learning opportunities to help them grasp the fundamentals of the scientific method and the logic behind everyday phenomena. Because of their innate curiosity about the world around them, secondary school children benefit greatly from scientific classes that encourage innovation, critical thinking, and future success (Kersting, Steier, & Venville, 2021). Science can reveal the mechanics and explanations for all sorts of complex systems, from the human body to the transportation network. Learning about science can help a country prosper and its people grow, making it more competitive and modern in the global marketplace. As important as it is for students to be able to name scientific facts and values, they also need to be practical enough to put that knowledge to use in the real

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world, both in terms of knowing themselves and the world around them Jack Gladys Uzezi, Danjuma Ezekiel, Abdul-Kadir Musa Auwal, 2017). Biology, chemistry, and physics are the traditional subfields of science.

The study of matter and its interactions, properties, and transformations is central to the study of chemistry, one of the natural sciences. As a result of chemistry, even the most insignificant aspects of daily life may be rationally explained, which in turn strengthens the human mind. Concepts in chemistry are notoriously difficult to grasp because of their inherent abstractness, complexity, and difficulty (M. Stieff & U.Wilensky, 2003, Satrianawati, 2018). Understanding the interconnectedness of the macroscopic, submicroscopic, and symbolic levels of representation is essential to a well-rounded education in chemistry (Geban & Stieff, M. 2005; Lathifa, U. 2018; Godfred Safo-Adu, 2020). Students and future educators alike often struggle to grasp the fundamentals of acid-base chemistry, making it one of the field's most challenging ideas that must be taught explicitly and thoroughly (Lathifa, U. 2018).

Since a concept is the compilation of prior knowledge that leads to the basis of an individual's thinking, conceptual difficulties are the most common problem of understanding among students. It is via deliberate mental work that we generate concepts, or ideas. Learning and teaching science are greatly aided by the use of concepts. Ideas that are abstracted from their concrete manifestations in the world are called concepts (American Heritage Dictionary, 2002). Conceptual problems arise when it's hard to generate new ideas. When asked a question that requires them to apply a subject they are struggling with, students almost never volunteer such information (Duit, 2007).

One of the obstacles to learning that secondary school student may face is conceptual difficulty with the instructional themes. Many students, from a wide range of educational and cultural backgrounds, have struggled to grasp the conceptual nature of acid-base chemistry (Muhd Ibrahim Muhamad Damanhuri, David F. Treagust, Mihye Won, A. L. Chandrasegaran, 2016). A good understanding of one idea in acid-base chemistry will help with learning about other concepts (Corrienna Abdul Talib, Hassan Aliyu, Adi Maimum Abdul Malik, Kang Hooi Siang, Marlina Ali, 2018). It's very uncommon for kids to muddle together ideas that have multiple connotations depending on the context, and some misconceptions are ingrained at a young age and persist all the way through college. Chemistry is a field of study that may be directly observed. Students learn more in chemistry as a result of interacting with other people and the world around them. Constructivists have the right to the idea that learning occurs when fresh information is combined with previously acquired knowledge (Bybee, Taylor, Gardner, van Scotter, Powell, Westbrook & Landes, 2006; Neslihan Ultay, Muammer Calik, 2015). As a result, they are able to relate, rightly or wrongly, to what the teacher describes in class. If a learner is given a wrong definition, they will have a skewed understanding of the subject and will find it harder to grasp related ideas. Thus, the concepts that students develop cannot accurately describe scientific phenomena and, ultimately, diverge from scientific conceptions or are not reliable with scientific ones. Conceptual difficullties, or student-generated conceptual differences, are the gaps between commonly held scientific understanding and student understanding.

To grasp the conceptual issues that form the basis of science is fundamental to both the teaching and learning of chemistry. Teachers need to be aware of the conceptual hurdles of their students face when learning chemistry (Drechsler, 2007). However, simply presenting material and unscientific students' attitude and mind are not efficient methods of overcoming conceptual difficulties; these factors, along with students' varying levels of background knowledge, educational and surrounding environment, prior experiences, teaching and learning materials used by teachers, textbooks, and world view, all have an impact on students' accurate interpretation of concepts (Geban, 2005).

Conceptual challenges are a common and necessary element of the educational process (Jason M. Lodge, Gregor Kennedy, Lori Lockyer, & Mariya Pachman, 2018). Students often make mistakes when trying to grasp the fundamental concepts of acid and base, including those related to the correct use of symbols, the correct interpretation of chemical equations, the correct understanding of neutralization reactions, the strength of acid, the difficulty of understanding the acid-base framework in chemistry, proton transfer, organic reactions involving nucleophilic and electrophilic attack, and the incorrect generalization of problems (Lathifa, Suhadi, and Endang, 2015, Cooper M. M., Kouyoumdjian, S. and Underwood, S. M. 2016). As a result, students are unable to absorb the new information presented in class and instead become even more confused. Ulya Lathifa (2018) argues that misunderstandings of core ideas make it hard for students to absorb new material, as they provide inaccurate descriptions of the concepts being studied. Several factors, including students' ages, cultures, genders, locations, and religious beliefs, can affect the nature of the conceptual challenges they face in school (Losh, et al, 2003).

Preparing the next generation with a foundation in science is a key goal of chemistry education at the secondary level. If more emphasis were placed on chemistry in the classroom, students would get the tools they need to tackle the scientific and technological problems of the future. The rapid pace of growth has elevated STEM fields to the forefront of global attention. Countries around the world are investing in education in an effort to foster innovation and technical skills in the next generation of citizens. This increases the demands placed on educators to devote more time and energy to enhancing the quality of scientific instruction in the classroom (Morrison, Bartlett, & Raymond, 2009). The acid-base idea is fundamental to the science of chemistry and has practical applications in many areas of our daily lives, including digestion, food preservation, acid rain, corrosion, pharmaceuticals, fertilisers, and soft drinks (Ultay & Calik, 2016). Many of the most important uses of acids and bases can be found in all three of these scientific disciplines. Students' ability to freely apply their information from disciplines like Biology, Chemistry, and Physics is hindered as a result of this confusion (Taber, 1998). Most countries' secondary-level chemistry curricula face a number of difficulties. To solve these problems, we need to look beyond chemical education alone. There must be a concerted effort, however, to gauge students' grasp of chemical concepts at the secondary school level (Lamanauskas, 2007). Numerous studies have been conducted in developed nations to determine the conceptual difficulties faced by students learning acid-base chemistry and to identify potential solutions (Chiu, 2004, 2007; Demircioglu, Ayas, & Demircioglu, 2005; Huang, 2004; Kala, Yaman, & Ayas, 2013; Sheppard, 2006; Drechsler, & Van Driel, 2008, 2009; Artdej et al., 2010; Muchtar, Kersting, M., R. Steier, & G. Venville. 2021). 2012; Akram, M., J. B. Surif. 2014. Lathifa, Suhadi, Endang. 2015. Ramprakash Prajapati. 2018. Godfred Safo-Adu. 2020. However, very little research work has been done in this sector in Pakistan and numerous poor nations; generally, no meaningful effort has been made to overcome the current problem. To a large extent, secondary school teachers and administrators are now focusing their attention on students' conceptual difficulties in the subject of chemistry. From this vantage point, the researcher oversaw a study of conceptual difficulties of high school students in understanding acid-base chemistry. The research aims to better understand the conceptual difficulties that secondary school students have when learning about acid-base chemistry.

RESEARCH METHOD

In this study the descriptive quantitative research design was adopted. A special test instrument labelled as test designed to measure the conceptual difficulties in acid-base chemistry (TCDAB) was developed as a research instrument to measure the conceptual difficulties of secondary school students in Acid-Base chemistry. For the development of test (TCDAB) the 10^{th} chapter of chemistry Text Book of 10^{th} class published by Punjab Text Book Board Lahore, edition Jan.2020 was consulted. A table of the specification was organized and the test was delimited to only the first three levels of the cognitive domain of Bloom's taxonomy. There were 45 items with four options in test. The population of the study was consisted of all the public secondary school students including boys and girls learning chemistry of the district Bahawalnagar city of the Punjab province Pakistan (Dist. BWN consist of five tehsils which having total 250 schools). For the survey of this study, twenty (20) Public secondary schools were selected using the convenient sampling method due to covid-19 in the district Bahawalnagar city. A sample of 500 students was selected from twenty (20) selected public secondary schools of five tehsils i.e 4 schools form each tehsil (two boys and two girls schools) and a sample of 25 students was drawn from each school.

Reliability and Validity of Instrument

The content validity and face validity of TCDAB was confirmed after checking and consulting from 15 chemistry teachers. It was also pilot tested to identify its reliability by test re-tests method and the value of correlation coefficient (r) was 0.92. The internal consistency of tool was also calculated through SPSS and the value of Cronbach alpha coefficient was 0.83.

Table No. 1: List of Major Topics of Acid Base Chemistry Class 10^{th}

Page number	Major topics
20	Introduction of acid base chemistry
21	Concepts of acids and bases
21	Arrhenius concepts of acids and bases
22	Bronsted-Lowry concepts of acids and bases

25	Lewis concepts of acids and bases
27	General properties of acids
29	General properties of bases
32	pH scale
35	Indicators
43	Neutralization reaction

Source: Punjab Curriculum Authority, Punjab Text Book, Lahore (2020).

Table 1 describes major topics of acid-base chemistry using TCDAB. In Table 1, table of contents of acid-base chemistry chapter are presented according to page numbers and major topics. All public schools of the Punjab province follow this content for teaching acid-based chemistry to 10th class students.

Table No. 2: Table of Items Specification

Level	Items Number	Total
Knowledge	3, 4, 6, 7, 11, 15, 16, 22, 23, 25, 31, 35, 37, 39, 45	15
Comprehension	2, 10, 12, 14, 19, 20, 21, 26, 29, 32, 33, 36, 38, 44	14
Application	1, 5, 8, 9, 13, 17, 18, 24, 27, 28, 30, 34, 40, 41, 42, 43	16
Total		45

Table 2 presents number of items based on levels of Bloom Taxonomy. It describes that under the cognitive domain of Bloom Taxonomy 15 items were from knowledge, 14 items were from comprehension, while 16 items were from application.

Data Analysis

The quantitative data obtained by TCDAB was analyzed using SPSS 20 (Statistical Package for Social Sciences), and the percentage was calculated for each correct and incorrect item. A standard established in TCDAB to measure the item difficulty. Students correctly answered item less than 40% were considered difficult (Akram, Surif, & Ali, 2014).

FINDINGS AND RESULTS

The results of the analysis described that 60% concept-based items in TCDAB were difficult to understand for students. The Table 3 showed that only 6.2% and 10.2% of the students correctly answered the items 24 & 17 respectively, which showed the most difficult concept to understand were concentration of H^+ in pure water and gas evolved when acids react with metals. The other difficult concepts were: solubility of alkalis (11.2% correct response for item no.22), Acid neutralizes base (11.4% correct response for item no.2), pH of HCl solution and pH range of our body (13.8%, 15% correct response for items no.34 & 32 respectively), bases turn red litmus, which thing turns blue litmus and gas evolved when acid react with carbonates and bicarbonates (18.6% correct response for three items no.4, 5 & 18), formula of the lime water (18.8% correct response for item no.6). Furthermore, treatment of bee's sting and the ionization of water into ions (21.0% correct response for item no. 43, 21.2% correct response for item no. 44 respectively), Lewis's acid -base characteristic (21.4% correct response for item no.12), nature of detergents and soaps and water is an electrolyte (22.4% correct response for item no.41, 22.8% correct response for item no.31), acids turn blue litmus (23% correct response for item no.3), pH of acid rain and correct increasing order of acid strength (23.8% correct response for item no. 33 and 24.2% correct response for item no. 21) are all found difficult by students. Similarly, students have difficulty in understanding the concepts, nature of tooth paste and apparatus used for the preparation of standard solution (24.6% correct response for both items no.20 & 37), the conjugate acid, what is the Lewis base (26.4% correct response for item no.14 & 28.2% correct response for item no.9), type of a solution having pH zero (30.0% correct response for item no.30), what is Lowry-Bronsted acid (30.4% correct response for item no.13), reduction of unpleasant fishy odour, which one bond is between the adduct specie and pH value of basic solution (30.6 %, 31.8% and 35.2% correct response for items no. 39, 10 & 27 respectively).

However, students had no conceptual difficulty in understanding the concepts; neutralization reaction (item 1), stomach acid (item 7), Arrhenius acid and Lewis's base (items 8 & 11), substances which act both as an acid and base, amphoteric substances (items 15 & 16), mineral acids (item 19), pH value related (items 23, 25, 26, 28 & 29). Similarly, some other non-difficult concepts were; sodium hydroxide base (item 35), Ionization of acid, citrus fruit property, nature of fruit and chemical used for the growth of plants (items 36,38,40&42), and "kw" is known as (item 45).

Table No. 3. Conceptual difficulties of secondary school students in understanding Acid Base Chemistry

No.	Items	Correct Answers n	Correct Answers %	Incorrect Answers n	Incorrect Answer %	Interpretation*
1	Neutralization reaction of acids	425	85.0	75	15.0	Not Difficult
2	Acid neutralizes base	57	11.4	443	86.6	Difficult
3	Acid turns blue litmus	115	23.0	385	77.0	Difficult
4	Bases turns red litmus	93	18.6	407	81.4	Difficult
5	Which thing turns blue litmus	93	18.6	407	81.4	Difficult
6	Formula of Lime water	94	18.8	406	81.2	Difficult
7	Acid present in stomach	347	69.4	153	30.6	Not Difficult
8	Arrhenius acid	379	75.8	121	24.2	Not Difficult
9	Lewis base	141	28.2	359	71.8	Difficult
10	Bond b/w adduct specie	159	31.8	341	68.2	Difficult
11	Lewis base	348	69.6	152	30.4	Not Difficult
12	Lewis acid -base characterstics	107	21.4	393	78.6	Difficult
13	Lowry-Bronsted acid	152	30.4	348	69.6	Difficult
14	Conjugate acid	132	26.4	368	73.6	Difficult
15	Substance which behave both as an acid and base	402	80.4	98	19.6	Not Difficult
16	Which one is Amphoteric	414	82.8	86	17.2	Not Difficult
17	Gas evolved when acid react with metal	51	10.2	449	89.8	Difficult
18	Gas evolved when acid react with carbonate and bicarbonate	93	18.6	407	81.4	Difficult
19	Mineral acids are	419	83.8	81	16.2	Not Difficult
20	Nature of tooth paste	123	24.6	377	75.4	Difficult
21	Increasing order of acidic strength	121	24.2	379	75.8	Difficult
22	Solubility of alkalis	56	11.2	444	88.8	Difficult
23	pH=	304	60.8	196	40	Not Difficult
24	Concentration of H^+ in H_2o	31	6.2	469	93.8	Difficult
25	pH value of neutral solution	436	87.2	64	12.8	Not Difficult
26	Lower value of pH means	324	64.8	176	35.2	Not Difficult
27	pH value of Basic solution	176	35.2	324	64.8	Difficult
28	Sum of pH and POH	421	84.2	79	15.8	Not Difficult
29	pH of Table salt, sugar & H_2o	434	86.8	66	13.2	Not Difficult
30	Type of a solution having pH zero	150	30.0	350	70.0	Difficult
31	Water is an electrolyte	114	22.8	386	77.2	Difficult
32	pH range of our body	75	15.0	425	85.0	Difficult
33	pH of acid rain	119	23.8	381	76.2	Difficult
34	pH of HCl soln.	69	13.8	431	86.2	Difficult
35	Sodium hydroxide is an acid or base	426	85.2	73	14.6	Not Difficult
36	Ionization of acid	420	84	80	16.0	Not Difficult
37	Apparatus used in preparation of standard soln.	123	24.6	377	75.4	Difficult
38	Citrus fruit property	423	84.6	77	15.4	Not Difficult
39	Reduction of unpleasant fishy odour	153	30.6	347	69.4	Difficult
40	Nature of fruit	434	86.8	66	13.2	Not Difficult
41	Nature of detergents and soaps	112	22.4	388	77.6	Difficult
42	Chemical used for growth of plants	419	83.8	81	16.2	Not Difficult

43	Treatment of the bee's sting	105	21.0	395	79.0	Difficult
44	Ionization of H_2o into ions	106	21.2	394	78.8	Difficult
45	"KW" is known as	384	76.8	116	23.2	Not Difficult

*Above 40% correct answers = not difficult, below 40% correct answers = difficult

CONCLUSION AND DISCUSSION

The study's overarching goal was to gain a better understanding of the conceptual difficulties faced by secondary school students when learning about acid-base chemistry. According to the data presented here, students in secondary school find it most challenging to answer questions that require them to apply their knowledge of acid-base chemistry concepts, such as the Arrhenius concept, the Lowry Bronsted concept, the Lewis concept, amphoteric compounds, conjugate acids and bases, the chemical properties of acids and bases, the concentration of acid-base chemistry, the strength of acid-base chemistry, the uses of acids and bases, the PH scale, and indicators. After looking at the data, it became clear that most high school students lacked a firm grasp of the fundamental concepts involved in acid-base chemistry. Australia's Muhd Ibrahim, Treagust, Won, and Chandrasegaran provided further research to back up the findings of this one (2016). Similar findings were found in an Indonesian study by Rosyidah Syafaatur Rohmah and Irma Ayu Virtayanti, with whom this work shares conceptual and methodological affinities (2021). Although students of all ages struggle with concepts (Losh, et al, 2003), this issue has become of greatest concern to educators since the number of students struggling with concepts is so much larger at the secondary school level (Lamanauskas, 2007).

RECOMMENDATIONS

Based on the result of the study following recommendations were drawn:

1. Chemistry teachers should develop the constructivist teaching techniques to encounter the students' conceptual difficulties in learning.
2. Before teaching begins chemistry teachers should explore students' previous knowledge which help them to investigates the conceptual difficulties.
3. To encounter the conceptual difficulties tough concepts might be taught at macro level, micro level, and symbolic level. Therefore, multiple representation of knowledge might be recommended for chemistry teaching.

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