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Causes Of Students' Learning Difficulties In Secondary School Chemistry: A Study In Context Of Content And Assessment Strategies

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Abstract

Chemistry is often regarded as a difficult subject, an observation which sometimes repels learners from continuing with studies in chemistry. The objectives of the study were to explore the content of chemistry and assessment strategies as a cause for students' learning difficulty in chemistry. The nature of the research was descriptive and quantitative data collection procedures were used to conduct it. The population was comprised of all public and private school systems which have ten or more than ten branches in Lahore. Multistage sampling techniques have been used in it. Questionnaire was used as a data collection tool in the study. Cronbach's Alpha was 0.879 while the minimum criteria of Cronbach's Alpha is 0.75 for reliability. The findings shows that the level of secondary students' perceptions about chemistry content and assessment strategies, as cause of learning difficulties, were at high level of agreement. The students of public and private shows high level of agreement toward content as a cause for difficulty in learning chemistry while as perceptions of private students shows high level of agreement as compared to public school students toward assessment strategies as a cause for difficulty in learning chemistry. It was recommended that teachers should use effective formative assessment methods for better understanding and learning of chemistry at secondary level.

Keywords: chemistry content, assessment strategies, learning difficulties, secondary school students

Introduction

Students think chemistry is really complicated. As a result, most students give up on the subject. To accomplish meaningful learning, it is vital to demonstrate its application to daily life, to the growth of a nation, and to societal progress. When a student can combine what they are learning into the frameworks of past knowledge they already have, learning becomes meaningful to them. (Blanco-Lopez, Serrano-Angulo, & Lopez-Guerrero, 2022). The Cambridge Dictionary of Psychology defines learning difficulty as the inability to perform or comprehend knowledge. Another definition of difficulty is a learning or emotional issue that impairs, or significantly impacts, a person's capacity to learn (Sabit, 2021). In this particular instance, the research seeks to pinpoint the pupils' struggles with secondary-level chemistry content learning.

One of the most significant areas of science is chemistry, which gives students the ability to comprehend their surroundings. For many students, chemistry is a challenging subject because many of the topics are based on or connected to the structure of matter. A large number of abstract notions that are essential to learning more about chemistry and other sciences are frequently included in chemistry courses. Chemistry lessons call for a high-level skill set due to the abstract nature of the subject matter as well as other content acquisition challenges (such as the overwhelming mathematical character of most of chemistry) (Taber, 2002). These abstract ideas are crucial because if students don't fully understand the underlying ideas, they won't be able to comprehend subsequent chemistry or science concepts or theories (Nakhleh, 1992).

Gabel, (1999) & Moore, (1989) stated that Due to its specialised vocabulary, mathematical and abstract conceptual character, and the amount of knowledge that must be acquired, chemistry is frequently thought of as being difficult. Researchers and academics in the field of chemistry have been attempting to explain how to improve students' understanding of chemistry for the past ten years. The abstract, contradictory, and particle nature of chemistry makes it challenging for students to comprehend its principles. According to Johnstone (1999), this challenge is even more difficult while learning chemistry because it requires quick switching between the macroscopic, submicroscopic, and symbolic levels of mind. The capacity to explain chemical phenomena using macroscopic, molecular, and symbolic levels of representation is correlated with conceptual comprehension in chemistry (Wu, Krajcik & Soloway, 2001). It is well established that students comprehend and learn more about chemistry when connections are made between these three levels of representation (Sanger, Phelps & Fienhold, 2000).

Childs & Sheehan, (2009) described that Students rated volumetric analysis calculations, redox reactions, and solution concentration as difficult topics in chemistry. The fact that these topics have consistently been perceived as difficult throughout the pupils'/students' experience with chemistry suggests that the issues related to these topics have never been properly addressed. The most challenging issues in the subject, according to students' perspectives, were the mole, chemical formulae and equations, and, in organic chemistry, condensations and hydrolysis, according to Johnstone & El-(1989) Banna's research. Since the topic of solutions contains critical ideas that are necessary to understand other ideas in the field of chemistry, it is crucial that students learn about it. According to studies on the subject of solutions, pupils exhibited widespread misconceptions and had comprehension issues (Yıldırım, & Canpolat, 2019).

According to numerous reports, many chemistry students find it challenging to understand how the macroscopic and microscopic worlds interact. Examples include the solution chemistry (Çalik, Ayas, & Coll, 2009), atomic structure (Harrison & Treagust, 2002), electrochemistry (Sanger & Greenbowe, 1997), chemical bonding (Ünal, Çalık, Ayas, & Coll, 2006), chemical change and reactivity (Ardac, & Akaygun, 2004), chemical bonds and energetic (1998; Barker & Millar, 2000), mole concept (Gilbert & Watts, 1983), mental models (TAYLOR, 2002), covalent bonding, metallic bonding and ionic bonding (Coll & Treagust, 2002), and enhancing students' conceptual understanding (Harrison & Treagust, 2000).

There are two other sources of false ideas in chemistry. Some are the outcome of the words we employ. Despite the fact that this theory is no longer acknowledged, we continue to use terms and phrases that had significance when they were first offered, such as "heat capacity" and "heat flows". While the terminology changes until it is misleading, the language frequently stays the same as science advances. The instructor is at blame for several other chemical misconceptions. Some come about as a result of how we break down concepts to make them easier to understand. The conversations that are more accurate and significantly more explicit are offered to students at later stages in their careers, but students frequently forget the explanations that help them understand the chemistry we require them to study for the first time. When teachers' obvious ideas aren't made clear to their students or when they can't understand them, misconceptions are also produced (Bodner, 1991).

Many college and high school students struggle to understand basic chemistry concepts. Despite the value of a solid understanding of the basics of chemistry, the majority of students leave introductory courses with just a very basic grasp of the material. Because of the abstract nature of many chemical concepts, the classroom teaching methods used, the dearth of teaching resources, and the challenging nature of the chemistry language, chemistry has long been considered a challenging subject for students by many researchers, teachers, and science educators. All of them lead to pupils' poor comprehension and misunderstandings, from elementary school to university. Over the past three decades, there has been increased awareness of chemical principles that are misunderstood. Numerous studies have been done on various themes in chemistry as well as other fields like biology, physics, or science in general. The abstract character of the chemical concepts was a recurring element in the pupils' struggles. The professors also acknowledge this. The course's mathematical requirements were the other challenge that was connected to the subject's nature, or general chemistry. Chemistry was thought to be overly mathematical by one in three students (Woldeamanuel, Atagana, & Engida, 2014).

Risch, (2010) described that the significance of addressing subject matter in chemistry as more than just knowledge of facts. To ensure that they can move beyond fundamental comprehension and enhance it, students must debate and discuss their grasp of chemistry with their lecturers. Make ensured that pupils understand the importance of role models in chemistry teaching is a key concern. It is impossible to overstate the importance of qualified teachers because they are the cornerstone of effective educational institutions (Broman, Ekborg, & Johnels, 2011).

A measuring tool's content validity denotes that the subject matter and behavioural goals as specified in a certain syllabus, core curriculum, or scheme of work for that subject area have been adequately covered. Accordingly, content validity, according to Aiken (2000), is concerned with whether the subject's material is able to elicit responses that are representative of the complete universe or domain of knowledge, abilities, and other behaviours that the subject is designed to measure (Amajuoyi, Joseph, & Udoh, 2013).

Wang, Rocabado, Lewis, & Lewis, (2021) described that Some students find it difficult to learn chemistry because they do not see the connection between the subject matter and their daily life or because they believe their intelligence is fixed. To deal with these problems, social-psychological interventions (SPIs), condensed therapies that concentrate on students' subjective experiences, were created. SPIs have been linked to improvements in students' academic performance, attitude, and perseverance in a variety of educational contexts; however, only a small number of research have examined SPIs in the context of chemistry. In a general chemistry course with a high-class size, this study assessed the efficacy of two SPIs, a growth mindset intervention (GMI) and a utilitarian value intervention (UVI), on enhancing students' academic performance and attitude.

Jagger & Yore, (2012) and Quinn, et al., (2009) stated that being able to apply the subject, learn to solve pertinent problems, adapt chemistry principles to real settings, and explain it in learning in the classroom are all skills that students who prepare themselves as science teachers at school must possess. To improve their capacity to analyse, evaluate, synthesise, and determine the knowledge that is pertinent to their everyday requirements, students must develop their critical thinking and scientific literacy skills (Sutiani, 2021).

Holme, Luxford, & Brandriet, (2015) stated that improved conceptual understanding of the science is undoubtedly a key objective among the many that instructors may have for their general chemistry pupils. Nevertheless, the difficulty of precisely describing what conceptual comprehension includes prevents us from being able to pinpoint what constitutes student success in accomplishing this goal. Although "we know it when we see it" may apply in this instance, a precise definition of conceptual knowledge is ultimately necessary for the design of tests. It is easy to argue that a proposed measure does not provide evidence concerning, in this case, conceptual comprehension because the construct itself is not sufficiently characterized, in the absence of such a detailed specification of the construct.

Since assessment promotes student learning, it is essential to the complicated network of education. Given that it is a powerful tool in the educator's toolbox, it merits careful examination. It is a commonly established standard that the purpose of assessment is not just to judge students based on a set of predefined standards, but also to support their learning through ongoing feedback and provide them the chance to get better (Prashanti, & Ramnarayan, 2019). The crucial role of assessment in the educational process. The formative and summative evaluations used in schools are the most noticeable.

Effective classroom instruction is centred on assessing students' learning. Assessment in education refers to techniques or instruments used by teachers to gauge and record students' academic readiness, teaching effectiveness, acquisition of skills, learning orientations, and educational requirements. According to O'Kaine (2014), educational evaluation is the process of documenting knowledge, abilities, attitudes, values, and beliefs, typically using explicit and quantitative terminology. It is a technique for learning about a person's performance or skills using tests, exams, projects, assignments, or other methods. The three main areas on which assessment focuses are the individual learner, the learning environment (such as a classroom, laboratory, workshop, field, or other organized learning environment), and the organization or societal educational system. Education assessment procedures are based on assumptions and views about the nature of the human mind, the source of knowledge, and how people learn, as well as the theoretical framework of the practitioners and researchers. For the purpose of considering various assessment approaches' objectives, assessments are sometimes split into formative and summative categories (Aaron, Tsouris, Hamilton, & Borole, 2010).

Formative assessment is an evaluation that takes place during the teaching process and involves observation, analysis of student performance in learning activities, and changes to the teaching strategy made by the instructor without formal assessment. This method allows you to track the fluctuations of students' learning and, if necessary, make changes to the course and the curriculum because it is consistently employed in the classroom. Both oral and written, formally or informally, can be used for student comments and responses. The most crucial step is to constantly review students' knowledge during the current learning process, to focus more on information that needs improvement, and to make sure that repetition will be used effectively during the following learning phases. At this point, continuous feedback is crucial, and the learner starts to feel the need to evaluate and keep track of their own learning progress (Dilova, 2021).

Summative evaluation is the ultimate evaluation that determines how well students have understood the material being studied in the subject and section being studied. It also determines how well they have demonstrated their mastery at the end of the quarter and academic year. With the use of this evaluation technique, students can learn more about what they have discovered via their learning activities (Dilova, 2021). The process of gathering, analysing, and summarizing learning data is summative assessment. The goals that students are expected to have attained at a particular point, such as the conclusion of a year, semester, or stage, are taken into consideration when interpreting the evidence. These objectives can be categorised as medium-term, as opposed to the short-term objectives of specific courses or topics and the long-term objectives, such as "big" ideas, which are accomplished over the course of a student's academic career (Dolin, Black, Harlen, & Tiberghien, 2018).

In the process of teaching and learning, assessment is crucial. In the teaching of chemistry, the use of assessment to determine students' levels of conceptual assimilation and comprehension is seen as essential to the learning process. Teachers can examine their students' comprehension and obtain useful feedback on their learning through assessment for learning. The information is utilized to adjust and enhance instruction (Opateye, & Ewim, 2021).

As a chemistry teacher, the investigator has seen that the summative assessment of secondary students' learning of chemistry in Punjab, Pakistan, uses the following diverse tools:

- Multiple choice questions
- Short question answer
- Easy type answer
- Practical activity

Teachers employ oral assessments, multiple choice questions, brief question and answer sections, and essay-style question and answer formats for formative assessment. Because the evaluation focuses mostly on very high knowledge, student motivation to pursue meaningful learning and have a good comprehension of topics is very low, and as a result, the assessment does not accurately reflect the course's objectives (Sirhan, 2007).

This study comprises of following research questions;

- To what extent the content of chemistry fulfills selection criteria of curriculum content?
- To what extent the content of chemistry fulfills organization criteria of curriculum content?
- To what extent the formative and summative assessment strategies used for assessing chemistry at secondary level are a cause for difficulties in learning chemistry?
- What is the difference between public and private students' perceptions towards the content of chemistry and assessment strategies as a cause for difficulty in learning chemistry?

Research design and methods

The research was descriptive in nature, and it was carried out using quantitative data collection techniques. A positivistic philosophical framework or paradigm serves as the foundation for quantitative research.

Population

All public and the private school systems having 10 or more branches in Lahore City comprised of the population.

Sampling technique and sample size

From the desired population, a sample was chosen in stages. First, the researcher used the stratified sampling technique to identify two strata (public/private). There were divisions of strata within each stratum. Seven school systems (sub strata) from the private sector were chosen for sampling. Using the cluster sampling technique, the researcher chose six schools (three for girls and three for boys) from each school system. These seven school systems were used to choose the twenty-one male and twenty-one female schools. Eight students were randomly picked from each cluster. Five tehsils (sub strata) of Lahore were found in the public sector. 10 boys' and 10 girls' schools from each tehsil, along with fifteen students from each school, were chosen at random. As a result, 300 individuals from the public sector and 336 from the private sector—a total of 636 participants—were chosen.

Table 1

Sample size of public and private secondary schools' students

Public			**Private**														**Total**
			DA		Unique		KIPS		Allied		Educator		Smart		City		
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	
Schools	10	10	3	3	3	3	3	3	3	3	3	3	3	3	3	3	62
Participants	150	150	24	24	24	24	24	24	24	24	24	24	24	24	24	24	636

Instrument of study

In the study, a questionnaire was employed to collect data. For gathering data, a questionnaire with a five-point Likert scale has been deemed beneficial. Strongly disagree to strongly agree were the scale's options. Expert evaluation and pilot testing were used to determine the validity of the instrument. Three experts were asked to respond to a questionnaire about the instrument's language, structure, relevance, and substance. Cronbach's Alpha was determined to assess the questionnaire's dependability. The reliability threshold for Cronbach's Alpha is 0.75, and its total value was 0.879. This demonstrates the instrument's reliability.

Data Analysis

Data were gathered by the researcher using questionnaires. Software from statistical packages for social science (SPSS) was used to examine the data. For all research questions, descriptive statistics (mean, standard deviation, and frequency) were utilized to get the answers.

Data analysis at Variable level

First of all, data have been reported with respect to the content as a cause of difficulty in learning chemistry at secondary level.

Table 2

Content of chemistry as a cause for students’ difficulty in learning chemistry (N=636)

Variable	Mean	Standard deviation
Content as a cause	3.51	0.57

The above table illustrates that students' perception regarding the Content of chemistry as a cause for students' difficulty in learning chemistry. According to the respondents' response, (M=3.51; SD=0.57) students' perceptions reflected toward the level of agreement.

Data Analysis at factor Level

After that, data have been reported with respect to the factor of content as a cause of difficulty in learning chemistry at secondary level.

Table 3

Content of chemistry as a cause for students' difficulty in learning chemistry (N=636)

Factors	**M**	**S.D.**
Organization criteria	3.3829	.71804
Psychological criteria	3.5008	.80647
Validity	3.4852	.78608
Utility	3.5519	.90169
Clarity of concepts	3.6326	.82760

The above table illustrates that with respect to five factors (Organization criteria, psychological criteria, validity, utility, clarity of concepts), the mean score (M=3.51; SD=0.57) of students' perceptions about the content of chemistry as a cause for students' difficulty in learning chemistry was a high level. The mean score ranges M=3.38 (organization criteria) to M=3.63 (Clarity of concepts). According to the response of the participants, the factors of Organization criteria (M=3.38; SD=0.71), Psychological criteria (M=3.50; SD=0.80) validity (M=3.48; SD=0.78), utility (M=3.55; SD=0.90), clarity of concepts (M=3.63; SD=0.82) were at high level.

Data Analysis at item level (Content)

Analyzing data of students' perceptions about learning chemistry at factor level, the data were further analyzed at item level for each of five factors separately.

1- Organization criteria

Table 4

Students' perceptions about organization criteria of chemistry content at secondary level (N=500)

Items	SD (%age)	D (%age)	U (%age)	A (%age)	SA (%age)	M	SD
Content of chemistry book is progression to the concepts you studied in previous classes.	150 (23.6)	65 (10.2)	82 (12.9)	257 (40.4)	82 (12.8)	3.09	1.400
Chemistry content has been organized from easy to difficult.	41 (6.4)	96 (15.1)	131 (20.6)	217 (34.1)	151 (23.7	3.54	1.189

In content of chemistry pre-requisite is given before each concept.	45 (7.1)	77 (12.1)	161 (25.3)	225 (35.4)	128 (20.1)	3.49	1.149
Content has been organized from concrete to abstract concepts.	43 (6.8)	70 (11.0)	192 (30.2)	243 (38.2)	88 (13.8)	3.41	1.071

The table shows that secondary level chemistry content satisfies organization criteria at a modest level (M=3.38; SD=0.71). According to the students' views, 53% of participants agreed that the concept progresses in the secondary level chemistry book (M=3.09; SD=1.40), 52% agreed with from tangible to abstract notions, the content has been arranged (M=3.41; SD=1.07) were at a moderate level. The majority of respondents (58%) agreed that the chemistry material has been arranged from simple to difficult (M=3.54; SD=1.18), and the majority (55%) agreed that each concept in the chemistry content has a prerequisite (M=3.49; SD=1.14) that is at a high level. Overall, student perception maintained at a moderate level (undecided).

2- Psychological criteria

Table 5

Students' perceptions about psychological criteria of chemistry content at secondary level (N=500)

Items	SD (%age)	D (%age)	U (%age)	A (%age)	SA (%age)	M	SD
Content of chemistry book is easy to understand.	42 (6.6)	122 (19.2)	63 (9.9)	254 (39.9)	155 (24.4)	3.56	1.231
Content of chemistry is difficult in comparison to the other subjects.	54 (8.5)	115 (18.1)	171 (26.9)	193 (30.3)	103 (16.2)	3.28	1.182
Content given in chemistry book is according to your mental level.	42 (6.6)	88 (13.8)	109 (17.1)	241 (37.9)	156 (24.5)	3.60	1.186
Content given in chemistry book is interesting for you.	52 (8.2)	84 (13.2)	108 (17.0)	237 (37.3)	155 (24.4)	3.56	1.221

This table illustrates how high-level psychological criteria are met by secondary level chemistry content (M=3.50; SD=0.80). Participants reported high levels of agreement with the following statements: 64% agreed that the content of the chemistry book is simple to understand (M=3.56; SD=1.23), 63% agreed that the content is appropriate for students' mental level (M=3.60; SD=1.18), and 62% agreed that the content is interesting to you (M=3.56; SD=1.22). Chemistry is challenging compared to other topics, according to 47% of respondents (M=3.28; SD=1.18), which is at a moderate level. Perceptions of students as a whole remained high.

3- Validity

Table 6

Students' perceptions about validity of chemistry content at secondary level (N=500)

Items	SD (%age)	D (%age)	U (%age)	A (%age)	SA (%age)	M	SD
Chemistry content can be completed within given time.	52 (8.2)	78 (12.3)	130 (20.4)	225 (35.4)	151 (23.7)	3.54	1.209
You know the objectives of chemistry at secondary level.	41 (6.4)	101 (15.9)	181 (28.5)	212 (33.3)	101 (15.9)	3.36	1.120
Objectives of chemistry are achievable within given time.	49 (7.7)	77 (12.1)	136 (21.4)	250 (39.3)	124 (19.5)	3.51	1.160
Content of chemistry is up to date.	58 (9.1)	91 (14.3)	115 (18.1)	227 (35.7)	145 (22.8)	3.49	1.242
Concepts given in chemistry are accurate (without any mistake or misconception).	56 (8.8)	84 (13.2)	114 (17.9)	234 (36.8)	148 (23.3)	3.53	1.229

This table shows that secondary-level chemistry content (M=3.48; SD=0.78) satisfies high-level validity requirements. Participants said that 59% of them concurred with Chemistry objectives are attainable in the allotted time (M=3.51; SD=1.16), Chemistry content is current (M=3.49; SD=1.24), and Chemistry content can be finished in the allotted time (M=3.54; SD=1.20). Chemistry concepts are presented accurately (without any errors or misunderstandings) (M=3.53; SD=1.22) and at a high level. 49% of respondents believed that pupils knew the secondary-level chemistry learning objectives (M=3.36; SD=1.12) were at a moderate level. overall opinions of students regarding the high level of veracity of the curriculum in chemistry.

4- Utility

Table 7

Students' perceptions about utility of chemistry content at secondary level (N=500)

Items	SD (%age)	D (%age)	U (%age)	A (%age)	SA (%age)	M	SD
Concept in your chemistry book is applicable in your daily life.	58 (9.1)	87 (13.7)	144 (22.6)	268 (42.1)	79 (12.4)	3.35	1.14
Content of chemistry will help you in your future life.	44 (6.9)	49 (7.7)	120 (18.9)	230 (36.2)	193 (30.3)	3.75	1.16

This table illustrates how secondary-level chemistry material (M=3.50; SD=0.90) meets high usefulness standards. The replies showed that 54% of respondents (M=3.35; SD=1.14) believed that a concept from a chemistry textbook is practical in daily life. Chemistry content will be helpful in the future, according to 67% of respondents (M=3.75; SD=1.16), which is a significant level of agreement. Overall, students' opinions of the content's usefulness were quite positive.

5- Clarity of Concepts

Table 8

Students’ perceptions about clarity of concepts of chemistry content at secondary level (N=500)

Items	SD (%age)	D (%age)	U (%age)	A (%age)	SA (%age)	M	SD
Sufficient explanation of concepts has been given in book.	33 (5.2)	84 (13.2)	103 (16.2)	278 (43.7)	138 (21.7)	3.64	1.11
In content of chemistry practical examples have been added for clarity of concepts.	49 (7.7)	74 (11.6)	98 (15.4)	261 (41.0)	154 (24.2)	3.62	1.19
In content of chemistry explanation of terminology is clear and easy to understand.	49 (7.7)	72 (11.3)	111 (17.5)	234 (36.8)	170 (26.8)	3.64	1.21

This table clarifies secondary-level chemistry content while maintaining high conceptual clarity (M=3.63; SD=0.82). According to the students' responses, 66% agreed that the concepts were sufficiently explained in the book (M=3.64; SD=1.11), 65% agreed that practical examples had been added to the chemistry content to help clarify the concepts (M=3.62; SD=1.19), and 64% agreed that the terminology explanation was simple and easy to understand. Overall, students gave very positive feedback on how well the chemistry topic was understood.

Data Analysis at Variable level (Assessment strategies as a cause)

First of all, data has been reported with respect to assessment as a cause of difficulty in learning chemistry at secondary level

Table 9 Content of chemistry as a cause for students’ difficulty in learning chemistry (N=636)

Variable	**Mean**	**Standard deviation**
Assessment as a cause	3.40	0.60

The above table illustrates that students' perception regarding the assessment strategies used as a cause for students' difficulty in learning chemistry. According to the respondents' response, (M=3.40; SD=0.60) students' perceptions remains at moderate level of agreement.

Data Analysis at factor Level (assessment)

After that, data has been reported with respect to the factor of assessment as a cause of difficulty in learning chemistry at secondary level.

Table 10 Assessment strategies as a Cause for Students' Difficulty in Learning Chemistry (N = 336)

Factors	M	SD
Formative assessment procedures	3.2683	.70177
Appropriateness of items	3.6069	.84964
Motivation through items	3.6027	.87610

The aforementioned table makes it clear that respondents' perceptions of assessment strategies as a contributing factor to students' struggles with learning chemistry were at a high level, with respect to three factors (formative assessment procedures, appropriateness of items, and motivation through items), with a mean score (M = 3.48; SD = 0.80). From M=3.26 (formative assessment technique) through M=3.60, the mean score is available (appropriateness of items). The factors appropriateness of items (M=3.60; SD=0.84) and motivation through items (M=3.60; SD=0.87), according to the participants, indicate that they were at a high level of participant perceptions (agreed), whereas in the case of the formative assessment procedure (M=3.26; SD=0.70), students were unsure of its role in contributing to students' learning difficulties in chemistry.

Data analysis at items level (assessment)

Analyzing data of students' perceptions about learning chemistry at factors level, data were further analyzed at items level for each of three factors separately.

1- Formative assessment procedures

Table 11

Students' Perceptions about formative assessment procedures of assessment strategies at secondary level (N=636)

Items	SD (%age)	D (%age)	U (%age)	A (%age)	SA (%age)	M	SD
Teacher generally uses oral test for chemistry assessment	88 (13.8)	70 (11.0)	91 (14.3)	239 (37.6)	148 (23.3)	3.45	1.32
Teacher generally uses written test in class for assessment	27 (4.2)	116 (18.2)	115 (18.1)	198 (31.1)	180 (28.3)	3.61	1.19

Teacher generally uses practical experiments for students' assessment.	85 (13.3)	159 (25.0)	137 (21.5)	152 (23.9)	103 (16.2)	3.05	1.29
Teacher generally takes surprise test for students' assessment.	92 (14.5)	138 (21.7)	103 (16.1)	195 (30.7)	108 (17.0)	3.14	1.32
Teacher assigns homework according to students' abilities.	124 (19.5)	110 (17.3)	82 (12.9)	201 (31.6)	119 (18.7)	3.13	1.41
Teacher gives comment on home assigned work.	53 (8.3)	140 (22.0)	115 (18.1)	209 (32.9)	119 (18.7)	3.32	1.23
Teacher assesses homework regularly.	56 (8.8)	135 (21.2)	143 (22.5)	172 (27.0)	130 (20.4)	3.29	1.25
Teacher gives group work to students for assessment.	84 (13.2)	160 (25.2)	125 (19.6)	174 (27.4)	93 (14.6)	3.05	1.28
Teachers' way of assessment is cause for rote learning.	45 (7.1)	113 (17.8)	162 (25.5)	187 (29.4)	129 (20.3)	3.38	1.19

This table shows how secondary level assessment strategies satisfy moderate level formative assessment procedures (M=3.26; SD=0.70). The responses showed that 61% of respondents agreed that teachers typically use oral tests for chemistry evaluation (M=3.45; SD=1.32) and 59% of respondents agreed that teachers typically use written tests in class for evaluation (M=3.61; SD=1.19) were at a high level. 40% agreed that teachers typically assess students through practical experiments (M=3.05; SD=1.29), 48% agreed that teachers typically assess students through surprise tests (M=3.14; SD=1.32), 50% agreed that teachers assign homework based on students' abilities (M=3.13; SD=1.41), 52% agreed that teachers comment on the homework they assign (M=3.32; SD=1.23), 47% agreed that teachers regularly assess the homework they assign, and 42% agreed that teachers assign group work and 50% of respondents (M=3.38; SD=1.19) at a moderate level agreed that the way teachers assess students contributes to rote learning.

2- Appropriateness of Items

Table 12

Students' Perceptions about appropriateness of items of assessment strategies at secondary level (N=636)

Items	SD (%age)	D (%age)	U (%age)	A (%age)	SA (%age)	M	SD
During Board Exams MCQ type items are appropriate for assessment of chemistry concepts.	47 (7.4)	67 (10.5)	115 (18.1)	255 (40.1)	152 (23.9)	3.63	1.17
During Board Exams short answer type items are useful to evaluate chemistry concepts.	33 (5.2)	61 (9.6)	133 (20.9)	254 (39.9)	155 (24.4)	3.69	1.09
During Board Exams essay type items are more appropriate for assessment and evaluation of students.	45 (7.1)	78 (12.3)	141 (22.2)	253 (39.8)	119 (18.7)	3.51	1.13

This table highlights secondary level assessment procedures that ensure item appropriateness at a high level (agreed to statement). Participants agreed that 64% of MCQ type items used during board exams are appropriate for evaluating chemistry concepts (M=3.63; SD=1.17), 64% of short answer type items used during board exams are helpful for evaluating chemistry concepts (M=3.69; SD=1.09), and 59% of essay type items used during board exams are more appropriate for evaluating students (M=3.51; SD=1.13) who performed at a high level. The majority of students continued to think that the items chosen for the summative evaluation were appropriate.

3- Motivation through items

Table 13

Students' Perceptions about motivation through items of assessment strategies at secondary level (N=636)

Items	SD (%age)	D (%age)	U (%age)	A (%age)	SA (%age)	M	SD
Using MCQ type items for assessment motivates the students for learning	42 (6.6)	70 (11.0)	117 (18.4)	250 (39.3)	157 (24.7)	3.64	1.15
Using short answer type items for assessment motivates the students for learning	37 (5.8)	75 (11.8)	102 (16.0)	257 (40.4)	165 (25.9)	3.69	1.14
Using essay type items for assessment motivates the students for learning	55 (8.6)	89 (14.0)	130 (20.4)	223 (35.1)	139 (21.9)	3.47	1.22

The secondary level assessment procedures described in this table (M=3.60; SD=0.87) motivate students with high-level items. Using MCQ type items for assessment motivates students for learning, according to 64% of participants (M=3.64; SD=1.15), using short answer type items for assessment motivates students for learning, according to 66% of participants (M=3.69; SD=1.14), and using essay type items for assessment motivates students for learning, according to 56% of participants (M=3.47; SD=1.22). For the motivational purposes of the summative exam, pupils' overall perceptions remained consistent.

Compare the perceptions of secondary students studying in public and private schools about the content as a cause of difficulty in learning chemistry.

Table 14

Difference between Public and Private Sector Students' Perceptions

Factor	School Sector	N	Mean	Std. Deviation	t-Value (df = 498)	p (∝ = 0.05)
Content as cause	Public	300	3.4974	.59019	-.554	0.580
	Private	336	3.5225	.55542		

The table discloses that the students studying in public and private schools differed significantly in their perceptions about the content as a cause of difficulty in learning chemistry. The groups do not significantly different for the content as cause of difficulty in chemistry learning (t (634) = -.554, p = 0.580), at alpha level 0.05. Private school students (M = 3.52, S.D. = 0.55) reflected higher level of agreement about content as a cause of students' difficulties in learning chemistry than that of public-school students (M = 3.49, S.D. = 0.59). So, there was no statistically significant difference between public and private schools' students with respect to the content as a cause of difficulty in learning chemistry at secondary level. The results support the null hypothesis in this regards.

Compare the perceptions of secondary students studying in public and private schools about the assessment strategies as a cause of difficulty in learning chemistry

Table 15

Difference between Public and Private Sector Students' Perceptions

Factor	**School Sector**	**N**	**Mean**	**Std. Deviation**	**t-value (df = 498)**	**p (∝ = 0.05)**
Assessment as cause	Public	300	3.4177	.61268	-2.896	0.004
	Private	336	3.5596	.62141		

The table discloses that the students studying in public and private schools differed significantly in their perceptions about the assessment as cause of difficulty in learning chemistry. The groups differed significantly for the assessment as cause of difficulty in learning chemistry (t (634) = -2.89, p = 0.004), where the difference was significant at alpha level 0.05. Private school students (M = 3.55, S.D. = 0.62) reflected higher level of agreement about assessment as a cause of students' difficulties in learning chemistry than that of public-school students (M = 3.41, S.D. = 0.61). It is concluded from analysis that the public and private school differed from each other at factor level in assessment as cause of difficulty were as; formative assessment procedures (t=.345, p=.730), appropriateness of items (t=-3.561, p=.000), motivation through items (t=-2.994, p=.003). So, there was a significant difference between public and private schools' students with respect to the assessment as a cause of difficulty in learning chemistry at secondary level. Hence, the overall data of this study didn't support the null hypothesis.

Findings and Discussion

Overall perceptions of students regarding the content as a cause of students' learning difficulty were reflected toward the level of agreement. The secondary students' perceptions of the five factors—organization criteria, psychological criteria, validity, utility, and concept clarity—were at a high level, with a mean score (M = 3.41; SD = 0.58) of students' perception of the chemistry content as a contributing factor to their difficulties with the subject. Many students view the subject in chemistry as academic, difficult to acquire, and disconnected from daily life (the living world), according to De Vos, Bulte, and Pilot (2002) (Gafoor & Shilna, 2013). One of the main issues students' faces is the challenge of connecting fundamental chemistry topics. Since they frequently lack the grounding necessary to understand complex and foreign concepts (Gafoor, & Shilna, 2013).

Participants believe that secondary level chemistry content meets criteria for a moderate level of organization (M=3.38; SD=0.71), which is reasonable. Students' levels of agreement with the structuring of the information from simple to complex are moderate. Because most of the content in the secondary level chemistry text book is unrelated to the content in the text book for eighth grade, which serves as the foundation for the content present in the text book for ninth grade, there is no progression of the concept in the content of chemistry at that level. Because it has a considerable impact on both the effectiveness of teaching and the extent to which important educational changes are implemented in the pupils, organization is regarded as a crucial difficulty in the construction of curricula (Kuhn, Andreae, Ammann, Araújo, Brancaleoni, Ciccioli, & Kesselmeier, 2007). The majority of the concepts in the secondary level chemistry textbook left the pupils unsure on how the concepts should be applied.

The students' opinions of how well the psychological criteria for the content of chemistry were met on average scored at a high level (M=3.50), indicating that they generally agreed with this conclusion. Participants also agreed that the content in the chemistry books is appropriate for their mental level and is not unclear, making it easy to understand. The subject of chemistry is recognized as being challenging for students. Both the fundamental character of the subject and human learning may be the source of the challenges. By identifying commonalities and regularities as well as by creating instances and non-examples, concepts are formed from our senses. It is feasible to recognize things directly, such metals or flammable chemicals, but it is quite difficult to do so for notions like "element" or "compound," bonding kinds, internal crystal structures, and family groups like alcohols, ketones, or carbohydrates. Most chemical concepts are formed using a psychology that differs greatly from that of the "regular" world. Operating on and relating three levels of thought—the macro and physical, the submicro atomic and molecular, and the representational use of symbols and mathematics—adds to the complexity of our situation. Introducing concepts at all three levels to students at once is psychologically foolish. The roots of many myths can be found here. These three can be maintained in balance by a skilled chemist but not by a novice (Johnstone, 2010).

The moment at which we assess whether an instrument uses a suitable sample of items for the concept is known as content validity (Hamid, Lee, Taha, Rahim, & Sharif, 2021). The concept of measurement is best understood when the content is valid; however, this does not mean that the instrument is measuring what it is intended to (Ad'hiya, & Laksono, 2018). The data's average score (M=3.48) demonstrates that students' evaluations of the content's veracity were very high. The participants agreed that the material of the chemistry text book had been finished in the allotted time because there are eight chapters in the text book for ninth grade and eight chapters in the text book for tenth grade. They were split on whether or not they knew the chemistry content objectives, but they did agree that they had learned the chemistry content. This indicates that they might not be familiar with the chemistry content objectives listed in the textbook, which is why they are split on whether or not to demonstrate their knowledge of the chemistry content objectives.

Students' opinions on the usefulness of chemistry content were quite positive. Chemistry and its uses in daily life are closely intertwined. Students that study chemistry should expect to gain information about themselves, their surroundings, and how to solve problems. This will allow them to use their knowledge in real-world situations (Irwansyah, Lubab, Farida, & Ramdhani, 2017)

Students had very positive opinions on how well-defined the concepts in the chemistry course were. One of the most significant factors for why students struggle to solve issues, according to Gabel and Bunce, is a lack of grasp of key chemical principles (Holme, Luxford, & Brandriet, 2015). This is due to their perception that the principles in the chemistry textbook have been well explained, and they also assumed that real-world examples have been incorporated into the chemical content. Participants can also think that the terminology explanations are simple and understandable.

Secondary students' perceptions about assessment strategies

The secondary students' opinions of assessment procedures as the root of their learning challenges in chemistry were at a high level, which indicates that they agreed with the statement in question. Students who have passed the PEC (Punjab Education Commission) exam for the eighth grade must deal with a different type of assessment when they enroll in the ninth grade. Science question papers at the elementary level have a different format and weighting of the questions than chemistry question papers at the secondary level.

In the PEC test, the head examiner must hold a master's degree in the relevant field; nevertheless, the sub-examiner level is required at the BISE Lahore. These discrepancies increase students' test anxiety, which has an impact on their performance. When taking board exams, students experience a great deal of anxiety and view the subject of chemistry as a brand-new subject. According to Rana & Mahmood (2010), test anxiety is a factor that lowers students' achievement. Gibbs (2003, 2006), Brown, Rust, and Gibbs (1994), studied how changes in evaluation affect students' learning. When students are actively participating in the evaluation process, it may be a powerful tool for learning (Michigan State Board of Education, 2017).

During the teaching and learning process, educators must assess whether the learning objectives have been met and whether the instructional strategies are helpful in accelerating students' conceptual learning. Consequently, one method to use is through formative or summative assessment (Nsabayezu, Mukiza, Iyamuremye, Mukamanzi, & Mbonyiryivuze, 2022). An assessment in chemistry includes a wide range of instruments for guiding and enhancing instruction, for assisting teachers and students in bettering their comprehension of the material, and for rating student performance and assigning marks. It is the duty of teachers to use more than one or two significant assessment methods in their chemistry classes. While some students may be good writers or mathematicians, others may be strong painters or speakers. Written exams put pressure on certain pupils while not others. A variety of assessment methods must be used in conjunction with the related planning and follow-up tasks to evaluate student learning (Tenaw, 2015).

These variations cause diversity in students' performance in chemistry at the secondary level and lead to misconceptions about assessment in secondary-level students' minds. They acknowledged that all assessment methods are appropriate for their mental capacity and aid in learning as they had no prior experience with chemistry. Bishop (1994) claims that the external curriculum-based tests that are administered at the conclusion of the high school semester disrupt middle school students, teachers, parents, and school administration (Bishop, 1994). Although the assessment method was primarily intended for summative purposes, the teacher instead used it for formative evaluation (Wiliam, 2013).

Overall students' perception about assessment strategies used as a cause for students' learning difficulty in chemistry were remain at moderate level of agreement. The respondents' perceptions of the three evaluation aspects were moderate, although secondary students responded favorably to the appropriateness of the chemistry question paper's items and the motivation provided by the BISE Lahore exam's items.

Compare the perceptions of secondary students studying in public and private schools about the assessment strategies and content as a cause of difficulty in learning chemistry

There was no statistically significant difference between public and private schools' students with respect to the content as a cause of difficulty in learning chemistry at secondary level as well as there was a significant difference between public and private schools' students with respect to the assessment strategies used as a cause of difficulty in learning chemistry at secondary level (students' perceptions about other factors appropriateness of items and motivation through items shows highly significant difference while on the other hand formative assessment procedures shows no significant difference among public and private sector students' response). Opateye (2012a) established that the success of pupils in chemistry is largely influenced by their school type. So, whether a school is public or private, it can have an impact on students' chemistry achievement when research- and assessment-based instructional practices are implemented. Good education in chemistry classrooms is based on effective assessment of students' learning (Opateye, & Ewim, 2022).

Conclusion

It was determined that students' perceptions of the content of chemistry as a contributing factor to their difficulty in learning chemistry were at a high level. While on the other hand, assessment strategies as a contributing factor to students' difficulties with learning chemistry were at moderate level. Students' response shows difference between public and private schools' students with respect to the content as a cause of difficulty in learning chemistry and shows no difference between public and private schools' students with respect to the assessment strategies used as a cause of difficulty in learning chemistry at secondary level. Overall, it was concluded that chemistry is a difficult subject and teachers should be used different assessment strategies to enhance students' learning and reduce students' difficulties.

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