Sir Syed Journal of Education & Social Research
Vol. 3, Issue 1, 2020 (Jan – March)
ISSN 2706-6525 (online), ISSN 2706-8285(Print)
ISSN 2706-9362 (CD-ROM), ISSN 2706-6525 (ISSN-L)
DOI: https://doi.org/10.36902/sjesr-vol3-iss1-2020(178-185)

SJESR
Sir Syed Journal of Education & Social Research

Multiple Representations: A Descriptive Analysis in Chemistry

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Abstract

Teachers sketch diagrams and use other representations as a portion of systematic inquiry in science. This study was consist of a qualitative paradigm that examined the five students' perceptions of teachers' instructional strategies with multiple representations in the learning of chemistry. The purposive sampling techniques were used to collect data from 5 students using interview protocol in a natural environment. The audio tapped data were transcribed by the researcher and found that the teacher use of diagram is an interesting activity, teacher draw diagram for imparting the knowledge, uses relevant diagram, lecture-demonstration method is used, using charts graphs and models, assessment is done through conducting test and using questions.

Keywords: Multiple representations; learning; model; chemistry; instructional strategies

Introduction

Representations play a fundamental job in illuminating scientific concepts to develop students' learning, understanding, and assist learners' theoretical learning programs. All these multiple representations have been engaged as an instructive tool throughout which learners contextualize and create all their understandings. For such purpose scientists make, perceive, and assign the meanings of representations - notes, reports, tables, graphs, equations, drawings, diagrams (Anderson, 1999).

The use of representations as a support to the transmission of scientific thoughts is proving to be one of several theoretical accounts pertinent to classroom use of representations to support the teaching and learning of science (Ainsworth, 2006).

Representation has to recognize which parts of the area are represented, has to correspond the representations to each other if the representations are (partially) outdated, and has to translate among the representations. One of the main problems learners have with using multiple representations is to try without effective teaching successful learning cannot take place. Effective teaching according to the constructivists is not like a one-way communication but rather productive learning occurs when students are being keenly busy in the learning process rather than attempting to receive knowledge passively (Jonassen, 2003; Olaleye, 2005).

The constructivists suggest that learners create knowledge based on their knowledge of previous understanding. They are not an empty slate but study best when permitted to be dynamic creators of their comprehension. It then appears that when learners turn into busy in activities, they shift from being a passive receiver of information to an active contributor in the learning procedure. Therefore, science teachers need to guarantee that the learners comprehend what is being educated and are also capable to set the comprehension into successful use (Adenekan, et al., 2006).

Therefore, to learn science effectively students must understand different modes of representations demonstrating scientific concepts and processes, and be able to translate the knowledge learned from one representation to another, as well as realize the coordinated relations in representing expertise Classification categories of representations generally include textual, visual, mathematical, figurative and gestural or kinaesthetic (Hubber, Tytler, & Haslam, 2010).

There is a broad consensus in the literature on representational teaching and learning in science that students need to develop an understanding of diverse representational modes if they are to develop a strong understanding of how the instructional use of representations demonstrate science concepts. Recent research in this area has focused variously on the conceptual learning across multiple representations in different topics and students' self-construction and explanation of

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diagrams and the role of visualization in textual and diagrammatic interpretation (Ainsworth & Loizou, 2003; Parnafes, 2005; Ainsworth & Iacovides, 2005).

Research Question

How students' perceive teachers' instructional strategies with multiple representations on their learning of chemistry?

Significance of the Study

This study has significance in evaluating students' perceptions of teachers' diagrammatic usage, and cognitive roles of diagrams and text in students' conceptual learning. While the research is part of the growing international interest in the representational teaching and learning studies relating to science education. This study is one of the few studies to date that describe how diagrams are used by textbooks, chemistry teachers' classroom teaching, and students. This type of research permits detailed directions to be opened in the analysis of diagram-inclusive instructional materials (Ainsworth, 2008b; Eilam & Poyas, 2010; Moreno, Ozogul & Reisslein, 2011; Waldrip, Prain, & Carolan, 2010**).**

Literature Review

Representation artefact that indicate an idea or notion in science (power, vitality, synthetic holding) and can appear as analogies, oral clarifications, composed writings, graphs, charts, and model. In that capacity, they are a basic piece of verbal communication in a science discipline. The National Science Foundation (NSF), bothers on the better intellectual capacity of symbols, two economically endorsed "cross-border" convocations that might bring researchers from the science learning, cognitive science, and schooling communities**.** These conferences exposed more frameworks and structures that expected to clarify that how a representation advances learning in science subjects. Particularly, more prominent understandings are required resting on two areas that follow a line of investigation on representation: that are multiple representations and multimodal representations (Hand et al., 2003; Yore & Treagust, 2006).

The expression "multiple representations" indicates the act of illustrating a similar concept to pupils through various illustrative structures. Multiple representational types of research have concentrated on the utilization of additional representation that influences learners' comprehension (Ainsworth, 2006; Gilbert & Treagust, 2009; Kozma, 2003; Prain, Tytler, & Peterson, 2009). The expression "multimodal representations" suggests that education utilizing at least solitary or supplementary representation generally incorporates elements of different modalities for example, language, illustration, and signs (Prain & Waldrip, 2006). Research work on multimodality analyses why learners construct science-related knowledge through any synchronized utilization of different models among and crosswise over-representation (Airey & Linder, 2009; Kress, Jewitt, Ogborn, & Tsatsarelis, 2001).

The rationale following this research work was to display a system to utilize the two measures to relate two domains of the study, straight away to recommend further guidelines for investigation. For this purpose, this work at first put forward the idea of various-symbolical structures; lay down by Yore and Treagust (2006). As for as the exterior and interior representations and their choice is concerned and the choiceness fixed among were outlined, presently it was meant to go quickly with the idea of multiple representations. The above idea incorporates different types of representations and despite these types, the link between these representations can be considered likewise. While understanding the theory of multiple representations the following characteristics are incorporated**:** i. distinguishing an arithmetical concept among various positions of representations, ii. Controlling the concept, different representations, iii. Interpreting the idea starting with one representation then onto the next, iv. Developing associations between interior representations in one's system of representation, v. having the option to choose the proper representation utilized in a particular topic, vi. Distinguishing the qualities and shortcomings, similarities and dissimilarities of different representations regarding an idea" (Owens & Clements, 1998). i. The explanation of the above six points would appear to be the important purposes of different representations. Even (1998) expressed that having the option to recognize and speak to a similar idea in various figurative models, are adaptable with the various representations, having the option to choose mainly appropriate representation between various symbols, and understanding the preferences and drawbacks of illustrations are among important problems for knowing theoretical comprehension in science

subjects. According to Hitt (1999) "An important objective of science instruction is taken to be that the learners have the option to go starting with one representation type then onto the next without falling into inconsistencies." Besides, the utilization of different representations of ideas gives adaptable and flexible knowledge (Keller & Hirsch, 1998).

Besides, other theoretical accounts of meaning-making pertinent to conceptual learning in science and classroom performance utilize a representational center to create a system in supporting students learning (Waldrip et al., 2010).

Current research inquiries about benefits on learning science discipline with portrayals have stressed on either recognizing outline important outline of fruitful representation that work as advance coordinators to energize prospering pupil explanation and knowledge (Ainsworth, 2006) or probing the situation beneath which learners' development of representations enhance knowledge (diSessa, 2004). Besides, other theoretical records of importance applicable to unique knowledge in teaching and learning of science and study classroom performance utilize an illustrative concentration to build a structure in supporting learners' learning (Waldrip et al., 2010).

Learning with multiple representations can be a difficult task for learners. Apart from other challenges one challenge is that learners incline to focus on the surface properties of a representation rather than negotiating the conceptual, deeper meanings represented (Ainsworth, 1999, 2006; Kozma, 2003; Schonborn & Anderson, 2009). This challenge is noticed when a student saw that a graph with a negative slope looks like amount relatively than observing that the value on the y-axis is decreasing.

An additional challenge is that learners find it hard to recognize mutual meaning among representations, and as an alternative, examine every representation as distinct and separate in meaning (Ainsworth 2006; van der Meij & de Jong, 2006). For example, a learner is presented with the elemental symbol for helium from the periodic table and anatomic structure diagram of a helium atom. The student must unite the features of each representation, to make sense of these two representations that point out the number of electrons or protons (atomic number) in the atom.

A third and associated challenge is that learners usually try their best to discover significant differences among representations (Ainsworth, 2006). A significant differentiation that students could not see among the representations shown is that the number of protons in the diagram is the same as the atomic number, or that the valance (outermost) electron shell is shown to be filled with electrons in both representations (as indicated by Helium's position in the periodic table and the two electrons in the valence shell). Pupils can also fail to perceive a difference: the top right portion of the periodic table, on the left, (Brewton-Parker College, 2010) showing helium (He) and, on the right, a diagram of a helium atom. It only has two electrons in a full shell, as opposed to the eight electrons in the valence shells of the elements below helium on the periodic table. Likewise, learning with multiple representations need that students recognize how to discuss each separate representation. To discuss the meanings of the representations of helium, a student requirement to know what is meant by the elemental symbol and its position on the periodic table (van der Meij & de Jong, 2006).

Hsu (2014) revealed that to assist students in developing reasoning abilities required visual image, because it can evoke sensory involvement of students, and further enrich the experience by drawing, then the sensory participation in the body can provide a better learning experience. The pictures are examples of creative imagination that can help students in understanding the phenomenon of the sub-micron level. Sunyono et al. (2015a) through sub-microscopic image visualization, students will be easier to build up their mental models. A mental model is a representation of the intrinsic (internal representation) of an object, idea, or processes produced by a person during the on-going cognitive processes (Harrison & Treagust, 2000). According to Mumford et al. (2012) found students' mental models can be generated through mapping tasks conceptual map or model which is expressed through pictures structural model that describes the relationship between the concepts chosen by students in problem-solving creatively.

Methodology

The study was conducted in the qualitative paradigm to study multiple representations: A descriptive analysis in chemistry

Selection of Participants & Data Collection

As recommended by Etikan, Musa, and Alkassim (2016) and Gentles, Charles, Ploeg, and McKibbon (2015), purposive sampling was conducted to find authentic information from key persons. All the

Government schools (Boys), of class 10 in Mardan, Pakistan constituted the population of the study. The researcher selected 5 students purposively; from three schools having strong oral power and were willing to give audiotaped interviews, for research purposes. The researcher sought consent of the participants from the heads of the school and conducted interviews for finding their perceptions and experiences for the phenomenon under study.

Tool of Investigation

An interview protocol, seeking open-ended answers, was constructed for the study. The interview protocol was pilot tested on two respondents out of the sample for making necessary changes. The interview questions were reduced from eight to six after getting feedback from the respondents with some language changes.

Data Analysis and Presentation of Results

The researcher transcribed all the10 interviews and conducted an inductive analysis. Themes and patterns were derived from responses of major research questions and probes through open coding. The responses of students regarding the teachers were presented and discussed under each research question. The data was analysed manually.

Results

For maintaining the anonymity of respondents, the interviews were given codes as S1, S2, S3 for respondents one, two, and three respectively. The responses and the interpretation is given below:

Q- 1: How do you feel the use of a diagram in teaching is an interesting activity?

The analysis of themes of the students' responses for the first item showed that diagram is an integral part of teaching and learning of science classrooms and has great value for imparting scientific knowledge, S1 replied, 'Without diagram, the teaching would not be interesting activity *If the diagram is not been there, then the concept clarity is difficult and remain ambiguous'*. S3 revealed, 'How might be a lesson without representation? The diagram motivates the students because only theoretical knowledge and no audio-visual aids make the students, bore, so if he is not using the different representations, how he will make the teaching conducive, He will not be able to satisfy the pupils for which they attend the classes. Another student (S6) said, 'As a result students understanding ratio increases, without the use of diagram it would not be possible, if representation were used it will produce thirst, so good activity results in better learning. As a result, attention and alertness for understanding will be guaranteed. S2 responded like this, the better use of diagram cause motivation, as presenting the atomic structure visualize the particles the atom has, and their location', while S5 explained, 'as diagram himself is nothing when someone not explain it, as it is the tool in the hand of the teacher, he either present it interested or vice versa'. S7 presented their views as and told. If the diagram is good but could not but the teacher could not interpret then how it be interested, so irrelevant teacher could not make them interested'. S8 claimed that, 'teaching and learning is not an interesting activity always, to present diagram simply and relate it to the teaching environment palsy a role in catching students' attention and motivation'. S4, S9, and S10 told that the representation makes a correlation with the text and tries to help the students regarding their alertness, attention, provides a true academic supportive environment that will be enhanced learning better.

Q-2**: What types of diagrams/representations are being used by your teacher?**

As for as the response of the second item is concerned, almost all of the respondents were in consensus that almost all types of diagrams are used by the teacher during teaching chemistry. Every type of diagram has its value, like chemical and mathematical representations, models charts and graphs, or the combination of the above during the teaching of different laws and topics of secondary school chemistry. S1, S4, S5, S6, and S8 believed that. S1, told, 'They have to prepare a lot various diagrams according to nature, as they know the importance of the using diagram and the creativity and clarity of the concept*'*. S2 and S3 claimed, 'Symbols of the element the representations of reactions, the equilibrium is shown on the graph, different shapes of molecules like tetrahedral, polygonal, all of them have been used for explaining the concept. The three students unanimously criticized their teachers that they have are only using Charts and graphs which are easily understandable to the students but the use of flow charts, structure formulas of various organic compounds, various functional groups, and mechanism of different chemical processes are not understood as due to the less competency of irrelevant subject teachers'. S8 exclaimed, '*the diagrams like icons, macroscopic, sub microscopic and symbolic representations are being widely used in chemistry by our teacher as*

these are the basic needs for the explanation of different chemical phenomena and lessons'. S6, S9, and S10, who were Bachelors in chemistry and having teaching experiences more than five years, their students claimed that our teacher uses conventional diagrams like pictures, charts, and graphs and during the teaching, they relate these diagrams with the text, so a little better we become clear with the help of reading and explaining the topic and as they are expert in their use of diagrams and complements the representation with the concept of chemistry, so these representations are helpful in the comprehension of the lesson'. S7 and S4 commented that models are used by my teacher as models are concrete pictures that are helpful in meaning-making'.

Q-3: What teaching method of your teacher is difficult about a particular diagram?

Almost all of the teachers were well aware of the nature importance and uses of instructional methods. As some are conventional and some are modern methods of teaching S1, S3, S6 & S4 revealed multiple representations are the key to illustrate and comprehend scientific phenomena especially chemistry concept, as for as all the methods of multiple representations are difficult, but the methods through which flow sheet, substitution and addition reaction are considered as tough and the teaching method without involving diagram is difficult'. S1 and S2 said that 'As our teacher used the conventional method of teaching in chemistry, use blackboard and chalk, and simple diagrams even are not visible how the things will become easy? It rather demotivates and cause hatred from education, as a result, most of the students leave school and endanger their life in case of leaving the school. S3, S4, S5, and S10 told that chemistry there are different representations like tables symbols, formulas reactions, and mathematical representation have become easy for clarification of the concept. Our teacher uses those representations which can explain a concept easily or combination any two or three as given particularly Charles law. Pictorial is used whenever matter and states of matter are used for better learning. Furthermore, S8, S9, and S2 commented

Student: Almost every type of diagram is used by my teacher which is related to the topic like when he discusses alkane series and talk about methane he represents it on board and other members of this series become easy to comprehend. S5, S10, and S6 spoke loudly against the challenges faced by them in science classrooms regarding the teacher use of representations, that our schools have no modern teaching aids and no multimedia for the explanation and interpretation of difficult representations as compare to the private school lack of funds for educational tours, as in industrial chemistry the whole process is represented through flow sheets diagrams of furnaces and chemical process, the students do not have any clue regarding the process and just see the

Picture of the process. S4 said, 'At the end of the academic year, that almost all the diagram inclusive methods are hard for us due students' incompetency, and not the use of modern technology in teaching'.

Q-4: How far your teacher cares about variety in using diagrams.

The students' responses to the current question showed that teachers care about the variety in using representation the teacher teaches the chemical bonding he uses the symbolic representation, teaching different types of elements uses periodic table.

S4 commented that, 'As a matter of fact as our teacher came across unit three he guided regarding Boyles law having volume and pressure inversely proportional to each other, he added that when one value increases that the other is always decreases at a constant temperature so he used here the textual representation and should that experimentally in the book pointed towards the figure… so he do that according to the topic'. S3, S6, and S7 said that 'he just comes the class *and urging teaching uses one type of representations like the model of the atom when he discusses the atomic structure and showing electron proton and neutron shells and their electronic configuration'.*S2 and S1revealed that, 'rarely… teachers care about variety, rather scarcely or not at all diagrams are used due to comparatively the large volume of contents and less availability of time, if diagrams are used then the lesson could not be completed in the allotted time of one year'. S4, S5, S7, and S10 exclaimed, 'that as a result of comparison between the acid and bases concept like in levis acid accept or tend to accept pair of electrons and vice versa.so explain with symbolic representations while in Arrhenius this sub microscopic representation could not be possible to show the process of acid disassociation in aqueous solution giving Hydrogen ion, so my teacher draws the symbolic representation regarding *but not in the case of Arrhenius concept so not cares about the variety*. S2 stressed that 'The teacher when feeling good and discuss various concepts and bring the charts

consisting the process of disassociation of acids and base and show o the chart and for symbolic representation shows the flex of reactions so he uses the wide variety and the topic regarding the diagrams are no more complicated. S9 said that, 'As our teacher cannot concentrate on one representation, because one representation can't meet the need of one methodology so, it is the need of teaching as multiple representation with various methods accelerate learning.

Q-5: How your teacher explains the diagram from the written text?

While throwing light to the fifth item, students explained that the teacher comes to the class tells one of the students to read the text the teacher then give the lecture on that lesson discuss it with the students and then represent it on the board in the shape of different diagrams like, If he talks about the addition reaction he write it on the whiteboard so he makes the relationship of text and diagram.

S2 said that, 'as our teacher is competent having 10 years of experience so he explains the topic and make the representation on the board not from the book but their own experiences*'*. S8 commented like that 'my teacher read out the verse from the lesson explain key words relate them with each other gives the concept and then sketch a diagram based on text. And then asked the students to repeat the process if some point needs explanation elucidate the topic with other examples also. S10 and S7 believed 'that sometimes explanation is made from the text and no diagram is explained. S7, S2, S5, and S6 told, 'as it is a common practice of our chemistry teacher that he stresses fifty on the textual representation and the related diagram as in the case of Charles law, first of all, he makes the statement clear and elucidate it thoroughly and tell the students to make the practice of this text and when the topic becomes known to the most of the students than from that statement text he draws the variables from the law and makes the direct relationship of volume and pressure at constant pressure write it in the form of mathematical representation. So when students know it mathematically then their relationship is made and the concept of a maximum of students becomes clear.

Q-6: How your teacher assesses the extent to which you understand a diagram?

Assessment is an integral part of the academic process.to judge the performance of the students. As for as the response of the last item is related'. S1, S3 and S4 added, 'for overall assessment teacher assign homework regarding diagrams and check it the next day. Either he asks the student to come to the board and draw a diagram and label it, ask students to write answers on their papers and then checking is made, if found some drawbacks then he explains again the key topic with representations. S5 commented, 'Student: our teacher conducts overall assessment like formative during the lesson, diagnostic reforming and summative at the end of the lesson or the end of the year. S5, S7, and S8 commented that'. 'As there are various forms of assessment like diagnostic evaluative and formative which are using by our teacher at the right time when required. Formative assessment is made when student response is not satisfactory then the teacher review the topic. And summative evaluation is done at the end of the academic year in the form of an exam'. ' For assessment and evaluation different tools are used assessment is done during the lesson after the lesson and at the end of the academic year. Our teacher assesses us through observation also, through random questioning from the students, brought the students to the board so these assessment is being used by our teachers'. 'Assessment is the overall phenomena for evaluating a lesson for assessment of student-teacher uses different strategies he told the students to write different chemical reactions on board write the symbols of different atoms this may be in the form of formative, evaluative and summative which is during the lesson and may at the end of session'. S5 and S8 pointed out that 'my teacher assesses the students in such a way that he invites the student to the whiteboard that and tells him to draw diagram/representation if our teacher wants to assess the chemical reactions so he tells the students to write that. If he wants to assess the students regarding acid and bases then he tells the student to write the formula of two acid and one base'. 'My teacher gives stress on assessment he assesses the students during teaching he judges the students to know the shortcomings of students. For this purpose, he is walking in the class and ask students randomly the given answer to the questions, so this is his methodology of assessment.

Conclusion

The findings of the study collectively showed that multiple representations are the part of teaching and learning process revealed good results for students' understanding, excellence, and academic improvement. The majority of students have the view that the diagram is an interesting activity. This

study showed the teacher draw diagrams on board and sometimes past on the wall and rarely use multimedia for the interpretation of diagrams. Though students claimed that whatever the method of drawing but the use of representation was ensured. Almost all the instructional strategies were used it was concluded that the lecture method of teaching is old method although it covers the corset but remains the concept unclear up to some extent. The majority of the students have the opinion that charts, graphs, grids, models, and symbols are used which are teaching and learning aids. Some students feeling that chemical reactions, the flow sheet diagrams in organic chemistry are very difficult and above the level of the students. As for as the explanation of written text from the diagram is concerned so he practiced that from representation text is easily explained. Assessment has many methods but our teacher uses conventional methods like asking questions, observing students during teaching, and checking of homework while focused made on representations.

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