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Effectiveness of Argumentation based instruction on achievement in science of secondary school students

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Abstract: *In recent years, there has been a major shift in perceiving learning from a process confined to individual mind towards process involving social and cultural dimensions. Considering science learning as something isolated from society and confined only to mere observation and experiment is a divorce to the material bond of science and society. The inclusion of argumentation and debate in the science classroom is a rising area of interest among science educators. Argumentative practices are central both to education and science. Pedagogies which foster argumentation lie at the heart of an effective education in science. In the present study, the investigators developed an instructional strategy infusing argumentative practices and named as Argumentation based Instruction. In order to validate effectiveness of Argumentation based Instruction on achievement in science; the investigators conducted a quasi-experimental research. Comparing the pre test and post test scores of experimental and control group, it can be concluded that Argumentation based Instruction is effective in improving achievement in science*

Keywords: *Achievement in Science, Argumentation, and Argumentation based Instruction*

I. Introduction

Science teaching has been dominated with constructivism over the past few decades. Constructivism views learning as a change in cognitive structures through interaction with environment (Fosnot, 1996) [1]. It has cognitive and social aspects. The social aspect of constructivism is attributed primarily to the magnum opus of Lev Vygotsky (1963) [2] and those who have further developed his ideas. The basic idea of this approach is that it is imperative to look beyond the individual mind to study learning, and that the outside world of the learner and how the learner interacts with that world is the primary milieu in which learning takes place. Research supports these thoughts, and further suggests that discourse is fundamental to students' construction of meaning (Pontecorvo, 1993; Rogoff, 1990) [3]. Accordingly, within the classroom, discussions are considered one of the most effective tools for knowledge construction.

But unfortunately current classroom practices in science education are giving more emphasis on cognitive aspects of constructivism than its social aspects. Denying social construction of knowledge is a major pitfall of an instructional procedure in science education since epistemology of science itself based on social aspects too. By analyzing the historical development of science, one can infer that social, political and economic structure of a society is greatly influenced in its scientific knowledge construction. Scientific knowledge is socially constructed, negotiated, validated, and communicated in the milieu of discourse practices of science.

Within the domain of science education, researchers have identified the importance of discourse in learning (Mortimer & Scott, 2003)[4], and have more recently focused on engaging students in scientific argumentation, where students are proposing, supporting, criticizing, evaluating, and refining ideas about scientific subjects (Driver, et. al., 1994[5]; Newton, Driver, & Osborne, 1999 [6] and Simon, Erduran, & Osborne 2002 [7]).

Engaging in the argumentative process comprises students developing claims, using data to uphold these claims, warranting their claims with scientific evidence. Students also use backings, rebuttals, and qualifiers to further support their claim as the arguments become more complex. During this process, students learn the scientific concepts and also engage in the practices of science. Hence argumentation is expected to not only help students to improve existing scientific knowledge, but also to construct new knowledge. When students are challenged with different ideas, they can reflect on their own ideas and the ideas of others, aiding them in developing better understandings. It equips students with opportunities to engage in an authentic form of discourse. Students can able to see science as a developing, continuous process in which ideas are arbitrated, questioned, and often changed or revised. It also gives a situation in which students can simulate the practices similar to those of real scientists, who collaborate to judge and assess their discoveries and inferences. Through this collaboration, scientists can confirm or discard their proposed ideas when faced with supporting or contradictory claims obtained through argumentation (Kuhn, 1993) [8]. Although there has been lots of research pointing out the advantages of argumentative discourse, it is often not incorporated into science classrooms.

Scientific concepts are often presented as a set of known facts that students are required to memorize. When students are exposed to science simply as a process of memorizing facts and concepts, it gives them a wrong notion of how science is actually practiced.

This paper tries to review the theoretical bases of the process of argumentation and suggests a practical strategy to incorporate argumentation in daily science classroom learning and teaching. Attempts also made to give empirical evidence to validate argumentation practices improve achievement in science.

II. Argumentation

Argumentation is central to people's ability in solving problems, making judgments and decisions and formulating ideas and beliefs (Kuhn 1991) [9]. Argumentation is a reasoning process in order to justify or refute a claim. It is a mode of thinking and reasoning. When one constructs an argument, he needs to consider alternative views, evaluate them and choose a solution that is supported by evidence. Hence, argumentation is an important skill for everyday life. The adeptness to question the authority and find alternative solutions is a skill associated with argumentation, which can promisingly help people move towards more abreast decisions in their everyday lives.

To delineate the elements of argumentation, Toulmin (1958) [10] proposed a model. The main components that constitute Toulmin's model include: (a) Claim, a conclusion, hypothesis, or opinion; (b) Data, facts that support the claim; (c) Warrants, explanation of how the data support the claim; (d) Backings, commonly agreed assumptions that help justify warrants; (e) Rebuttals, providing evidence to contradict other opinion that has been presented; and (f) Qualifiers, identifying where there are limitations or restrictions on a claim.

III. Argumentation and Science Education

The importance of argumentation in science education can be demonstrated by a number of ways. Argumentation is central to the philosophy of science. There is a wrong view about science is that; it is primarily an empirical process, where claims to truth are based on observation and where conclusions are seen as unproblematic deductions from those observations. But observations are theory laden (Kuhn, 1962) [11] and, therefore, it is impossible to ground claims for truth in observation alone. Instead, claims are seen to be grounded through processes of argumentation, where the function of argument is to formulate reasonable links between the inventive inferences of scientists and the available evidence.

Also, Science is the product of a community and new scientific assumptions do not become public knowledge until they have been evaluated by various establishments of science. Thus, discoveries are reviewed by peers before being published in journals; assertions put forwarded in published papers are analyzed and appraised by peer; may be experiments are repeated and checked; alternative interpretations are claimed and debated. All these processes can be included as the aspects of argumentation. Thus scientific knowledge is socially constructed and the argumentation plays the central role in the process of the construction.

So learning science should involve the practice of argumentation for the meaningful understanding of the process of science. It is necessary for students to develop their own arguments and appreciate alternative claims. It is not enough for students just to hear explanations from experts; they also need to practice in posing and answering scientific questions. Then only students become active participants in the community of science rather than just passive observers. By the process of argumentation they can gain an insight into the epistemological foundations of science.

But science teaching is paying diminutive consideration to argumentation and dispute. This has given a wrong notion of science as the unproblematic collation of facts about the universe, thereby masking disputes between scientists, whether historical or contemporary. Students are facing many social controversies related to science. But they are failed to take a stand since they do not expertise with epistemology of science. If we want pupils genuinely understand scientific practice and develop the ability to think scientifically through everyday issues, then argumentation will need to be a foremost feature of their education in science.

IV. Argumentation Based Instruction

Kuhn (1993) [12] broadly defined argumentation in science education as the process of proposing, supporting, criticizing, evaluating, and refining conflicting or competing ideas about science related ideas or topics. Discourse is a central point in any argument based strategies. Recent researches indicate that argumentation can be nurtured through collaborative, inquiry-based approaches in science classrooms (e.g., Jimenez-Aleixandre, Pilar, Diaz de Bustamante, & Duschl, 1998 [13]; Kelly, Druker, & Chen, 1998 [14]; Niaz, Aguilera, Maza, & Liendo, 2002 [15]). Also many researchers provided evidence supporting the use of socio-scientific issue based contexts to foster argumentation in elementary, middle, and high school science classrooms (e.g., Mason & Santi, 1994[16]; Mortimer & Machado, 2000 [17]; Patronis &Spiliotopoulou, 1999

[18]). Hence the investigator tried to develop a strategy infusing collaborative inquiry based approach and socio-scientific contexts to promote argumentation.

As an instructional strategy, the investigator develops the following mode of instruction as argumentation based instruction. The strategy is based on Toulmin(1958) [19] work on argumentation. The following steps are suggested:

1. Pausing a question

Teacher introduces a socio-scientific issue related to the topic covered. The introduction may via exhibiting pictures, newspaper articles, YouTube video presentation, other media formats etc

2. Group work

The students separated into groups and start to investigate on the question.

3. Presentation of the group consciences

Each group presents their findings. The presentation should be in the following format:
Claim: The conclusion drawn
Data: Facts that support the claim
Warrant: Explanation of how the data support the claim
Backings: Commonly agreed assumptions that help to justify warrants
Qualifiers: Identifying where there are limitations or restrictions on a claim
Rebuttals: Providing evidence to contradict other opinion that has been presented

4. Open discussion

The class elicits which explanations are more suitable for solution of the question

5. Teacher reiteration of the subject matter

Teacher reviews the discussion processes and focuses students attention on the subject matter

In order to validate effectiveness of the argumentation based instruction, the investigator conducted a quasi-experimental research.

V. Objectives of the Study

The following objectives were formed

1. To compare the mean achievement scores of two groups, Experimental (E) and Control (C), in science of secondary school students to be taught through Argumentation based Instruction and conventional method before experimental treatment.
2. To compare the mean achievement scores of two groups (E and C) in science of secondary school students taught through Argumentation based Instruction and conventional method after experimental treatment.
3. To compare the mean gain achievement scores of two groups (E and C) in science of secondary school students taught through Argumentation based Instruction and conventional method.

VI. Methodology

The present study used a pre test-post test experimental design and the experiment was carried out in nine-week time period. Both groups were equated on the basis of intelligence. Achievement test in Physics was administered to students as both pre test and post test.

6.1 Sample

A sample of 100 students from 9^{th} standard was selected through random sampling technique. The students were divided and formed experimental group and control group.

6.2 Tools used

Following tools were used for the present study

1. Non-verbal intelligence test
2. Achievement test in Science
3. Lesson transcripts based on Argumentation based Instruction

6.3 Procedure for data collection

The experiment was conducted in the three phases as depicted in "Table 1".

Table 1 : Design of the study

Phase	Experimental group	Control group
Pre phase	1. Measurement of Non-verbal Intelligence 2. Measurement of Achievement in Science	1. Measurement of Non-verbal Intelligence 2. Measurement of Achievement in Science
Treatment phase	Teaching Science through Argumentation based Instruction for 9 weeks	Teaching Science through Conventional Method for 9 weeks
Post phase	Measurement of Achievement in Science	Measurement of Achievement in Science

6.4 Statistical techniques used

1. Mean and standard deviation
2. t-test was applied to compare the performance of the two groups

VII. Data Analysis and Interpretation

The present study was conducted to examine effectiveness of Argumentation based Instruction on achievement in science of secondary school students. The objectives of the study were to compare the mean pretest achievement scores, mean post test achievement scores, mean gain achievement scores of experimental and control groups. t-test was applied on the achievement scores and the results are depicted in "Table 2". The mean pretest scores, the mean post test scores and the gain scores are presented graphically in "Fig 1".

Table 2: Mean Intelligence test, pretest, post test and gain scores of Experimental and Control groups

Scores	**Group**	**N**		**Mean**		**S.D.**		**t-value**
Intelligence test scores	**E vs C**	50	50	32.7	32.49	11.56	11.19	0.1142(NS)
Pretest scores	**E vs C**	50	50	8.4	8.6	3.75	3.98	0.258 (NS)
Posttest scores	**E vs C**	50	50	14.5	11.8	4.25	4.19	3.14**
Gain scores	**E vs C**	50	50	4.36	1.7	2.43	1.19	4.17**
NS = Not Significant	**Significant at 0.01 level							

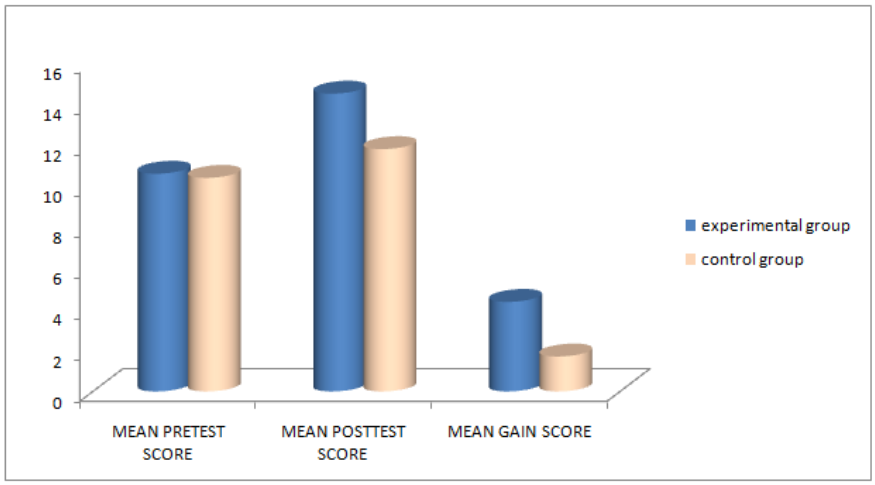

Figure 1: Comparison of Mean Pre test, Post test and Gain Scores of Experimental and Control Groups

t-value (0.1142) shown in the Table -2 for the difference in Intelligence test scores for the two treatment group was found to be not significant. t-value (0.258) vide "Table 2" for the difference in pretest scores of the two treatment groups was found to be not significant. It induces to the conclusion that there is no significant difference in the intelligence test scores and in the mean scores in the pre test of the two groups (E and C). Therefore, experimental group and control group were similar in their intelligence level and performance in science initially.

On perusal of the "Table 2", it is obvious that t-value (3.14) for the difference in mean achievement scores of experimental group and control group in post test is significant at 0.01 level, which exposes that experimental group performed better than control group in post test of achievement in science. Thus the students

subjected to Argumentation based Instruction scored higher than students taught by conventional method of teaching. It can be concluded that Argumentation based Instruction is more effective than conventional method in boosting achievement in Science

It can further be shown from the "Table 2" that t-value (4.17) for the difference in the mean gain achievement scores of students of experimental and control group is significant at 0.01 level. This leads to the conclusion that Argumentation based Instruction is more effective than conventional method in improving the achievement level in Science.

The findings that the students taught through Argumentation based Instruction achieved higher score than those instructed through traditional methods are in tune with Cross, Taasoobshiraz, Hendricks and Daniel (2008) [20], they analysed argumentative structures are crucial in influencing student achievement and learning in science. Osborne, Erduran, and Simon and Monk (2001) [21] provide a body of evidence that the teaching through argumentation can increase students' engagement in science, their ability to perform argument, and their understanding of science. Munford and Zembal-Saul (2002) [22] vividly consolidated the advantages of a focus on argumentation as (a) learners can experience scientific practices that situate knowledge production in original contexts, which provide them with opportunities to learn not only science content, but learning about science, as well as providing an understanding of the role of language, culture, and social interaction in the process of knowledge construction; (b) engagement with argumentative discourse can make learners' understanding and thinking visible and provide a valuable tool for reflection and assessment and (c) argumentation can support learners in developing different ways of thinking.

VIII. Findings of the Study

1. No significant difference was found in the pre test scores of experimental and control group in achievement in science of secondary school students.
2. The post test achievement scores in science of experimental and control group differ significantly in favor of experimental group. This indicates that students who are taught through Argumentation based Instruction show significant improvement in their achievement in science than the students who received instruction through conventional method.
3. The mean gain achievement scores in science of experimental and control group differ significantly in favor of experimental group. This implies that students who are taught through Argumentation based Instruction benefited more in their achievement in science than the students who received instruction through conventional method.

IX. Educational Implications

- Argumentation based Instruction provides teachers with effective ways to deal with diverse students. In the present study, Argumentation based instruction was found more effective than conventional method of teaching with respect to achievement in science.
- Efforts should be made by teachers to create suitable argumentative learning environment for enhancing argumentation skills
- Argumentative based instruction supports social construction of knowledge, revealing students thinking and providing its critical judgment by the teacher, the student and his/her peers.
- For effective transaction of Argumentation based Instruction, teachers should be trained in the skill of effective scientific argumentation.

X. Conclusion

Argumentation based Instruction is an effective technique in teaching science because there was an improvement in the achievement of students. In Argumentation based Instruction, students are given the opportunity to argue on science related issues than merely swallowing the concepts learned. Its sharpen students understanding of science. They can take decision on their societal issues as a science learner. This student centered approach restricts the one-way delivery in traditional classroom and create an atmosphere where students can come with different ideas, debate upon it and take a stand based on clear scientific norms. The change from passive reception to active cooperation and exploration stimulate their interest in science learning. Students can familiarize with the epistemology of science. Teaching of science needs to be concentrated much more than simply familiarize with basic concepts of science; it should educate students about how we know and why we trust it.

XI. Suggestions for Further Research

The present study unlocks certain avenues for further research which are briefly listed below:

- The present study has been carried out only on limited topics of Physics at 9th standard; more studies may be conducted involving larger content area and different subjects at different grade level.
- This study only examined achievement in science. Further studies can be conducted to investigate effectiveness of Argumentation based Instruction for other variables such as attitude towards science, scientific temper, academic motivation, retention, inculcating democratic values etc
- Research needed to study effect of Argumentation based Instruction on exceptional children
- Research needed to be done to study how teachers facilitate argumentation contexts in classrooms
- Research can be done how does gender affect argumentation skills

References

[1] C. T. Fosnot, Constructivism: theory, perspectives, and practice (New York, Teachers College Press, 1996).
[2] L. Vygotsky, Thought and language (Cambridge, MA: MIT Press, 1963).
[3] C. Pontecorvo, Social interaction in the acquisition of knowledge, Educational Psychology Review, 5, 1993, 293–310.
[4] E.F. Mortimer & P.H. Scott, Meaning making in secondary science classrooms. (Buckingham, Open University Press, 2003).
[5] R.H. Driver, J. Asoko, E. Leach, P. Mortimer and P. Scott, Constructing scientific knowledge in the classroom, Educational Researcher, 23, 1994, 5–12.
[6] P.Newton, R. Driver and J. Osborne, The place of argumentation in the pedagogy of school science, International Journal of Science Education, 21, 1999, 553–576.
[7] S. Simon, S. Erduran and J. Osborne, Enhancing the quality of argumentation in school science, Proc. Annual Meeting of the National Association for Research in Science Teaching, New Orleans, LA, 2002.
[8] D, Kuhn, Science as argument: Implications for teaching and learning scientific thinking, Science Education, 77, 1993, 319–337.
[9] D. Kuhn, The skills of argument (Cambridge, Cambridge University Press, 1991).
[10] S. Toulmin, The uses of argument (Cambridge, Cambridge University Press, 1958).
[11] T.S. Kuhn, The structure of scientific revolutions (Chicago, University of Chicago Press, 1962).
[12] D. Kuhn, Science as argument: Implications for teaching and learning scientific thinking, Science Education, 77, 1993, 319–337.
[13] M. P. Jimenez-Aleixandre, M. Pilar, J. Diaz de Bustamante and R.A. Duschl, Scientific culture and school culture: Epistemic and procedural components, Proc. Annual meeting of the National Association for Research in Science Teaching, San Diego, CA, 1998. (ERIC Document Reproduction Service No. ED 418 850)
[14] G. J. Kelly, S. Druker and C. Chen, Students' reasoning about electricity: Combining performance assessments with argumentation analysis. International Journal of Science Education, 20(7), 1998, 849-871.
[15] M. Niaz, D. Aguilera, A. Maza and G. Liendo, G, Arguments, contradictions resistances and conceptual change in students understanding of atomic structure, Science Education, 13(3), 2002, 504-525.
[16] l. Mason and M. Santi, Argumentation structure and metacognition in shared knowledge at school, Proc. Annual meeting of the American Educational Research Association, New Orleans, LA, 1994. (ERIC Document Reproduction Service No. ED 371 041)
[17] E.F. Mortimer and A.H. Machado, Anomalies and conflicts in classroom discourse, Science Education, 27(2), 2000, 429-444.
[18] T. Patronis and V. Spiliotopoulou, V, Students' argumentation in decision making on a socioscientfic issues: Implications for teaching, International Journal of Science Education, 21(7), 1999, 745-754.
[19] S. Toulmin, The uses of argument (Cambridge, Cambridge University Press, 1958).
[20] D. Cross, G. Taasoobshirazib, S. Hendricks and D.T. Hickeya, Argumentation: A strategy for improving achievement and revealing scientific identities, International Journal of Science Education, 30(6), 2008, 837–861
[21] J. Osborne, S. Erduran, S. Simon and M. Monk, Enhancing the quality of argumentation in school science, School Science Review, 82, 2001, 63–70.
[22] D. Munford and C. Zembal-Saul, Learning science through argumentation: Prospective teacher's experiences in an innovative science course, Proc. Annual meeting of the National Association for Research in Science Teaching, New Orleans, LA, 2002. (ERIC Document Reproduction Service No. ED 465 520)