



## SCIENTIFIC ARGUMENTATION AND COOPERATIVE LEARNING: WHY SHOULD THEY BE COMBINED?

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### AUTHORS' CONTRIBUTIONS

This work was carried out in collaboration between both authors. Author AD designed the study, performed the analysis, wrote the protocol and wrote the first draft of the manuscript. Author LT managed the editing of the study, the literature searches. Both authors read and approved the final manuscript.

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### ABSTRACT

Cooperative learning and scientific argumentation are two contemporary topics in educational literature. The claim made in this paper is that the two concepts support and fulfill each other. Cooperative learning takes place when students work in groups and share information based on alternative ways of thinking. Too often, however, the group discussion does not stimulate alternative views, and students too quickly fall into a common and narrow way of thinking, because of leading group dominance, and the guarding of given material (text book) influence. This is still cooperative learning, but of less value. The most valuable learning happens when students put forward multiple views based on their different background and personal theories, in addition to; the given materials and this enhances students challenge each other in real debates. In this way of learning, students act similar to scientists, historians, mathematicians and other academics, because all academic debates are based on argument about contrasting views. Debate about contrasting views, however, is also the fundamental idea in teaching based on scientific argumentation. The basis for the claim of the paper, accordingly, is that scientific argumentation, as a means (pedagogy), can be used to stimulate meaningful cooperative learning by encouraging contrasts and variation in students' thinking. And the other way, that cooperative learning is a useful perspective that can help and guide teachers who want to use scientific argumentation in the teaching. The aim of the paper is therefore to combine the two concepts in a common rationale for science teaching using analytical review. The paper was first analyse cooperative learning and scientific argumentation in more details separately, and from these analyses conclude with similarities and differences in pedagogically and in nature of science to underlying rationales. Next, the paper was merging the two perspectives into a common rationale to guide science teaching.

**Keywords:** Alternative thinking; cooperative learning; pedagogy; scientific argumentation.

### 1. INTRODUCTION

Collaborative argumentation is a technique for arriving at an agreed-upon position among members of a group [1]. While in debate, students learn how to prevail over an opponent, which is emphasized in

certain domains, such as law. In contrast, collaborative argumentation is emphasized in the scientific domain and is practiced when scientists build on and refute one another's theories and empirical research to arrive at scientific conclusions.

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In the educational literature [2] find out the following different kinds of cooperative learning technique, the most common once are: learning together (LT), jigsaw grouping, teams-games-tournaments (TGT), group investigation (GI), student teams' achievement division (STAD), and team accelerated instruction (TAI). Dialogical teaching is also a type of cooperative learning technique, which let (a group) students dialogue with each other, with the teaching materials, and teacher [1]. All these techniques of cooperative learning types are striving to achieve a common goal, by mostly depend on given materials(especially text book), which is to have group members understand a given problem in the same manner or ways of thinking. These techniques also aim to have all students may have the same pattern of knowledge construction from evidence to claim in the same way or try to confirm the given theory(claim) with the given teaching material.

Therefore, learning may take place within the group, mostly based on the given teaching materials and led by the dominant group, thus cooperative learning techniques have limitations in stimulating critique and debates about contrasting views. Because of this could say it, they all are a linear way of learning. Even the teaching approach has limitations, it has also merits in students' social and self-behaviors' that research has proven such as: students exhibit better social skills and higher self-esteem, as well as more positive attitudes about their educational experience and higher cognitive and affective outcomes [2]. It is also effective in knowledge acquisition, retention, accuracy, creativity in problem solving, and higher-level reasoning [3]. In cooperative learning the above mentioned impacts are exhibited because students may have an opportunity to generate, compute ,and evaluate/critique alternatives, but their ideas are dominated by common goal(given material) and this let them to focus to confirm with the same given theory or problems rather than select/ construct better idea. These are because of the approach has not meaningfully providing any particular structure to make student discourse. The main cause to this bias is not using manageable structural model that incorporates scientific practices such as: generate, compute, assess, critique...etc. about alternatives and to construct claim.

Scientific argumentation, in contrast, is a concept that highlights exactly critique and contrasting views. The concepts stem from science philosophy [4] as a description of how science works. Scientists, when developing new knowledge, review alternatives, debate, assess, evaluate, and finally select or construct better claims about the natural world. These practices in science, argumentation as pedagogy [5] are made

into both means and aims of science teaching. Because of this, the method of teaching merge with scientific argumentation is multi-dimensional, because it incorporates all the practices in philosophy of science and in education).The main contention of this article is therefore that cooperative learning ought to be merged with scientific argumentation for better learning of students. And cooperative learning has used the same platform with scientific argumentation when we use it as a means. And when we use it as an aims it better develops students' scientific reasoning ability/skill, because the practices in scientific argumentation better facilitate and magnify the impact in the three educational domains than only cooperative learning.

Scientific argumentation is a social discursive practice which is used in the construction of scientific knowledge. It is a practice of assessing alternatives, weighing evidence, interpreting texts, and evaluating the potential viability of scientific claims [6]. Thus, the characteristics of scientific argumentation are: it considers theories as open to challenge, and that progress is made through dispute, conflict, and paradigm change, thus it used as both aims and means in educational practice [7]. Furthermore, it considers knowledge and the human nature as dynamic, and claims that there is no absolute universal method to confirm theory. Also, it considers the appropriateness of interpretation of evidence in the light of alternative theories [7]. From a social perspective, argument is a means of socializing the norms and to develop a deeper understanding of function and values the scientific society. When a person to be in a member of a certain social group, there should argumentation takes place to accept or reject or improve the functions/values of the given society, because knowledge is socially constructed and requiring discursive practices. When this type of practice in a form of argumentation is invented in science, it is a central feature of the resolution of scientific controversies [8], because the practice of argument has the ability to critically examine the scientific claims generated by the plethora of socio-scientific issues in everyday lives [9].

In addition to the mentioned issues, it encourages construction of knowledge takes place by the society (students). How and by what means can this take place? There are many ways that a given scientific society can interact and develop scientific knowledge, such as: through journals, conferences, classroom discourse/dialogue and the wider media...etc. National Council of Teachers Mathematics [10]. As Van Eemeren FH [11] explains scientific argumentation as "Argumentation is a social, intellectual, verbal activity serving to justify or refute

an opinion, consisting of statements directed towards obtaining the approbation of an audience". It is also a creative process by which thoughts are built into an abstract structure linking premises with conclusions and that leads to the shift in position. To this Binkley RW [12] describe the process of arguing as "constructing a reckoning. Thus, scientific argumentation is both a means and aims which may let students(society) struggle in common by use of (not using single / linear way) but different lens (multi-dimensional/ alternatives ways) to find out relationship among variables which better explain/represent the natural phenomenon ,because the practice in it are both means and aims.

This approach encourages knowledge construction to taken place by individuals/society, and encourages active participation in generation, and selection of better alternative to represent the phenomenon. This is because the approach believes on that "knowledge construction is a social process and that involves conjecture, rhetoric, and argument", [8]. And the knowledge construction is better, because it is socially constructed, to this Longino [13] said that "Influence exerted by public critique and peer review on ideas results in public accepted scientific claim being more effective in explaining nature than any individual could produce it alone". Argumentation incorporates observation (evidence) and its qualifiers, warranties, backings, rebuttals, and alternatives in different perspective/lenses by the group members (society). This practice in argumentation is known as "inter textuality". According to Posner GJ et al. [14] inter textuality is the connection of within and across class room resources for learning science". The term "text", refers to the written materials/documents in a form of letters, voice or pictures. As Vareals and Pappas, Posner GJ et al. [14] text is written documents (fiction, nonfiction books, writings on blackboard in class room posters, books from home or elsewhere, drawings...etc.) shared oral texts (songs, poems, rhymes, media events),current and prior class room discourses, recount events, and hands-on data explorations (inside or outside class room)".

Text is not just language that is written or spoken, but it can also include the wide Variety of social practices (gestures, physical models, and attitudes [13]. These are the rational practices of arguments in support or dispute of knowledge claims to relatively construct better understanding, rather than depend on single absolute /objective reality or observation to claim (linear) way of knowledge construction. Mainly argumentative practices are scrutiny and critic by the wider community of scientists, thus they ought to be practiced in classrooms by students and teacher, in the way that, experiments are repeated, checked, and

alternative interpretations are put forward (multi-dimensional). If this version approach supports cooperative learning in class room, better and meaningful learning may take place.

The reason is that, in the scientific argumentation student may practice is inter-contextuality, which is the linkages among events in the past, present, and future" [14]. This is because science advances when previous investigation is provided as justification for current investigations. Thus teaching argumentation through appropriate activates and pedagogical strategies is a means to promoting students epistemic, cognitive ,and social goals as well as enhancing conceptual understanding of science [15]. To this cooperative learning method is the one that fulfils and supports this approach, and which has the same philosophical platform with it. As well it will create conducive environment to implement scientific argumentation in class room. So far the researcher identify the uses of scientific argumentation and cooperative learning to teach science fields but not shows advantage of combing the two. Hence, addressing these research gaps, attempts were made in this review. The aim of the paper was therefore to combine the two concepts in a common rationale for science teaching using analytical review.

## **2. COMPARING COOPERATIVE LEARNING AND SCIENTIFIC ARGUMENTATION**

The following table is the summary of similarities and differences between cooperative learning and scientific argumentation/reasoning in pedagogical and in nature of science views as well as issues, and may reflects how, and why merging the two is necessary for educational purpose.

## **3. MERGING SCIENTIFIC ARGUMENTATION AND COOPERATIVE LEARNING. WHY MERGING IS NECESSARY AND HOW?**

One of the main objectives of education is to build a new generation with scientifically literate, high level thinkers, and practitioners, but in past and current situations, students are leaving the school with limited /low level knowledge [16]. This method of teaching may give little explicit attention to fundamental aspects of education in general and science education specially. Thus, there is a need of improvement in scientific practice in assessment and method of teaching knowledge (pedagogy) rather than only focused on the what (products of science and rhetoric

form of teaching) in science education. Because, students should be engaged in the practices of historians, mathematicians, scientists, artists etc., rather than just learning the products of the activities. To do these, countries using cooperative as active learning method are in the way of development/progress, but needs an additional improvement in practice of science education and pedagogy.

Engle RA et al. [17] tested the impact of dialogical teaching in scientific argumentation skill development amongst other things, an improvement in the quality and sophistication of arguments and the development of new ideas and disciplinary understandings are the main impacts of dialogical argumentation. So, by this merging it may be possible to positively affect students' cognitive, affective and psychomotor

domains meaningfully. Because, in addition to; the listed behavioural outcome of cooperative learning, the scientific argumentation equip students with the capability to generate alternatives, debate, assess, evaluate, and finally select or construct better claim about the given problem. The strongest side of scientific reasoning / argumentation over that of pure cooperative learning is that it uses structural model to managing the practices such as: generating, computing and evaluating theories, reporting both orally and in written form. With this it is easy to evaluate students' progress and to feedback easily based on their misconceptions, and develops outcome space in item development in modern theory of item development. This is the point why scientific argumentation is necessary and can be combined with cooperative learning to strengthen/support or fulfil/

**Table 1. Comparison of scientific argumentation and cooperative learning**

Scientific argumentation	Cooperative/collaborative learning
<b>Pedagogically</b>	
<ul style="list-style-type: none"> <li>✚ Different perspectives are being examined and the agreement is made on acceptable/ better/ claims or courses of action</li> <li>✚ It takes place within an individual or within a social group</li> <li>✚ All students in the group has a duty to do (job distribution is mandatory)</li> <li>✚ Uses structured model of assessment format to follow up the progress which includes (evidence, qualifiers, warranties, backings, rebuttals, and claims)</li> <li>✚ Doing not to achieve specific objective only ,rather to better construction of knowledge and forward</li> <li>✚ Better /quality idea is dominant (winner),because it uses model to evidence→claim</li> </ul>	<ul style="list-style-type: none"> <li>✚ Mostly the same perspectives are being examined around the given problem and the agreement is made based on the dominant group</li> <li>✚ It takes place within a social group</li> <li>✚ May not all students in the group has a duty to do, leaders may do every thing</li> <li>✚ Not uses structured way of assessment format to follow up the progress</li> <li>✚ Works to solve the problem of today(work to achieve specific objective)</li> <li>✚ Active students are dominant and leads the group</li> <li>✚ Dominant/leaders group idea is dominant(winner)</li> </ul>
<b>In nature of science</b>	
<ul style="list-style-type: none"> <li>✚ Observations are value-laden, therefore, it is not possible to ground claims for truth in observation alone, thus alternatives have to be assessed</li> <li>✚ It is the process of constructing an alternative positions or competing theories</li> <li>✚ It considers the dynamic nature of humanand knowledge a is socially constructed in alternative ways</li> <li>✚ It considers one's beliefs, other individuals' beliefs, and the problem solving task/phenomena / at hand                             <ul style="list-style-type: none"> <li>○ in both supportive and in opposing way, but batter idea is selected based on the model</li> </ul> </li> <li>✚ It is the process of reconstruction and challenging of the given theory for better representation of the phenomenon</li> </ul>	<ul style="list-style-type: none"> <li>✚ Observations are value-free, therefore, it is possible to ground claims for truth in observation alone (by depending on the given materials/text books---etc. only)</li> <li>✚ It is the process of bringing supportive theories/ warrants to the theory/ observation to persuade one another</li> <li>✚ It considers the dynamic nature of human knowledge and knowledge is socially constructed with supporting given evidence</li> <li>✚ It considers one's beliefs, other individuals' beliefs, and the problem solving task/phenomena / at hand in supportive way</li> <li>✚ It is mostly process of confirming ideas with the given theory, I .e used evidence to claim , mostly alternatives are not assessed, evaluated and the group works to meet/attain one thing/objective</li> </ul>

the cooperative learning. The other drawback thing in view of cooperative learning is that: common goal is achieved by bringing evidence to claim for a certain event is the dominant, because the leading group idea dominance with no looking after qualifiers, warrants, backings, rebuttals / alternative in computing theories and critique in each of the components, because of low participation of lower achievers and material influence. But in scientific argumentation debate takes place on the alternatives to decide which better explain the phenomena in structural and organized way; due to these may the group not simply float together (not think in the same way easily), because of the challenge of bringing/generating alternatives and evaluating/critique the alternatives and increase the engagement of group members.

This is because structured format support group members to participate/ engage in the debate, and reflect their position. Thus, relative to cooperative learning only, in combination with scientific argumentation it let students in group to engage in different scientific practices. Learning is nothing, it is the struggle of students with the problem at hand, develop and come up with their alternative to solve the given problem. This is happened/ achieved when; alternatives are assessed and evaluated before students float together. Another thing that, the two support each other is that: cooperative learning is a well set initial condition for scientific argumentation by creating society (students with different cultural or achievement difference). When cooperative learning/working is supported by scientific argumentation/reasoning meaning full and better knowledge construction takes place, because a group of societies (students) will come together to work/dialogue with their different lenses or backgrounds.

Thus, from cooperative learning what we strongly share is the group spirit or the society with different alternatives due to differences in culture, achievement/performance , sex , economy etc., and from the scientific argumentation what strongly we share are valuing the scientific practices of each group members such as: generating, computing ,evaluating alternatives , dialogue/debate ,and critique to decide better rational idea. Thus, positive outcomes of cooperative learning in cognitive domains are mainly the impact of argumentation even it is not scientific (structured or used manageable form), because of conflict of ideas, conceptual change, assessment and evaluation of alternatives are the practices conducted in argumentation. In addition to these, their merging may diversify the learning styles (means), and allow students for critical thinking skills to better scientific reasoning as aims.

According to Slavin RE [18] Students will not only learn through experience and reflection but will also learn from one another because in their discussions of the content, cognitive conflicts will arise and adequate reasoning will be exposed and leading to high quality understanding of concepts. Thus the two approaches to instruction will be treated as teaching arrangements in combination (pedagogy), and inherently integrate deep approach to learning as constructivism. So, to merge the two, using the above comparison table both in pedagogically and in nature of science by taking the strength points from the two is one alternative.

The selection may depends on the background information of the evaluator/ practitioner, but my alternative to merge the two is by taking the whole points under scientific argumentation, but when we use scientific argumentation as a means use it in dialogically (in cooperative/ discursive) way and philosophically (as aim) in implicit way by using (Toulmin,1958). So ,what improvement has been made in cooperative learning due to merging it with scientific argumentation as a means is that, start from the same initial point ( observation or problem, given teaching materials), follow most probably the same path (linear way) by lead of the dominant group and reached to the same final goal (dominant group idea) consensus or the same orientation of knowledge construction to start from the same initial point but follow different path (views or alternatives etc.) and reached to the final better idea (claim) orientation of knowledge construction.

In cooperative learning the group members (dominant group interference) has a factor to accept or reject the claim, but in scientific argumentation the quality of idea has a factor. In scientific argumentation formats are being used to assess the quality of claim and progress of participants (students) but cooperative learning has not.

#### **4. CONCLUSION AND ITS EDUCATIONAL IMPLICATIONS**

The socio-cultural view of learning suggests that knowledge is socially constructed. The owner of the knowledge is the society (student), because it is constructed by a given society via different social activities. To these currently developing approach to enhance these activities is scientific argumentation/ reasoning with it with cooperative learning to facilitate and increase the interaction of societies (students) with each other, teacher, the teaching material, and with the problem (social, cultural, political, economical, technological--etc) at hand. The knowledge is constructed via this approach is due

to active participation /engagement of society or students. In comparison of the two concepts we have seen that there is strong relationship between cooperative learning methods and scientific argumentation both pedagogically and in nature of science (philosophically) because they support and fulfil each other to better construction of knowledge.

The merging of the two incorporates observations, account different social norms/values , and discourses are made to construction of knowledge .The educational values earned under this merged approach are: students use their own lenses to construct knowledge ,generate ,compare ,critique ,debate on theories ;therefore, claim is not only based on the dominant groups and the provided textbook only rather based on the quality idea by use of models which incorporates observation/evidence, qualifiers, warrants, backings, and rebuttals which are generated from students. With the support of scientific argumentation/reasoning to cooperative learning it is even possible to shift the trend of knowledge construction from follow the same path (linear) by lead of the dominant group and reached to the same final goal (dominant group idea) to start from the same initial point but follow different path (multidimensional views or alternatives etc..) and reached to the final better idea (claim).

On the basis of the findings and conclusion drawn with respect to the blending of the two approaches the followings are the expected outcomes:

- ❖ **Learning takes its products from history and/ experience:** because practices have history, and that it was built on the memories and products of past society, and these provide resource/back ground/ starting point for the future. This practice in scientific argumentation is known as “inter-contextuality” which means the linkages among events in the past, present, and future.
- ❖ **Debate (dialogue) dominates the classroom:** In this approach, not the number of supporter of idea matters rather the better idea matters. And students dialog with each other, with the data, and with their peers about the observations, warrants, backings, rebuttals, and claims before develop socially accepted claim.
- ❖ **Students do collaborative work:** students’ achievement, motivation, attitudes towards science and scientific issues will increase positively. Because students in the combined approach are encouraged to role distributions for all students in a group, thus the dominant group impact will be minimized and be balanced.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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