Argumentation about data: learners' ability to think critically

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This paper reports on research that was undertaken with Grade 10 learners at 5 schools in the Western Cape. It provides baseline data of their spontaneous, i.e. untutored, ability to engage in argumentation, one of the key-areas of critical thinking. The learners are expected to provide written responses to experimental data. They are also expected to justify their choices. Their responses are categorized and analysed. Inspection of the data shows a variety of levels of argumentation between individuals. The limitations of the study are discussed and tentative factors are explored such as experience in practical work and the ability to articulate ideas, which may have some bearing on the ability of learners to engage in an argument.

Introduction

When a new curriculum is introduced in Grades 10-12 in South African schools, considerable emphasis will be laid on developing learners' abilities as critical and creative thinkers. If teaching is purported to be constructivist, in the sense of building on learners' existing ideas (Driver *et al.* 1994), it is crucial to document the ways learners cope with situations where critical thinking is required. The South African Department of Education (DoE 2004), like many other curriculum developing agencies, recognizes that a school science curriculum involves 'critical inquiry, reflection, and the understanding of [science] concepts and processes, and their application in society' (p46). Kuhn (1993) reckons that the ability of critical inquiry forms the basis of scientific knowledge, and especially building up new scientific knowledge using evidence. Dealing with evidence in a critical way should therefore be central in the teaching of school science. One major area of critical thinking is considered to be the ability to formulate an argument, using evidence to support the argument and, even stronger, to dislodge any counter argument. Toulmin (1958) developed a typology of arguments in normal discourse and suggested a progression for the different types of arguments, and Walton (1996) suggested a classification of arguments in scientific reasoning. More recently research has been reported on the teaching of argumentation (Newton *et al.* 1999) as part of supporting understanding in the major area of *ideas about evidence* (Osborne *et al.* 2004). The same authors developed and tested sets of pre-written lessons materials fostering argumentation for the national curriculum in England together with professional development materials for training of teachers.

However, little research has been done on the argumentation abilities of learners in African contexts. There is a likelihood that cultural perspectives, especially with regard to the perceived prominence of the role of an external authority and the aspiration towards consensus (Tabulawa 1997), may influence the conventions of argumentation in science classrooms in Africa. Thus, this study addresses the following research questions:

a. What is the untutored ability in argumentation of students of grade 10?
b. To what extent do grade 10 students develop their ability in argumentation in group discussions without a teaching intervention?
c. What factors seem to hinder or encourage the ability in argumentation in these circumstances?

Description of research

The sample consisted of 266 (10–15 friendship groups) Grade 10 learners. These groups were drawn from classes in 5 schools across the Cape Town metropolitan area. Teachers from these schools volunteered participation and were identified for reasons of convenience, such as having been involved in previous curriculum projects.

We decided to collect written rather than oral data, as these are less dependent on contributions of peers' in-group interactions. The critical thinking task consists of two sets of data for repeated measurements of the distance a ball will roll off a slope, each with their (slightly different) average values. The readability of the task had been tested as part of the suite used by Buffler *et al.* (2001). First, individual group members are asked to write down if they feel the two sets of data are similar or not, and to support their view. These written responses are shared and form the basis for a group discussion. Afterwards each individual group member again writes his or her view with justification. The instrument was refined and validated through an initial pilot with students of similar backgrounds. The pilot responses were used to draft a coding scheme using levels of sophistication of argumentation developed from those suggested by Osborne *et al.* (2004). These levels are defined as follows:

- Level 1: a single claim versus a (counter) claim
- Level 2: claims with either data, warrants or backings, but no rebuttals
- Level 3: a series of claims or counterclaims with either data, warrants or backings with a weak rebuttal
- Level 4: a claim with a clearly identified rebuttal. An argument with several claims and counter claims.
- Level 5: an extended argument with claims supported by data and warrants with more than one rebuttal.

Frequencies of initial levels of argumentation are used to survey the spontaneous ability of argumentation, whereas frequencies and the nature of changes in levels of argumentation indicate students' ability to incorporate evidence to strengthen an argument. In cases where obvious, but tacit claims are made these have been inferred. For instance, several respondents noted the differences in the averages of the experimental results derived by the two groups in the task, but their response focused on suggesting how to decide whose result was correct. Such responses have been coded as making the tacit claim that the results of both groups did not agree. Where one summary statement was provided for the post-discussion views of a whole group, these views were attributed to each member in the group.

Results and discussion

Preliminary, non-systematic, inspection of the data showed a variety of levels of argumentation between individuals, although the lowest levels (making a claim without any tangible evidence) rarely occurs. Generally, changes in the level of argumentation after the group discussion fall in two types. The first type shows no change in the argument, with a focus on speculation of why the differences of the mean have occurred. The second type shows an improvement in the level of argumentation, but rarely by only adopting a more sophisticated argument of a peer. Most often, the more sophisticated argument incorporates elements of the individual's initial argument. As a result the final argumentation is not always entirely common across a group. The change in the level of argumentation seems to depend on the diversity of the initial claims within the group. The further the initial claims are apart, the more the improvement in the level of argumentation.

Students' use of levels of argumentation

Table 1 provides a summary of the untutored ability in argumentation of Grade 10 students.

Table 1. Frequencies of spontaneous levels of argumentation of Grade 10 students.

Levels of argumentation	**Total (n=266)**
Level 1	77 (29%)
Level 2	148 (56%)
Level 3	2 (1%)
Level 4	3 (1%)
Level 5	-
Unclassifiable	36 (14%)

The data in the last column of Table 1 show that more than half of the students (56%) provide an argument at Level 2, whereas almost one in three students (29%) make a claim with no supporting evidence, typical of Level 1. A very small proportion of students spontaneously provide rebuttals, characteristic of the higher levels.

Levels of argumentation

The following paragraphs illustrate the learners' argumentation ability by presenting quotations of arguments representative of the different levels 1-4. Since the quotes illustrate the argumentation structure, they are drawn from across the choices A-C, i.e. the claims, made by the students. Each quote is presented *verbatim* and followed by a student identification with the first number indicating the school, the second the group, and the subsequent letter identifying the group member

Level 1 argumentation

Level 1 argumentation emerged in two main ways. Firstly, this level was allocated when students repeated one of the claims they were invited to select without much supporting amplification. Typical examples are as follows:

> I choose B, because A is not the same with B, and B it is the correct answer. (4/12B)
>
> I think is group C because they are not agree with any of this average. They just have another view which they will explain. (3/24B)
>
> We choose C because there will be no solution if these two groups are not agree. That is why I choose C, because C has another views to explain these two groups to be combine. (4/17B)

Secondly, a much larger cluster of students focused on identifying the correct average. This concern had its origin in the claim that the averages provided did not agree or were not the same. Several students stated this claim explicitly before suggesting ways of identifying the 'correct' average. Typical arguments are the first two quotes provided below. In addition, several arguments used an implicit claim that the averages for Groups A and B did not agree as a reason for the need to determine the 'correct' average, as illustrated by the subsequent quotes below.

> I choose Group C because for students in Group A and in Group B the measurements for distance are not the same, which means we don't know who is right and who is wrong. Group C students will provide another view, and maybe C measurements will be similar to another group wheather it is A or B. (3/24C).
>
> I choose B because the result are not the same, in the diagram. So I calculate my own way which disprove the diagram answers. (3/08A)

> The reason why I have chosen the calculation of Group A: if you calculate all answers and divide it by 5 you get 433.02. The difference here is only 2, but they left that out, the 2. So I agree with A. (5/05A)

> I choose B because I agree its average. We've calculate again (4/15A)

> My choice is B, because all the readings in B are more closely matched than in Group A. They vary too much in Group A. (2/07A).

Level 2 argumentation

A large number of students provided a claim simply based on the data provided. The following responses are typical.

> I agree with A. If you look at the average of the distance in Group A, it does not differ that much from Group B, so that's why I say their results agree. (5/03C)

> I choose B: No, our results don't agree, because the results of column A is low than B, because A is 433.0 and B 434.8. That's why I choose B. The results of A and B is not equal. (3/07A)

> No the results are not the same because the average are not the same and the distance mm are not exactly the same. From release number 1 to release number 4 are not agreed each of them. (4/03C)

A number of other students based their claim on a warrant, often expressed as a theoretical statement that the results *should* or *should not* agree. This is often accompanied by an explanatory backing.

> I think the results agree, because you will seldom get the same results each time you repeat an experiment. The ball could roll in a (slightly) different direction at a different speed and end up landing in various places. There could be quite a variety in distances although they are more-or-less in the same region of distance (2/01A)

> I chose C because the differences between the averages are because of the new theory that mathematicians have found, called the "chaos theory", which means that although the height h is the same, the ball released could be at a different speed. It could hit an irregularity in the wood, which would affect where it lands. (2/05D)

Several students use an argument with a claim, no explicit warrant but with backings similarly focussing on the procedures of experimentation.

> I think the results agree. There are different factors that can affect the distance of the ball when it lands, such as wind etc. (2/12A)

> The results do not agree, because the landing of the ball depends on the way you put the ball on the height. If you put it, in the same time pushing, it will land far, but if you just let it will land close. (3/20B)

> I agree with A. When the first group releases the ball it will land on distance d and because of the special paper the ball will leave a dent or mark. So when the other groups release the ball it might land near the spot where the previous group's ball landed (2 or 3 mm away) but because of the mark the previous ball left, the ball will slightly roll into the dent of the previous group's ball. (1/02D)

Level 3 and Level 4 argumentation

Arguments at Level 3 include a hint of a rebuttal. Often this mode emerged from students selecting option C which was then justified by reasons why they did not opt for A or B as illustrated in the quote below. Note the qualifier towards the end.

> I think it is C. If we look at the averages they seem fairly equal but what makes up those averages? Distance d in mm at each release makes up the average but are we accurate at each release? Each time the ball hits the ground there must be change in the pressure that is inside (air) which means that the test is not fair, as probably with the change of the ball's pressure there will be a change in weight influencing how far it will go. This theory might be true if we are dealing with an air inflated ball. (1/01A)

Arguments at Level 4 contain a clearly identified rebuttal. The quote below includes a claim (B), followed by a warrant and qualifier, then a rebuttal, possibly even two, with reference to the data, closing with a second warrant.

> I agree with B because the distance will always be different, although it wont differ by a great amount. The average is almost the same but it wont be exactly the same. You may get a drop distance similar, such as Group A's drop 1 and Group B's drop 2. And the measurement would be slightly out which would also affect it. (2/09A)

Possible factors affecting argumentation

The different quotations illustrate the point that some students struggle to express sometimes quite sophisticated ideas in written English. The mastery of some topic-specific terminology is also crucial. Only in one school, students use (or over-use) the term 'fair testing'. The verb 'to calculate' is used by many students for any manipulation with numbers: adding, dividing, but even recording experimental readings. The suggestion to 're-calculate' then means 'to collect a new set of measurements'. Terms like *accurate* or *precise* measurements are rarely used, and if so, they have a very general meaning as in *good* or *acceptable* measurements.

Another factor affecting the level of argumentation on interpreting experimental data is the exposure to practical work. The reference of balls all rolling into a hollow may well be based on experience with a standard school investigation exploring the impressions balls make in sand when dropped from different heights. Several students said they resolved the argument by *doing* the task and based their argument on their own findings. Other students showed no understanding of the function of a diagram and made attempts to measure the distance d on the task sheet and based their argument on comparing this with the reported numerical readings.

Change in the use of argumentation levels after discussion

Students discussed their viewpoint within their groups, and recorded their claim with its justification after this discussion. They were also asked to explain why they did not support the alternative claims. Table 2 summarises for each student the level of argumentation before and after the discussion. The 16 students (i.e. 4 groups) who did not write a post-discussion response have been included in the category of unclassifiables.

Comparing the data in the summary column and row, Table 2 shows that for the total sample the use of Levels 3 and 4 has increased after the group discussion from 2% to 15% of the students in the sample. The proportion of unclassifiables has also risen due to the 16 non-responses.

Table 2. Changes in the use of levels of argumentation after group discussions.

		Pre-discussion levels of argumentation					
		Level 1	**Level 2**	**Level 3**	**Level 4**	**Unclassifiable**	**Total**
Post-discussion levels of argumentation	**Level 1**	**46**	7	-	-	6	59 (22%)
	Level 2	16	**88**	1	1	8	114 (43%)
	Level 3	3	15	**-**	-	2	20 (8%)
	Level 4	4	11	1	**2**	-	18 (7%)
	Unclassi-fiables	8	27	-	-	20	55 (21%)
	Total	77 (29%)	148 (56%)	2 (1%)	3 (1%)	36 (14%)	266 (100%)

If we disregard the unclassifiable responses, a total of 195 students provided codeable pre- and post-discussion responses. The shaded diagonal indicates those students who used the same level of argumentation before and after the discussion. The area above the diagonal includes the students who decreased their level of argumentation, i.e. 9 students. The area below the diagonal includes those that increased their level of argumentation after the group discussion, i.e. a total of 50 students. In summary 70% of students (136/195) continue using the same level of argumentation, 26% of students improve (50/195) and 5% regress (9/195).

Issues affecting improvement of ability of argumentation

The perceived purpose of the group discussion affects the level of argumentation. For instance, ten groups saw the purpose as reaching an agreement on choice A, B or C, so they reported only post-discussion claims, but no warrants, data, backings and rebuttals. Several of the group members formulated this as ‘I was right!’ or ‘X was right as usual’. Seven other groups considered the discussion to lead to a selection of one of the proposed arguments, thus adopting (and copying) the argument verbatim. A majority if groups (41), particularly in the less-resourced schools, formulated one common agreed group argument, occasionally copied by all group members.

The improvement of the levels of argumentation to include larger numbers at Level 3 and Level 4 required students to include rebuttals. These rebuttals were generally not included in the formulation of the main argument. They emerged when students were asked for their reasons for not choosing the alternative claims. However, most of the responses to this question were bland, along the lines of ‘the reason why we have not chosen X is because we don’t agree with it’.

Conclusion

The study was limited in terms of the narrow scope of the ability of argumentation tested only by asking students to consider experimental data. For many of these learners this seemed to be a novel experience. There was a tendency to be concerned about the correct answer rather than trying to justify the reasons for their own choices. Language abilities and experience in practical work also seemed to influence the level of argument. However, it provides useful information that could inform appropriate teaching strategies to support the improvement in argumentation in learners.

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