Discourse in the classroom and its place in learning

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This workshop presents a number of activities to encourage the use of language and discussion as an aid to learning.

What do I mean by discourse? By discourse I mean the communication in the classroom between learners where they are using their own language to explain their ideas and discuss their knowledge. This paper explores a number of activities which encouraged discussion between students in their own words, allowing them to ask each other questions and requiring their participation, while at the same time encouraging them to take control of their own learning.

Truth debates

The purpose of this task is for students to question and discuss mathematical ideas, explaining their reasoning. The task can be used for any idea. It starts with a mathematical statement about which students must make a decision on veracity and be able to explain their reasoning. It involves group discussion.

The idea of this activity is to have the students discussing and arguing in groups to clarify their ideas about whatever aspect of mathematics is put forward. It encourages them to ask questions of their own knowledge but also to try to justify their beliefs about certain aspects of mathematical knowledge.

Begin by displaying the instructions as shown in figure 1. Explain the process where for each statement the student must decide on its truth. Allow about five minutes for the individual students to clarify their own ideas. The groups are then formed and the students share their ideas in the groups being aware that they are trying to reach agreement and that by the end every member of the group needs to be able to justify the group's position. This explanation/justification is a really important part of the activity, and while the groups try to reach consensus within they also must try to find ways of explaining their viewpoints which would convince others. Depending on the particular statements it may take the groups 15 minutes, or more, to reach consensus.

For each of the statements below decide whether it is

- Always true
- Sometimes true – and specify conditions when it is true
- Never true

Figure 1. Instructions for truth debates.

There are a number of statements given here which could be used but in a class it is better to focus on one or two statements at a time and to create new statements to meet the mathematical purpose at hand.

Once the groups seem to have reached consensus within call the attention of the whole class and ask each student to commit themselves on the truth of the first statement by using the following:

- If you think Statement … is always true fold your arms *(I model this to illustrate).*
- If you think it is only true sometimes clasp your hands in front of you *(again I model this).*
- If you think it is never true place your hands flat on the table.

Sometimes someone asks what to do if you do not think. The answer is to place your hands on your head and massage your brain to help it along. This is usually a joke between us.

Now chair the debate asking someone to justify their position, preferably choosing that person by name, noting their opinion on the statement's truth from the position of their hands and asking them to explain their position. I explain to the class that at any stage of this debate any people may change the position of their hands, but that they may be asked to explain why they changed their mind. I explain to the students that the important thing here is not whether one was right or wrong at the start but whether everyone understands and can explain why at the end of the debate. Making mistakes is part of the learning process and it is the learning that is important. The debate continues until the group is happy with the answer to the statement.

The statements that are used can come from a variety of sources. I often hear students say things in class that are only partly correct, or are incorrect, and I note those statements and give them back to the class on another day to debate. The statements should highlight an aspect of mathematics that is often misunderstood, link directly to the development of the concepts that the class is currently studying, or be used as revision of previously studied topics. Some of the statements I have used are shown in Figure 2.

Statements 1, 3, and 4 are sometimes true, but there are also questions of interpretation of the statements. Statement 2, for example, is taken by some to be true for multiplying whole numbers by ten, but others who are stricter with the meaning of words would say that adding a zero to 23 means 23 + 0 which is 23. This difference in interpretation is pa rt of the discussion that needs to be held in a classroom.

Considering the geometry statements leads to some interesting geometric ideas. Statements 5 and 6 deal with tessellations. In order for a shape to tessellate a number of the shapes need to be able to be arranged around a point so the angles around the point will need to add to 360^{o}. As well as this the sides that are touching will need to be the same length. Usually groups need to decide on a shape and cut a number of them out, physically trying to tessellate them. Since the three angles of a triangle add to 180^{o}, it will always be possible to arrange a group of congruent triangles so that they tessellate. Rotating one triangle through 180^{o} and placing two together so that they form a parallelogram will enable this to be easily seen.

1. Multiplying numbers makes them bigger
2. To multiply by ten add a zero
3. Multiplying a number by 2 makes it bigger than if you add 2 to it.
4. Two negatives makes a positive
5. Triangles will tessellate
6. Quadrilaterals will tessellate
7. A quadrilateral with two diagonals equal in length is a rectangle
8. The main diagonals of a cube intersect at right angles

Figure 2. Statements for truth debates.

The four angles of a quadrilateral add to 360^{o} so it should also be possible. If the quadrilateral is a square, a rectangle, a rhombus or a parallelogram it is easy to see how they can tessellate. The difficulty comes with quadrilaterals like the two shown in figure 3.

Students need to cut out a group of such shapes and experiment to see how they can tile with them. They need to find a systematic way to do it and then try to explain it. This means that, for this activity, materials such as scissors, scrap paper, rulers, etc. need to be available.

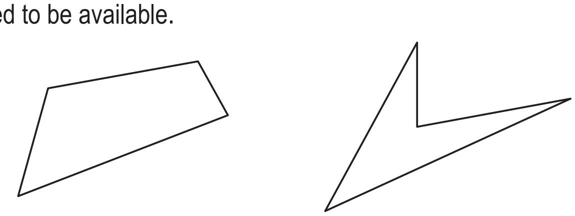

Figure 3. Quadrilaterals for tessellations.

Considering the angles for the shapes, any arrangement has to have all four different angles around a point. If a shape is rotated through 180^{o} and aligned with another shape, this combination can then be translated, and the whole row then also translated making a tessellation as in the diagram in figure 4 below. The same system will work for both shapes but only one is shown here. This means both statements A and B are always true.

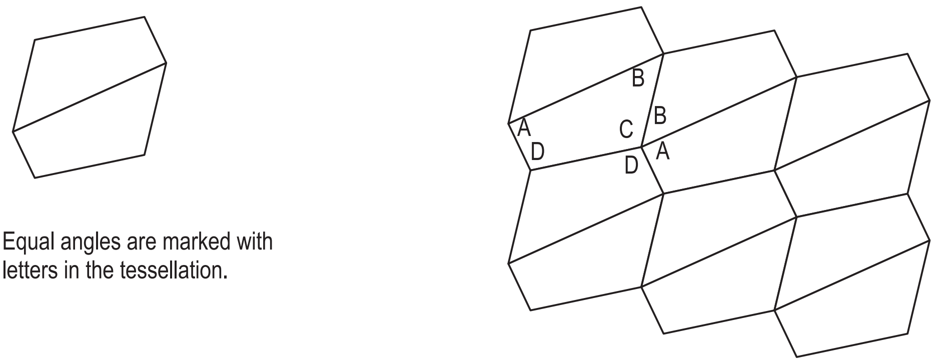

Figure 4. Demonstration of a tessellation of a quadrilateral.

While I have explained the tessellation here I have not explained it to a class. Usually at least one group in the class finds a way of tessellating with these quadrilaterals and explains it quite clearly to the rest of the class, who are all quite happy to question what they do not understand.

For statement 7, a 2D quadrilateral with diagonals equal in length, intersecting at right angles, might be a square. However if we start with two lines of equal length intersecting at right angles, other shapes can be made. If one line bisects the other a kite will be made, but if neither bisect then an isosceles trapezium or an irregular quadrilateral can be created as shown in figure 5. This makes statement 7 sometimes true.

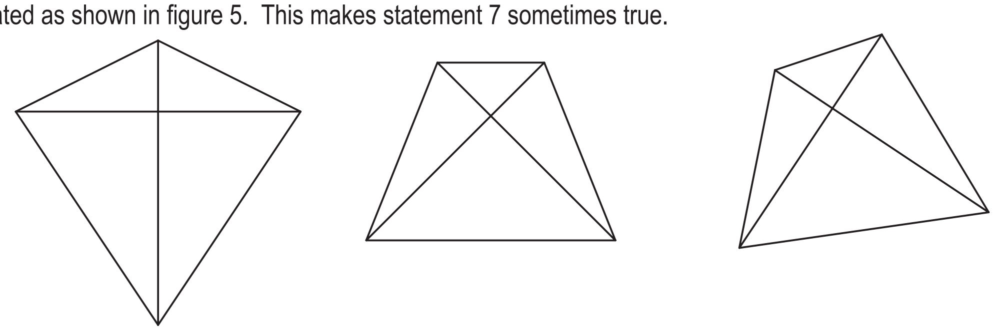

Figure 5. Quadrilaterals with two diagonals equal in length and intersecting at right angles.

Statement 8 is false. The immediate image most people have of the diagonals of a cube is that they must intersect at right angles. It is true that the diagonals on the faces of the cube intersect at right angles but the main diagonals which pass through the centre of the cube do not. Imagine a diagonal cut across the top of the cube as shown in the diagram on the left of figure 6. The shape of the cut face will be a rectangle that is not a square as the top of it is the diagonal of a face of the cube and the side of it is the edge of a cube. The diagonals of this rectangle are the diagonals of the cube so this statement is false.

Figure 6. The major diagonals of a cube.

Learners need to take some control of learning

When a teacher structures a lesson to introduce a concept or skill the students will all leave the class with different memories and different ideas of what the lesson was about.

Learning is very much the province of the learner. The teacher tries to facilitate that learning but the actions of the learner are crucial to the outcomes. Two critical components of learning that I see are action and reflection.

The action may be physical and/or mental action. Taking action though requires some level of commitment and engagement with the concepts and ideas in the lesson. There are many ways of actively involving students. Some of these require physical action such as interacting with manipulatives. Others just require mental action. Just the act of making a decision as in the truth debates task actively involves students – they want to know if their ideas are right and they become involved in the discussion.

As well as decision making being one way of active involvement, students also need to consciously be making decisions about their learning. They need to see that they are learning - in fact be aware of their learning. These metacognitive aspects are enhanced by consciously and openly encouraging reflection.

Reflection and metacognition.

One critical aspect of our teaching is that we are not only trying to assist the students to learn about mathematics but we should be trying also to help them learn how to learn mathematics. Students need to take more control of their own learning and that means as teachers we need to be willing to give them more control.

One way of building in this reflection on learning is to ask students to step back from trying to work on a problem and to reflect on what mathematics they are doing, what they have tried, what else they could try, what they have learned, what else they need to may need to learn, etc.

Another example of this in mathematics is when they are to practice skills from textbook exercises or other exercise sources, instead of giving them the specific questions to do, discuss the types of questions and let them choose.

Another idea is to have them write questions for each other or for a test.

All of these ideas are aiming to transfer some of the control of learning deliberately to the students.

Journals are another approach that has been shown to be useful in encouraging students to reflect on their learning. At first it is really useful in journal writing to give students specific reflection questions.

Black Box

This is another task which encourages the use of language and discussion in the classroom. The purpose of this task is for the participants to identify a 2-D shape or 3-D object by asking questions about it. This will require them to use language to ask about its properties. At the same time other participants are identifying shapes by touch and answering questions about their properties, but without being able to see the shape or object.

Using a copy-paper box (a smallish cardboard box with a lid) holes are cut in each of two opposite sides large enough to allow hands to be comfortably put in. A sheet of paper is taped as a flap over each hole so that it is not possible to see inside. Objects such as 2D shapes cut from strong thin cardboard or 3D shapes such as prisms and cones are placed inside the box. There are then many activities which can follow.

Students work in pairs or small groups. One student reaches into the box, one hand on each side, and picks up a shape, holding it inside the box. The student describes the shape to the rest of the group. The other students name the shape and draw it. The shape is then removed from the box and students compare it to their drawing. The box then passes to the next student.

Discussion during and following this activity can focus on language. What types of descriptions were most helpful in enabling the students to see the shape in their minds? Were there any problems with interpretation where the listener had a different understanding of the words used? What specific geometric language was used in comparison to the common language used?

The task can easily be altered for different purposes by restricting the types of language used. Banning the use of the word *like* or *similar to* or such equivalents can overcome the use of van Hiele's level 1 ideas of "it is like the door" (Clements, 1992). Sometimes the focus may be on common language and specific geometric names are banned, for example the use of *it is a right angled triangle* is banned but descriptions of properties are allowed such as *it has three straight sides and one right angle*. On other occasions it may be that the use of geometric terms and language are encouraged to show the value of specific well defined terminology.

The student with hands in box is translating from the actual object to language and the other students are translating from the language to a representation of the object.

Another form of the above activity is to restrict the student with hands in box to answering only *yes* or *no* to questions from the group who are trying to draw the object. This forces the students to think more about properties that enable identification, thus move more towards van Hiele level two. Sometimes in this situation the person answering may not understand the question so it is necessary to allow them to answer *I don't understand your question. Please ask the question again in another way* if they not understand the question. Sometimes they might understand the question but not know how to find the answer in which case the response would be *please tell me how to find that out.* This then puts it back to the questioners to think about both their language use and their visualization of the shape. It is useful to have these responses to questions on display and they are reproduced on a sheet at the end of this activity.

Working with groups, I allow each group to ask one question then we stop and the groups discuss what they know and what else they would like to know in order to be able to identify the object and draw it.

Questions will generally focus on properties and may be about sides, angles, diagonals, and symmetry. Sometimes the *please tell me how to find that out* can lead to interesting discussions of properties – for example how do you know if two sides are parallel when you cannot see them? This reflects back on the real meaning of parallel. Another difficulty many students have is to identify a right angle without vision, and class discussion about how to do this can be very informative as students often make excellent suggestions. This discussion is partly about estimating angles.

Open questions

Another activity which I find encourages a lot of discussion within groups and allows the students to learn from each other and to make their knowledge connected is to use open questions. An open question, such as the one in figure 7, is presented to the group. The question is one given to me by Peter Sullivan, who has written more extensively in Sullivan and Lillburn (1999), a book aimed at grades 0-6 but with a rich source of ideas for all levels. The first stage is for everyone to read the question for understanding. If there are any words they do not know they may ask others in their group, but at this stage the discussion is only about understanding the question and not about how to find answers. The group may call on the teacher's assistance if the whole group has a problem or to arbitrate a disagreement.

> A player in a junior basketball team looked at his individual scores for the 11 matches he had played.
>
> The mean score was 6, the median score was 7, and the mode was 8.
>
> The three games with the lowest scores had scores of 1, 2 and 4.
>
> What might the 11 scores have been?

Figure 7. Open question

A quiet work time follows, when individuals try the problem and no discussion is allowed. This does not have to be very long but it allows each participant to come to the group discussion with some ideas.

Each group then works together to find as many solutions as possible. The teachers role is to monitor and ask questions such as 'What is the largest score he could have in any one game?' 'How many solutions are there?' and 'How do you know if you have found them all?' These provide further challenges if necessary.

The task ends with the groups sharing of the solutions they found with the rest of the class, paying attention to how members of the group approached the problem and their solution strategies.

Concluding remarks

The activities above all encourage the class discussion. The use of language can assist students to connect their knowledge and build on their past experiences and current knowledge structure. There are many other types of tasks that can support this aspect of learning such as problem solving and investigations, particularly seated in real contexts. The ideas suggested here are just a few that I have found to be very effective.

References

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