FaSMEd

Raising Achievement through Formative Assessment in Science and Mathematics Education

Graphing in mathematics

Subject:	Mathematics
Age of students:	11-13 years
Technology:	Interactive whiteboard and tablet
Functionalities:	Sending and displaying
Time:	15 minutes before the lesson, a 90-minute lesson (or two 45-minute lessons), and 10 minutes in a following lesson (or homework). Timings are approximate and will depend on the needs of the class.
FaSMEd partner:	Maynooth University
Short Abstract:	This lesson unit is intended to help you assess how well students are able to interpret distance–time graphs. As graphing is a boundary object used in both mathematics and science, this lesson can be used in both subjects.

1. Content

Graphing.

2. Activity

2.1 Aims

This lesson unit is intended to help you assess how well students are able to interpret distance–time graphs and, in particular, to help you identify students who:

- Interpret distance–time graphs as if they are pictures of situations rather than abstract representations of them.
- Have difficulty relating speeds to slopes of these graphs.

2.2 Structure / Methodology

The lesson unit is structured in the following way:

1. Before the lesson, students work on a task designed to reveal their current understandings and difficulties. You review their work and create questions for students to answer in order to improve their solutions.
2. A whole-class introduction provides students with guidance on how to work through the first task. Students then work in small groups on a collaborative discussion task, matching verbal interpretations with graphs. As they do this, they translate between words and graphical features, and begin to link the representations.
3. This is followed by a whole-class discussion about applying realistic data to a graph.
4. Students next work in small groups, matching tables of data to the existing matched pairs of cards. They then explain their reasoning to another group of students.
5. In a final whole-class discussion, students draw their own graphs from verbal interpretations.
6. Finally, students return to their original task and try to improve their individual responses.

2.3 Technology

- Each student will need two copies of the assessment task Journey to the Bus Stop, a mini- whiteboard, a pen, and an eraser.
- Each small group of students will need copies of Card Set A: Distance–Time Graphs, Card Set B: Interpretations, Card Set C: Tables of Data, a large sheet of paper, and a glue stick for making posters. The cards should be cut up beforehand.
- You will also need a supply of graph paper to give to students who request it. There are some projector resources to support your teaching.

The teachers using this lesson in Ireland, used tablets and interactive whiteboards to share students work and promote discussion on the students thinking.

2.4 Aspects of Formative Assessment

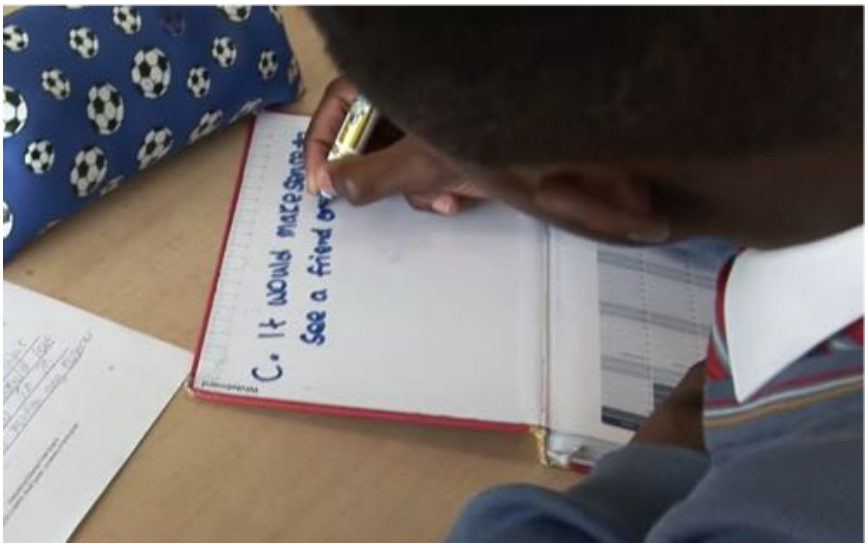
- *Engineering effective classroom discussions and other learning tasks that elicit evidence of student understanding*
- *Provide feedback that moves students forward*
- *Activating students as instructional resources for one another*
- *Clarifying, sharing and understanding learning intentions and criteria for success*
- *Activating students as the owners of their own learning*

3. Further Information

The aim of the distance time lesson was to alleviate misconceptions students might have about graphing, in particular reading a graph as a picture rather than a diagram showing the relationship between two variables. The teacher accomplished this by identifying and responding to student's conceptual difficulties through questioning, feedback and the use of a pre-assessment task. She also made use of co-operative learning pairs and groups so that students could help each other with tasks and peer assess each others work by moving to the other groups within class to review and challenge other's answers to the different matching activities.

Classroom set up, students working in pairs

Within the distance time lesson the students had to work in groups on three tasks. Task 1 involved students working in groups on a multiple-choice problem presented by the teacher. During this activity the students could make use of their mini- whiteboards to demonstrate their understanding. This task was carried out using a think, pair, share activity.



Student utilising a mini-whiteboard to share his thoughts with the class

Task 2 was the first matching different representations activity of the lesson, whereby students had to match stories to graphs and make up their own stories for graphs, students worked co-operatively on this task. The final task (Task 3) was another card matching activity, it required students to decide on appropriate units of measure for the distance time graphs; they completed this task in groups. Throughout the lesson the students took part in discussions with the teacher on the tasks, they utilised each other as resources for learning and they also had the opportunity to work alone at points to build their own self-regulatory skills.

Co-operative Learning and Peer Assessment

Throughout the lesson it was observed and documented in field notes that the students were very engaged in their class tasks, and appeared to be both motivated to complete the activities while simultaneously enjoying the lesson. This was observed to be due to the teacher's use of co-operative learning tasks and peer assessment. The first co-operative activity the teacher tasked the students with was a think, pair, share exercise. It was clear from observations that students were very familiar with this type of activity and got immediately involved. To motivate the students and keep them focused on the lessons activities, the teacher constantly encouraged students to have a *mathematical argument* with their peers. What the teacher meant by this was that she was encouraging them to challenge their classmates and make sure that they were able to defend and explain their reasoning. This demonstrated how the teacher was promoting peer assessment among the students in a simple and effective manner. In addition to developing their peer assessment skills, the teacher was providing an environment where students could build skills around self-regulation.

Students engaging in the lesson and having mathematical arguments.

Students were gaining confidence in their own work and did not rely on the teacher to give them guidance. The teacher observed that method of peer assessment was particularly of benefit to low achieving students.

Further in the lesson while the students were involved in pair and group work, student engagement could clearly be witnessed. On numerous occasions students of all abilities were seen to probe each other for understanding and participate in *mathematical arguments* as suggested by their teacher. Students can be heard asking each other questions such as "*why do you think C matches*" and explaining their reasoning to their peers. This once again emphasises the teacher's strategy of peer assessment among students. A misconception that many students were having in the class was that the graph was a picture and therefore if the graph increased then the person was walking up the hill. In this lesson it was observed how co- operative learning resolved this misconception among peers. One student (S1) believed that "*if he ran down (the hill) then the line would be down*", this is clearly not the case for a graph and her peer (S2) explains to her that if the line is going down it means that the person is returning home not going downhill. The students (S1) *eureka* moment was clearly witnessed on her face when she suddenly understands more clearly the concept of distance on the graph.

Students helping each other with matching activity.

S2 then went on to relieve the same misconception with another of his peers by clarifying that " *he's going down the other side of the hill so he's going away from home*". The fact that the students are using colloquial language to help resolve each other's misconceptions is of great benefit to students, especially low achievers, as they are becoming more independent of the teacher and therefore can take charge of their own learning without constantly relying on the teacher for guidance.

S1 explaining to another student on her table the difference between graphs and pictures.

Interestingly when S1 had resolved her misconceptions, later in the class she was seen to help another student figure out the graph versus picture dilemma by explaining to him that "*if he was at his house the it would be down here (pointing at the bottom of the graph), he didn't come from his house*". This once again demonstrates how co-operative activities are helping students to learn without the need for the teacher present.

Field notes gathered from this lesson further support the students' excellent co- operative learning skills. Notes gathered illustrate how students co-operative learning skills and communication skills were very well developed, they show how it was clear that the students are familiar with this type of learning and they demonstrate how throughout the lesson the students engaged in co-operative learning to problem solve, peer assess and

make their reasoning visible to others.

Questioning and Feedback

The teacher made use of the lollipop stick questioning method to randomise the questions, her questions also challenged the students to think for themselves. For example, during a conversation between the teacher and a group of students she probed a student for understanding by asking her higher order questions:

Teacher: Do you want to explain to me why you went with that one?

Student: Because the steeper the slope the less time you take and the distance doesn't go further up, that means that's where the bus stop is. So he ran from home so it shows the shorter amount of time and he walked back so it's longer.

Teacher: And why do you think this one is run and this one is walking (pointing at the graph)?

Student: Because it's not as steep, it shows that maybe he took more time to go back.

Teacher: And what about here (pointing at the graph)? Why do you think that he's standing still here? How did you come to that conclusion?

Student: At the bus stop he stopped and waited.

Teacher: How do you know he is waiting here?

Student: Because the distance isn't changing.

Teacher: And what is happening with time?

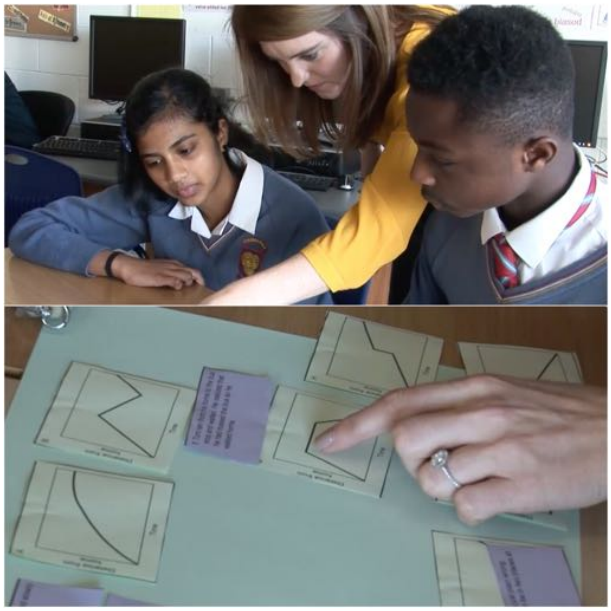
Student: The time is passing.

Teacher: The time is passing, well done, very good; you're really starting to get the hang of it. Keep going there guys.

Field notes illustrated how the teacher made use of higher order questioning throughout the lesson to elicit evidence of student understanding and to move students forward with their learning. The teacher made use of questions such as "*what do you think (about a certain card match)"* and *"how do you know it's changing (in relation to speed on the graph)"* so that the students could think for themselves about the activity rather than her giving them all the solutions.

Video analysis established how the teacher was probing for understanding during group work. The teacher, throughout the entire lesson was posing such questions as *"if he's running back to his house, what is happening here with the distance from home?"* With this question, the teacher was in the process of giving a student feedback on an incorrect card match up. Following on from asking this question the teacher is then seen to encourage the student to have a conversation with her peer about the mismatch. This highlights how the teacher is not focused on giving the student the correct answer but how she wants the student to come to the right answer herself perhaps by using the help of her peer.

The teacher made use of effective feedback within the lesson to guide students to the correct solution without her revealing it to them. During the distance time lesson it was observed how the students were at ease with the idea of not knowing the right answer. Video analysis revealed how when the teacher told the students she would not be telling them the right answers to the matching activity during the lesson, students were comfortable with this, demonstrating how they are now familiar with this way of learning. Following the lesson when the teacher was interviewed, she commented on how their reliance on having the correct answer had been reduced by her providing students with effective feedback to move the learning forward. In her own words she commented on how the FaSMEd students "*don't mind if they're not right"* (by FaSMEd students the teacher meant the class using the FaSMEd materials). They understand that she was aiming to lead them to a point of *"self- discovery, self-learning and self-assessment"*. She was also very positive about how during the lesson she witnessed a *eureka* moment when the students were realising the right answers not from her telling them but from her asking them certain higher order questions.



Teacher engaging with the students

Field notes communicated how the teacher was using her feedback to guide students away from their misconceptions and toward graphical understanding. Notes gathered illustrate how the teacher's feedback to students was clear and descriptive and how it related to student interpretation by focusing on the graphic activity. Her feedback also helped the students move forward in their learning by suggesting to students that they should have a conversation their peers about the activity and that they should explain their reasoning explicitly. Time was allocated during the lesson to give students a chance to make use of teacher feedback on the card matching activity and she also mentioned to students that they would have the chance re-attempt their *Journey to the Bus Stop* task in the following lesson. The teachers questioning and feedback practices were clearly of benefit to the students as at the end of the lesson the students conveyed that they wanted to alter their original *Journey to the Bus Stop* pre-assessment, demonstrating that they had learned from the teachers questioning and feedback during the distance time lesson.

Sample pre-assessment task completed by a maths student.

The pre-assessment task was an important aspect of this lesson. It would allow the teacher to assess any misconceptions students were having about graphing prior to the lesson and help her to plan her lesson accordingly. She commented that this was important for her

" to jot down a couple of misconceptions that I'm spotting by quite a few students and to take a bit of time outside the classroom to reflect on that and see how I could address them and how I could direct the learning so they could spot those misconceptions, those errors, as opposed to just saying you did this wrong, this is what you should have done."

From the pre assessment task the teacher deduced that the students were having difficulties with calculating speed and with relating distance travelled with time taken. At the beginning of the lesson, the teacher used feedback in the form of questioning during a group discussion to clear up their misconceptions. At the start of the lesson she posed such questions as: *"do you think Tom's speed is steady or is it changing?"* and *"how do you know it's changing?*" She encouraged students to get involved in the discussion by asking them if they disagreed with their peers and why. She also asked other students about their opinions on Tom's speed *"who else feels it's changing?"* She asked students to challenge their classmates on their responses leading to the class becoming engaged in the activity whilst addressing their misconceptions. The bouncing of questions around the room worked very well and many students shared their opinions. While the teacher's use of higher order questions was good, during the activity she gave the students little wait time to answer the questions. Perhaps this was due to her eagerness to move on to the main activity as later on in the class it was observed that she allowed students appropriate time to answer questions on occasion. However it was felt that because she was trying to cover a significant part of

the lesson plan during the class, her wait time for questions was reduced.

Conclusion

In terms of teaching strategies that were supportive of formative assessment in the classroom, the teacher made use of questioning, feedback, co-operative learning and peer assessment. She utilised these formative assessment strategies to *engineer effective classroom discussions and used other learning tasks that elicit evidence of student understanding* and to *provide feedback that moves students forward* while *activating students as instructional resources for one another.* She adopted the techniques of *clarifying, sharing and understanding learning intentions and criteria for success* and *activating students as the owners of their own learning* however these strategies were noticed to a lesser extent and the teachers practices around these strategies still needs to be refined.

ICT did not play a crucial role in this lesson. Although the teacher made use of her tablet device and the interactive whiteboard throughout the lesson, the card matching activity stimulated the rich discussion and feedback. The technology was merely a more efficient tool to display student answers and to allow the teacher move between groups and use the tablet to add material to the interactive board. The students also could share their answers using the tablet; this enhanced their engagement with the learning.

The teacher's Surface was often shared among students in class to demonstrate work and for students to work as a class to aid other students who were having difficulties. She also made use of it to detach herself from the whiteboard and become more involved with the class. This impact of technology was evident with students in their comments during interview. They remarked that:

"If you're in class and you're doing a question on the tablet, if you get something wrong it's easier to tell than just writing it in your copy where only you can see, then the whole class can see it and tell you where you went wrong." (S15)

"She (The teacher) *could still be walking around class and helping people but I guess it gives us more options so that the whole class can participate so it's not just one person and she* (The teacher) *doesn't have to walk back and forth to the board." (S9)*

Hence the technology functioned to send and share information between, students and teacher and to a lesser extent, engineering effective classroom discussions and providing evidence.

Within teaching and learning improvements can always be made and with regards to practices that were hindering formative assessment, such as the teacher's allocated wait time for answers from her students was very short. Making use of self- assessment with students was mentioned by the teacher when interviewed after the class, however due to time constraints the teacher did not get to practice this with her students during this observed lesson.

In relation to what the teacher thought about the lesson, she felt it was successful in alleviating student's misconceptions around graphing. She credited the pre- assessment task for aiding this. She had praise for the task commenting how it gave her time to reflect on her lesson planning outside of the classroom and allowed her to plan structured feedback for

the students prior to the upcoming lesson. She commented on how questioning formed a big part of the lesson and how she was constantly getting students to explain their reasoning even when an answer or a particular card match was correct.

4. References

Full lesson plan and supporting materials available at http://map.mathshell.org/download.php?fileid=1680

Bell, B., & Cowie, B. (2001). The characteristics of formative assessment in science education. *Science Education*, 85(5), 536-533.

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