Investigating how formative assessment through the use of coded qualitative feedback can improve graphing skills of Physics students

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Abstract

Constructing graphs as a form of presenting findings in O-level Science Practical is an important skill but it is known that students at secondary school level face many problems with graph construction and interpretation. Based on the perceived need to improve graphing skills, the goal of this study is to produce and evaluate an innovative approach to effectively address common graphing errors for upper secondary Physics students. By using formative assessment through coded qualitative feedback, discrete chunks of graphing criteria are established through weekly tasks and are made known to students by teachers on what they have achieved and where they need to improve. These feedbacks provide specific suggestions about how that improvement might be achieved. This approach also encourages students to take ownership for their learning. It renders self-monitoring, self-assessment and self-evaluation.

Keywords: formative assessment, graphing, qualitative feedback

INTRODUCTION

In Woodlands Secondary School, all teachers with curriculum study 1 (CS1) or curriculum study 2 (CS2) of Physics teach graduating students offering O-level Science (Physics). O-level Science (Physics) comprises of three papers. Paper 1 and 2 are written papers whereas Paper 5 is a practical test with an assessment weightage of 15%.

Paper	Type of Paper	Duration	Marks	Weighting
1	Multiple Choice	1 h	40	20.0%
2	Structured and Free Response (Physics)	1 h 15 min	65	32.5%
3	Structured and Free Response (Chemistry)	1 h 15 min	65	32.5%
4	Structured and Free Response (Biology)	1 h 15 min	65	32.5%
5	Practical Test	1 h 30 min	30	15.0%

Table 1(SEAB, 2014)

Students offering Science (Physics) were given three 50-minute periods per week to cover the syllabus and practice practical works. An average of 20 periods in the final year is dedicated to practice practical works. Students enrolled into Woodlands Secondary School have an average PSLE mean score grade of 193. To value-add to these students, they will need to score an average of B3 for the Science (Physics/Chemistry) in the O-Levels.

Identifying the Problem

To achieve a score of B3 for Combined Science (Physics), students should target to do well in the Paper 5 practical test. The practical test is designed to test appropriate practical work and experimental skills. One of the experimental skills is to perform graphing. This is a crucial component in the practical test as marks are awarded for the graphing skills and thereafter, the conclusion drawn from the graph constructed. Since graphing is skills based, students can be trained to do well in this component.

General criteria of constructing a good graph are as follows:

- The axis of the graph is properly labeled with appropriate units.
- The graph occupies at least 50% of the graph paper.

- The scale used is appropriate and with a reasonable interval.
- At least three points are plotted correctly.
- A best fit line/curve is drawn.

Yet in Woodlands Secondary, students are observed to make fundamental graphing mistakes even after multiple graphing practices and feedbacks given. This is of great concern as the learning intentions and criteria for success were not met even though large amounts of man hours were dedicated to practicing practical works.

A Professional Learning Circle (PLC) team was formed to address the problem. The team was motivated to implement an innovative approach to developing graphing skills of students in order to address common graphing errors.

The key problems identified were:

- Graphs were marked and scored but hardly any written comments/feedbacks were given. Students were more fixated on the score rather than the corrective strategies.
- There was no standard way of marking graphs. Individual teachers marked their students' graph using their own annotations.
- A good graph had to fulfill many criteria and students could not remember these criteria.
- Feedback to students was not explicit and often not specific to address individual's graphing errors.

Research Question

The PLC team began to question ourselves on how might we improve the graphing skills of graduating students through providing better feedback.

The intervention chosen by the team is based largely on the five key strategies of Formative Assessment. (Leahy & Wiliam, 2012)

The five key strategies are:

1. Clarifying, sharing, and understanding learning intentions and criteria of success
2. Engineering effective classroom discussions, activities, and learning tasks that elicit evidence of learning
3. Providing feedback that moves learning forward
4. Activating learners as instructional resources for one another
5. Activating learners as the owners of their own learning

METHODS

In our intervention, notes were given to students with clear intention on how to score for graphing (Annex A). Because of the number of criteria involved in constructing a good graph, the team decided to break down the information into chunks and use codes to represent each chunk. Chunking is a metacognitive strategy to allow students to better recall the graphing criteria.

According to Dawson:

Chunking strategies break a body of information up into smaller units, or discrete chunks. (West, Farmer, & Wolff, 1991) This enables the information to be manipulated into sequences and for relationships among the chunks of information to emerge. The sequences and relationships become metainformation about the material that can support its integration into cognitive structure and aid its accessibility in the future (West et al., 1991). Such a strategy establishes the groundwork for the concept of the knowledge object, which is one of the fundamental elements of this study.(Dawson)

We assign the following qualitative variables with codes for effective graphing:

(S)cales

(L)ine

(A)xes

(P)oints

Data collection

Sixty secondary three students from three classes were chosen for data collection, broken down as follows:

Class	Population	Teaching	Marking/Feedback	Mode of assessment
Sec 3A	20 students (mixed ability)	Conventional method	Scores only	Teacher assessment
Sec 3B	20 students (mixed ability)	Coded qualitative criteria (Annex A)	Coded qualitative feedback with rubric for student's self-assessment (Annex B) only	Teacher assessment
Sec 3C	20 students (mixed ability)	Conventional method	Detailed comments only	Teacher assessment

Table 2

For the quantitative pre-assessment, all students were taught the graphing criteria. Only one class, Sec 3B, was taught using the coded qualitative criteria (Annex A). Classes Sec 3A and 3C were taught in the conventional way.

All students were to take a marked quantitative pre-assessment. Refer to Table 2 above for details on marking, feedback and assessment. All students were also to rate their confidence in drawing a good graph.

The question on confidence were phrase as follows:

You are confident in drawing scoring full marks in graphing.

1. Disagree 2. Somewhat Disagree 3. Neutral 4. Somewhat Agree 5. Agree

After marking, the graphs were returned and students performed a self-assessment on whether the marking method helped them to improve their graphing skills.

A quantitative post-assessment was given a week later to assess whether the marking/feedback method helped students to improve

Data analysis

Average score of the graphing is collected. (Full score: 5 marks)

Class	Pre-assessment	Post-assessment	Percentage improvement / (regression)
3A	3.30	2.65	(19.7%)
3B	3.40	2.35	(30.9%)
3C	2.31	2.86	23.8%

Table 3

Average confidence rating is collected.

Class	Pre assessment	Post assessment	Percentage Confidence improvement/(regression)
3A	2.50	2.65	6.00%
3B	2.45	2.40	(2.04%)
3C	2.33	2.36	1.29%

Table 4

Sec 3A recorded a decrease in post-assessment score but rated themselves better in confidence.

Sec 3B scored the best in the pre-assessment yet scored the worst in the post-assessment. There was a decrease in confidence rating as well.

Sec 3C scored the lowest in pre-assessment but had the best post assessment score. There was increase in confidence rating.

Data reveals that by only awarding scores (Sec 3A); there is no improvement in post-assessment scores. However, students are generally rated themselves positively in their confidence in graphing skills. This could be because students do not explicitly know the learning intentions since no meaning feedback is given and the perception is that they know how to construct a good graph.

The data also shows that chunking of criteria of good graphing skills through qualitative codes could help to improve the score of students as students in Sec 3B received the highest pre-assessment score. However, using the codes as a feedback method did not increase in post-

assessment scores. Without teachers' intervention, students receiving the coded qualitative feedbacks may not pay attention to the rubrics given to them for improvement.

As observed in Sec 3C, quality feedback does help to increase the post-assessment score of students. It is possible that with detailed comments given by teachers, students' learning is moved forward. However, it is unusual that despite detailed comments given by the teacher, students still rated themselves to be the least confident in graphing skills.

Limitations

Some of the limitations of the research includes the small sample size of the group, a larger sample group will give rise to higher accuracy in the results obtained. The differing abilities of the group also poses a problem as 3A generally performs better than 3C as they were banded by results. Another limitation stems from the teachers teaching the various classes, different teachers may induce different strategies to teach the code feedbacks.

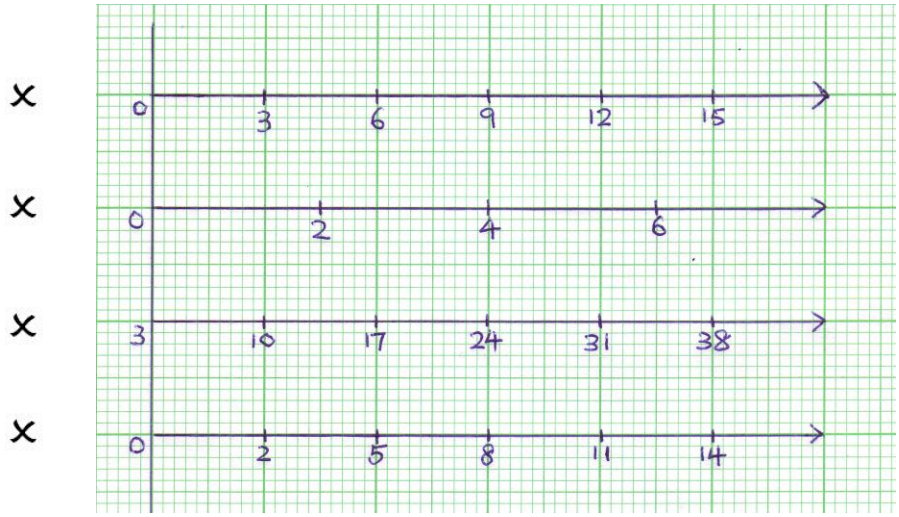
Conclusion

There is a great motivation in using the coded qualitative feedbacks as a mean for formative assessment to improve students' graphing skill. The chunking of codes (S.L.A.P.) should improve metacognitive handling of information. The qualitative feedback by teachers is focused and related to the learning goals, and should encourage students to take charge in their own learning. Further experimentation is recommended to study the effect of using coded qualitative feedback with teachers' explicit guidance during correction sessions. The coded feedback seems to raise the confidence level of the students, showing that they know what the expectations on them are. However, they may not be able to use the feedback or are not looking at the details of the rubrics or they do not know how to improve based on the rubrics.

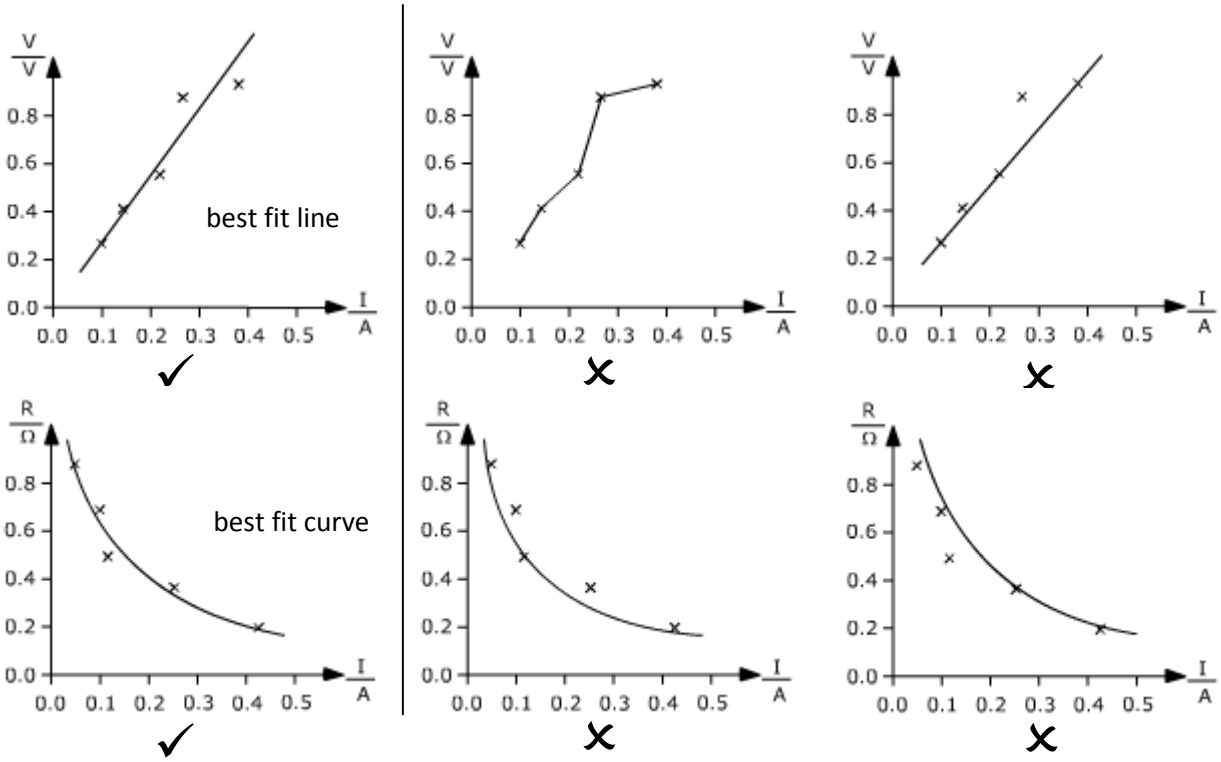
Annex A

<u>Graphing</u> – marks may be allocated to ***S.L.A.P***, which stand for

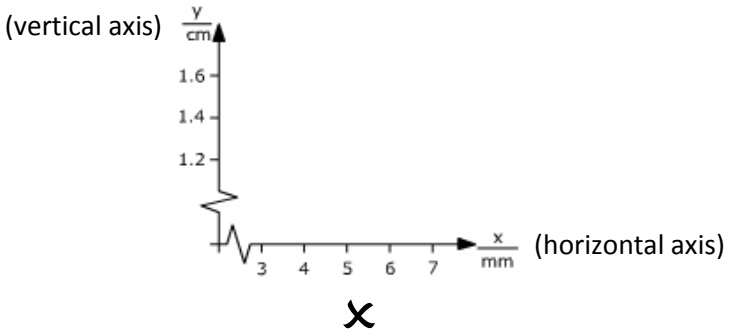
- **S**cales: both vertical and horizontal scales should enable the **first** and **last** plotted points are separated by **at least 50% of the available spaces**.
  Also, do **not use odd scales**. Examples of odd scales which **must not** be used:



- **L**ine of Best-fit: In most graphs, data points do not fall exactly in a straight line or form a smooth curve. In this case, draw a **best fit line** or a **best fit curve**.
  Try to balance the number of points that are left out of the line on the left and right side of the line. The distance of these outliers from the line should be balanced too.



• **A**xes: Both axes should be **labeled with units**. These labels are names of the axes. Please do not name them as *x* or *y* all the times. Question papers will tell you what their names are. Both axes must have **arrowheads** at the ends. Break-symbols are **not** allowed on both axes.



- **P**oints: Did you transfer your points correctly from the table to the graph paper?

Additionally, you should also note the following:

- Do you know how to tell which variable is to plot as vertical axis and which is to plot as horizontal axis?
- Do you know that you need not join the first point and last point as part of best-fit line when they are obviously outlier points?
- You **need not start axes from (0, 0)**. But, if question paper asks for this, then you have to follow.

Annex B

Rubrics of Coded Self-Assessment for Graphing Competency of Students

Competency	Check Points	Checkbox
(S) – Scaling	○ First and last plotted points occupy at least 50% of **vertical** axis. ○ Good scale (e.g ratio of 1, 2, 5, 10 and their multiples) are used for **vertical** axis.	
	○ First and last plotted points occupy at least 50% of **horizontal** axis. ○ Good scale (e.g ratio of 1, 2, 5, 10 and their multiples) are used for **horizontal** axis.	
(L) – Line of Best-fit	○ About the same numbers of points are left out on each side of the line. (allow up to a difference of 1 point difference) ○ About the same distance from the points left out on each side of the line to the line drawn.	
(A) – Axes' Labels	○ Both axes are labeled with the correct symbols with correct units. ○ Correct quantities are used for vertical and horizontal axes respectively.	
(P) – Points Plotted	○ At least 3 points are plotted correctly. ○ Small crosses are used to plot the points	

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