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IMPROVING INTERNATIONAL RANKINGS THROUGH ENHANCED LEARNING THROUGH REPRESENTATIONAL REASONING

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Abstract

There is growing concern over students' performance in international testing like PISA and TIMMS. All countries desire to improve their ranking compared to other countries. While it is reasonable to focus on teacher performance, it neglects the students' learning processes and how students develop their understandings. This concern about teacher performance is resulting in increased bureaucracy on monitoring what is done in classrooms to the detriment of understanding how students learn. In this presentation, I will argue that it is important to address student learning and reasoning processes if a gain in ranking is to be achieved. Hence there is growing research interest in the challenges and opportunities learners face in representing their scientific understandings, claim making, verification and reasoning during student learning. The research outlined in this presentation involved both primary and high school students and their teachers. It also explored the introduction of enhanced student voice through the use of peer and self assessment in an inquiry learning project designed to improve the quality of their explanations. In these studies, students verbalized initial understandings of key terms, then negotiated with partners the meanings of their explanations. They tested the adequacy of their descriptions and claims through guided inquiry using simple everyday equipment. In each lesson, the teacher prompted students to test and justify the adequacy of their verbal and subsequent multi-modal representations through new questions, or activities, to challenge and clarify some of their views. The activities and questions required students to refine or modify 2D or 3D representations of their emerging claims. In each case, after the students had resolved different representational accounts within groups, the class discussed these representations in teacher and/or student-led discussion. The teachers maintained a pivotal role in developing student understanding. This project gave students the opportunity to choose both the type and the context of learning activities. Students needed to declare their understandings and explain their reasoning behind their explanations. This set the scene for testing of the adequacy of peer assessment about their claims.The findings show the benefits of peer assessment as a valuable learning tool that gave targeted feedback to students, allowing them to have more of a voice in their education and challenged students to reflect critically on the quality of their reasoning. Data from classroom observations, transcripts of discussions, and interviews with students and teachers, suggest the value to students' learning in this topic through reasoning about representational adequacy. The finding demonstrated clear learning gains, when compared to similar schools, in national testing outcomes.

Keywords: Representational reasoning

INTRODUCTION

Currently, there is strong interest in a country's performance on international testing. This concern has impacted beyond the national level to the classroom. Governments claims that schools need to be accountable for their performance with the clear expectations that rankings must rise, There is clear evidence that teachers are teaching to prepare students for these tests. However, the impact of this teaching seems to be marginal after the first few years. Some countries are clearly declining in their ranking on these tests while others can have a variable ranking result. It is not surprising that governments desire a constant improvement in these rankings. How to achieve this has been a source of a range of attempts.

To be literate, a student must be able to communicate. If one cannot communicate what they have learnt, then it can be claimed that they don't really understand. One could ask what practices should students learn to interpret and construct during primary and secondary school as evidence of learning? What teaching and learning practices will best enable this acquisition? What perspectives and practices will enable effective broader student participation in this learning? Researchers in this field now broadly agree that learning this competence (knowing how, why, and when to interpret and construct models, graphs, tables, and diagrams, and integrate these representations with written language to develop claims) is fundamental to successful education. This presentation will explore means to (a) show student understanding, (b) develop students thinking and reasoning processes and (c) monitor what is being learnt. The presentation will explore the quality of learning, role of the teacher, use of representations in learning, teaching strategies, reasoning in learning, student views, student voice, assessing learning and personalized learning. Practical examples will be presented during the presentation.

What is quality learning?

A reasonable definition of learning is that it involves acquiring new or modifying new understandings and can include the process of synthesising a range of information or experiences. Quality learning involves interpreting, constructing, and refining representations of this emerging conceptual understanding, rather than simply negotiating changes in stored conceptual space.It includes developing the ability to acquire or modify understandings and being able to transfer these understandings to unfamiliar situations. This quality learning can involve students drawing on perceptual links through constructions of their pictorial views, reasoning, negotiating and justifying the adequacy of their explanations. In fact, students develop individual approaches to what is important to their understanding that results in generating different understandings. That is, knowledge emerges from this process that is continually being refined and re-represented.

Particular meanings in subjects and their referents are always "dependent on being embedded in the context of natural language commentary". In other words, the learners' everyday language is the crucial resource for negotiating understandings of (and between) the three components of the sign system in mathematics and science. By implication, students need repeated opportunities to translate disciplinary understandings into natural language, even if such translations can only ever be partial rather than complete, because of the abstractedness of the mathematical or scientific forms of representation.

Role of the Teacher

With such a variable context, the teacher has an extremely important role to play in the classroom. The teacher needs to develop a supportive atmosphere where students can explore the adequacy of their understandings rather than an atmosphere where students refrain from exposing their ideas and understandings. The teacher's role involves a three-way reciprocal linkage between teacher, student and domain. Guided by appropriate scaffolding, students are encouraged to generate their own understandings of the concept to explain observations and predict future outcomes. Students can then compare and reconcile these understandings with those of their peers, and with those of their teacher, or those presented by their teacher as current within the mathematics and science community. The teacher acts as coach and negotiator of the meanings of these understandings and their refinement through a range of representational tasks. Students are directly involved in the construction and critique of the representation in developing understanding.

This approach both recognizes the need for active participation by the learner, and teacher responsibility to coach students about the reasons behind the acceptance of understandings and interpretation. As students move into the "community of a subject" it is crucial for them to be aware of and conversant in the languages and practices of this subject. Whilst established conventions and

interpretations are no longer negotiated, it is also important for students to recognise that they once were, and this is still the case for some new procedures and findings.

The teacher's role in monitoring students' learning entails (a) designing and implementing challenges to understanding, (b) monitoring and probing emerging accounts, (c) making explicit connections with past understandings and experiences, (d) extending understanding through posing additional representational and explanatory challenges based on students' current explanations, (e) assessing responses and providing timely verbal and visual feedback, and (f) facilitating purposeful dialogue on the topic. The teacher needs to have planned their lessons very carefully and to recognise the value of students justifying their explanations. The teacher need to provide opportunities for the students to negotiate, integrate, refine, and translate ideas across their understandings.

What is a Representation?

A representation is something that stands for something else.It becomes part of the reasoning process that assists in showing one's understanding. In class, they can include: drawings, video, graphs, models, role play, verbal descriptions, animations, etc.It becomes a tool through which the student explores, verifies, justifies and explain their understanding, recognising the limitations of their ideas. Besides convincing themselves that their understandings are robust to challenge, students engage with their peers to explore the adequacy of their claims.

Principles behind the Use of Representations.

1. Student learning is an active process that requires the development of listening skills of both the students and the teacher
2. Students need to have the ability to explain and justify their understandings to others.
3. Teacher has a very important role in scaffolding the learning and to utilize key questions to prompt greater understanding. In fact, this requires the teacher to be well prepared.
4. Assessment should not just prompt recall but embedded reasoning should be displayed.
5. These classrooms will have "learning noise".
6. The students will be involved in discussions, drawing on the board and explaining and clarify reasons improved their learning;
7. The teacher will use less talk and bookwork but facilitates learning by requiring students to think through possible explanations;
8. The teacher requires students to work out possible solutions rather than tell them the answer, resulting in improved understanding;
9. There is a need for the students to tell the teacher and others what they thought and why they thought their view was a reasonable explanation because this often helped clarify their understanding and a number stated they did not understand what was being discussed until this occurred;
10. The teacher must listen carefully to what the students are saying and then think why these thoughts are expressed and then interact with these thoughts in the teaching -learning process; and
11. Group and classroom discussions are a key features in developing, clarifying and evaluating understanding of concepts.

Summary of Teaching Strategies

Working in teams of students, requires students to work as a group (collaboration) and not as individuals in a group. The teaching sequence based on series of challenges. In addition,

- Challenges are explicitly discussed
- Cognitive Student engagement is a focus.
- Students develop the ability to recognising Equivalent Solutions.

- Students develop the ability to transfer understanding and Group Skills become embedded.
- Reasoning skills are facilitated
- Ability to design and solving problems are developed.
- Ongoing Formative and Summative Assessment.
- Reporting by student to students and to the teacher

Reasoning in Learning

Reasoning in school is generally characterized as defending, justifying, or validating a claim talk and writing. Quality learning entails students demonstrating they understand concepts and processes by applying a range of appropriate self-generated and expert explanatory representations to particular contexts. This account of quality learning implies that students need multiple opportunities to reason before, during and after they construct and interpret explanations, rather than focusing predominantly on justifying a given account through subsequent claims and evidence.

Student learning is generally enabled by timely teacher scaffolding to guide students' attention to critical dimensions of learning tasks or hard-to-learn aspects of topics and includes perceptual clues, affective and aesthetic responses, embodiment of learners, and use of metaphors to guide thinking. This implies that students can learn from various informal reasoning processes and strategies, including role-play, thought experiments, pattern-spotting, improvisations, associative recollection of relevant experiences, visualization, including visual/spatial reasoning, and the use of imagination to devise explanations as they seek and solve problems.

Experimentation can be understood as a four-stage process where reasoning about inquiry involves:

i. Constructing representations to make causal claims,
ii. Submitting these representations to the scrutiny of observations and the viewpoint of others
iii. Investigating the adequacy of these representations by modifying or transforming them, and then
iv. Generalizing results.

Students can develop reasoning and representational skills concurrently. Teachers in this process function as expert guides and respondents to students' individual and group emerging accounts and claims about topics. Where students have a high degree of certainty about initial verbal understanding of causality in a topic, the teacher can prompt them to justify their reasoning through clarifying their claim by representing its application to a particular context. They can be asked to draw what is happening and its cause or causes. Where students are uncertain about the persuasiveness of their verbal or visual represented claim, the teacher can provide scaffolded prompts to guide further reasoning and representing. While most students might not initially know how to ask appropriate questions about the representational adequacy of their account of a topic or part of a topic, the teacher can promote very useful class discussions to consolidate student understanding.Effective learning can be built on a process of representation and re-representation, where students transfer their understanding to new or novel examples and applications of the concept.

Reasoning is now broadly understood as a set of higher-order thinking capacities with multiple strategies and goals. Reasoning entails both constructing representations as well as judging them.

The approach demonstrated today conceptualizes student learning through reasoning in terms of a three-way reciprocal linkage between teachers' and students' representations and domain knowledge.

Research shows that:

1. If the teacher focuses on students' thinking and reasoning as they attempt to represent concepts and processes in a sequence of representational challenges, this guided inquiry facilitates conceptual learning;
2. The teacher needs to recognize that students' understandings often diverge from the teacher's expert domain knowledge, and that there is a need to make explicit students' reasoning around representational adequacy to facilitate this learning; and,
3. The teacher needs to explore students' initial understandings and then build towards student understanding of the 'expert' view

Common Reasoning Phases:
Teaching Sequence.

The topic begins with the teacher asking the students to define in writing what they thinkis the meaning of the key terms. Students discuss with their partner to negotiate the meanings of these terms. Students are challenged to represent their understandings using simple everyday equipment. In each subsequent lesson, the teacher will prompt students to test and justify the adequacy of their understanding by a new question or an activity that was designed to challenge their representation of their emerging explanations. In each case, after the students had negotiated an account within their group, the class discusses each perspective in a student-student, student-teacher, and teacher and/or student-led discussion. This public justification stimulates a robust debate about the persuasiveness and clarity of different representations. Students are asked to reflect on the adequacy of their representations and, where appropriate, to modify them. In a number of cases, students will raise examples that challenge other students' accounts of key concepts.

In each lesson, the teacher tries to facilitate student discussion where students represent their understanding of a concept and justify their views. Overall, the students are asked to represent a claim, provide evidence for it, and then after further representational manipulation, refinement, discussion and critical thought, to reflect on and confirm or modify their original case.

Phase 1: Establishing student knowledge. The teacher asks the students to represent in writing the meaning of key terms. Students reason from their prior experience, their past exposure to these terms, and from discussion/debate with peers.

Phase 2: Small group student discussion. Students are asked to discuss with partners the clarity of their definitions. This sets the scene for testing the adequacy of student verbal meanings. The teachers do not provide a set of commonly agreed definitions. Students' reason from identifying shared and contested account in the definitions.

Phase 3: Students re-represent their understanding.Studentsare challenged to demonstrate their understandings using simple everyday equipment. The teacher circulates amongst the students asking them to think about what they were planning to do to illustrate their explanations. Many questions are asked to prompt students to think why their proposed explanations are reasonable. After this, students combine their understandings with a verbal commentary in their reports to the class.

Phase 4: Further Re-representation work. In each subsequent lesson, the teacher prompts students to test and justify the adequacy of their understanding by a new question or an activity that was designed to challenge the representation of their emerging explanations. The activities and questions could require students to take a 2D (or 3D) representation and then re-represent these explanations (3D or 2D). In this stage, students were required to participate in more detailed class discussion on the meaning of these terms, with the teacher using questions to gauge the clarity and adequacy of their representations. This public justification often stimulates a robust debate about the persuasiveness and clarity of different representations.

Phase5: Students modify and compare their representations using reasons. Students are asked to reflect on the adequacy of their representations and, where appropriate, to modify them. This process often raises students' questions or examples that challenged other students' accounts of key concepts. Any reasoning from authentic examples is pivotal in the development of students' understandings. It allows them to reason inductively through noting generalizable ideas from different examples.

Phase 6: Transferring understanding to new contexts. Students need to demonstrate the ability to transfer the understandings to new contexts.

Phase 7: Public defense of claims. Studentsare asked to re-work their explanations and include examples. They could draw a picture to clarify or elaborate their explanations. The students are expected to defend their understanding through a teacher-facilitated class discussion and to show their understanding publicly. All students will use visual, verbal and gestural explanations to illustrate their viewpoint. The discussion about the adequacy of their explanations should led these students to refine their viewpoints to what can be considered as scientific or mathematical explanations. The process of students declaring their understanding through visual representations of their reasoning usually leads to a more explicit explanation of their understanding after they had clarified and re-represented their views.

In summary, students use a range of reasoning processes and strategies to generate and critique their own and others representations. There is a constant interactive cycle of constructing a claim (verbally, visually), seeking evidence, justifying and validating with appropriate revisions of understandings that occurs within and across a series of lessons.

Results of using a representational reasoning approach:

- Students appear more confident when explaining their reasoning to other members of the class.
- Students appear to be genuinely interested in their learning, characterized by the types of questions they asked, and responses given to teacher questions.
- Students appear more willing to participate in all set activities.
- Students state that they are more engaged in learning and look forward to these science lessons more than in previous science and mathematics classes.

Student views of this approach

Students report that compared to traditional classes:

- The classes were more interesting and engaging. They felt that being involved in discussions through drawing on the board, and that explaining and clarify reasons improved their learning;
- The teacher used less talk and bookwork but facilitated learning by requiring them to explain and justify possible explanations;
- The need to re-represent their understanding through activities, diagrams or showing the class by drawing on the board assisted their understanding of the concept;
- They felt that their ability to explain was improved through the necessity to reason and explain their viewpoint. They felt that the teacher requires them to work out possible solutions rather than being told the answer had resulted in improved understanding;
- This approach allowed them to examine real life examples which deepened their understanding of the concepts; and
- Group and classroom discussions were a key feature in developing, clarifying and evaluating understanding of concepts.

These findings suggest that student learning in this topic was supported by the following pedagogical principles. The teacher needs to set up a guided inquiry entailing a sequence of

representational challenges for students relevant to understanding and applying key concepts and processes in the topic. In this learning sequence, students need repeated opportunities to construct, critique, justify and refine their representational claims through discussion and various kinds of re-representational activity.

Student reasoning is influenced by (a) prior understanding of the need to build a coherent account that links properties/behaviour of objects with plausible claims, (b) prior experience with science class methods and the need for accurate measurement of change as the basis for hypothesizing, (c) informal qualitative reasoning around patterns of observed phenomena, and (d) everyday language use of technical terms, and everyday accounts of causality. This re-representation work can draw on perceptual contextual clues, as students attempt to identify key observed aspects of phenomena for investigation, as well as problems/gaps/inconsistencies, and also evaluate the adequacy of their own views compared to what they observed with other groups and their representations.

Guided student representational work provides opportunities for students to develop conceptual understanding through various kinds of formal and informal reasoning. The most complex form of reasoning by students arises when they communicated results, and were "*using logical arguments to defend their findings*".

By using representations as creative, provisional, emergent contestable artifacts needing justification and elaboration of their meaning, students are practising habits of mind and reasoning skills central to literacy. Students can be assessors of their own learning, and a critical audience and sounding board for the other students, thereby co-operatively fostering reasoning and literacy development aligned to subject practice in a micro learning-community. Importantly, the teacher facilitates this guided inquiry through critical feedback on the adequacy of student-generated claims evident in their representations.

Student Voice

Involving students in dialogue about their own learning helps students become better learners, and assists teachers to improve their pedagogy. Learning is enhanced when the teacher monitors the views and beliefs of the students that they bring to learning and to monitor these during teaching of a concept. Students want to voice their ideas as they participate in the learning process. Student voice is the active opportunity for students to express their opinions and make informed decisions regarding their learning experiences. Student voice can serve as a means to engage students.

Outcomes

1. Improved achievement when compared to similar schools (see Figure 1)
2. Improved student engagement
3. Improve student retention and subject choice
4. Less teacher stress
5. Students more aware of progress and achievement (Greater personalization)

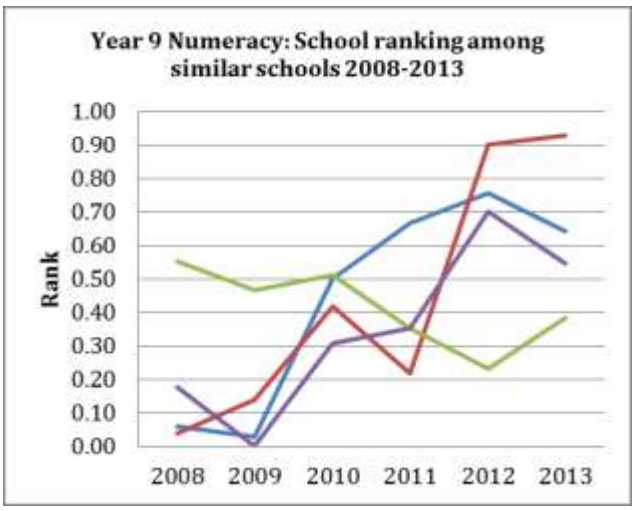

Figure 1. Academic Ranking Improvements, comparing to similar schools.

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