FROM CONTROLLING TO COMMUNICATING: INNOVATION IN BOTSWANA'S TEACHER PREPARATION PROGRAMME ON INTEGRATION OF ASSESSMENT AND INSTRUCTION

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This paper reports on an analysis of part of a wider study to investigate innovative approaches in the preparation of mathematics preservice teachers in the integration of assessment and instruction (IAI). Student-teachers' teaching practice was analysed to reveal the effects, if any, of IAI training that emphasised communication over control. The reported case studies show that training student-teachers in this way facilitated their application of IAI, and led to increased reflexive use of information from pupil responses in the their teaching, compared to that observed with previous cohorts of students.

Introduction

The integration of assessment and instruction (IAI) refers to teaching and assessment being intertwined, to assessment being used formatively. Torrance and Pryor (1998) suggest that IAI occurs when assessment is intended to generate information about children's knowledge and understanding while at the same time contributing to the process of creating that understanding. In mathematics teaching, the main aim of IAI, as Chambers (1993) explains, is to access students' mathematical thinking, and reflect on how to use that knowledge as the basis for instructional decisions for both individual students and the class as a whole. Feedback from such assessments should inform the student of what he or she can do to improve or move further in his or her learning, as suggested by Black and Wiliam (1998). IAI in this study made limited use of techniques of assessment that rely on written work such as tests. More focus was placed on assessment techniques that may be used hand-in-hand with on-going teaching, such as oral questioning and observations of students on task.

The wider study

The wider study from which this report is taken is an action-research project on my own practice as a mathematics teacher educator. It was formulated in the context of the purpose of equipping student-teachers with the necessary tools for their teaching career. It was conducted at Tonota College of Education (TCE) in Botswana, which trains teachers for a Diploma in Secondary Education qualification (DSE). A class of 21 student-teachers training to teach mathematics was involved in the study. The practical element of the study was undertaken over a period of six months covering college-taught sessions and Teaching Practice in placement schools.

In my previous work with student-teachers, I had observed a general failure in their application of IAI during Teaching Practice, despite them receiving several lectures about its techniques and methods, and its importance in the teaching and learning of

mathematics. The students of previous cohorts could not assess students' mathematical thinking effectively or use the knowledge to make appropriate instructional decisions. Invariably, their teaching was characterised by "telling" students rather than engaging them in the negotiation of meanings or construction of knowledge. This observation was also made by educators from the University of Botswana (UB), which validates the DSE programme, and questions were raised about the nature of teaching at the college, which is dominated by the lecture method. The UB, through Hopkin (1999) recommended that:

> The College (TCE) should explore the use and development of co-operative teaching in their training programme.

In recognition of this problem, I focused my investigation on how my methods of training affected student-teachers' learning. In other words, the study addresses what Russell (1997) calls the 'pedagogical turn'. I also investigated the 'content turn' by training student-teachers in IAI. However, as indicated by Webb (1993), IAI is not easy and requires teachers to be prepared for its application. As suggested by Heid et al (1999), mathematics teachers do not automatically attempt to determine students' understandings. They need to be empowered to act in that sense, for example by learning to listen with student understanding in mind, rather than as part of a method to control student responses.

In order to make a deliberate difference I designed a new teaching programme to illuminate aspects of IAI that I wanted student-teachers to use. It involved (i) oral questioning (ii) responding to students' responses and (iii) practical ideas that a teacher can draw from to facilitate his or her use of the proposed approach. This was designed to enable student-teachers to reduce control over the students' responses and allow the students to communicate their mathematical thinking.

As this study was a practitioner-based research seeking to improve practice, I employed action research methods that allowed me to monitor and modify the training as it unfolded. Therefore, it is likely that my influence on student-teachers' applications of IAI was not constrained by the research process, in that I had the freedom and experience to assist professionally. However, the fact that I was learning at the same as the students may have influenced them.

Data collection and analysis procedures

A lesson observation instrument was used to collect data on student teachers' implementation of IAI, focusing on their planning, on their questioning and other strategies for identifying and eliciting students' mathematical thinking, on their feedback to students, and on their self-evaluation. The lesson observation instrument was supplemented by other data sources such as detailed notes of class incidents, particularly the exact questions and responses exchanged by the student-teacher and their students, and student-teachers' self-reports. The analysis of data focused on the characteristics of student-teachers' application in comparison to each other and in

reference to the aspects of the IAI approach covered during training. The overall objective of the analysis was to establish whether training student-teachers in IAI in the way I adopted enabled them to apply it during Teaching Practice.

Results

Three case studies are reported in this paper. They have been chosen to illustrate the range of degree of application of IAI in the cohort studied.

Elvis

Elvis's lesson planning explicitly made use of information obtained from previous classroom assessment, a point repeatedly emphasised during training. For example, in one of his lesson plans, under the introduction section he wrote:

Time	Content
10 min	Introduction General comments on marked exercise from last lesson (errors detected) $5\frac{1}{4}$ not $5\frac{1}{4}$ make reasonable statements after solving word problems ie (encoding) add: $2\frac{3}{5} + 4\frac{1}{2}$ If 6 (2 + 4) is done Therefore $6 + (\frac{3}{5} + \frac{1}{2})$

In his lessons, Elvis evidently elicited alternative problem solving strategies by advising students to make realistic decisions on the strategies they preferred to use. He commented that the strategy chosen should be what the individual student understood rather than that it was used by the teacher or other students. He posed questions that informed students clearly that there were alternative strategies that may be used. This is illustrated in the following dialogue:

T: How do we go about simplifying this? (Pointing to 2.4 : 2.7 on the board)
(Students suggest changing the numbers into fractions and the problem is worked through on the board.)
T: Is there another way of doing it besides changing it to fractions?
S: Multiply by ten and simplify
T: Why did you decide to multiply by ten?

This line of questioning required students to feel free to express themselves. Nevertheless, Elvis found it hard to promote the student-to-student interaction that he wanted so that students would communicate their thinking and share their strategies. His recognition of the importance of this revealed his understanding of students as well as that of the demands of IAI. Indeed the issue of giving students opportunities

to express their understanding is recognised by Black and Wiliam (1998, p11) to be essential in the design of teaching for formative assessment to aid learning. I assisted him in planning and implementing activities that allowed students to interact with each other in one of the lessons. We agreed that he could ask me to intervene during the lesson and I could participate in ways demanded by the situation. After receiving this moral and practical support he regained his confidence in posing questions that required students to communicate their thinking. Without this extension of the training into the Teaching Practice period, Elvis may not have been able to sustain his initial application of IAI due to a failure to get students to express their understanding.

As a result of it he became increasingly able to ask questions that illustrated or revealed certain aspects of the mathematical concepts, and this provided students with an opportunity to learn in the process. In one lesson, students were asked what they would do to simplify a ratio. The response was that they would divide by the LCF and the teacher decided to illustrate that the LCF of any two numbers is 1 by using factors of 10 and 20. He then asked them what they could say about 1 and 10 from the lists of factors. The fact that 1 is the LCF of the two numbers was illustrated and they were asked which of the two would they use to simplify a given ratio. This exchange was giving students an opportunity to learn about the difference between LCF and HCF as well as for them to realise that 1 would be the LCF of any two or more whole numbers, which is usually not considered when teaching the topic.

Elvis often provided students with feedback that supported their knowledge and also extended it in a challenging manner. This was done by asking students to account for their solutions, for example by questions such as:

Why do you multiply 4 by 500? Say it out, I'm not saying you are wrong.

The student is supported by being told that questioning them does not mean that they are wrong, but is intended to extend their knowledge.

What about if this was 10m and 2kg? Can we compare them?

Here, Elvis wanted students to realise that in ratios the quantities must have the same units. He then moved on to m and km and to conversion of units to express the quantities in ratio form. This type of questioning, to provide challenges to students' knowledge in the process of giving them feedback on what they already knew, was explicitly encouraged during training.

Elvis also reflected on how to improve his practice. Motivating students to feel free to communicate their thinking was identified as an area for improvement in his teaching. He pointed out that making connections between topics explicitly was also found to enhance such communication for his students. He suggested that some topics might be easy to understand, thus making it possible for students to say something on them spontaneously. By the end of the last lesson that I observed he engaged comfortably in an extended exchange with one student. However, he

continued to experience problems with making decisions about when to persist in the extended exchanges with individual students. This was a reminder to me that there can be no recipe that would work for everyone, as observed by Wiliam (2000, p22).

Tina

In Tina's case, lesson planning was significantly different from other student-teachers' planning and this seemed to have an effect on how the lessons progressed. Her initial lesson plans reflected a shallow consideration of content coverage and insufficient student involvement in the development of the concepts. This was evidenced by her failure to recognise alternative solutions raised by students. In one of her self-evaluation statements, she wrote:

> *"Most of the students were responding well except in the last part where I was unable to use some of their wrong answers well as they gave unexpected answer but some were correct e.g. They gave 18 x 2 while I expected 9 x 4. I could have asked them to expand 18 to get 9 x 2 then have 3 x 3 x 2 x 2."*

Either Tina had not considered various ways of expressing 36 as a product of its factors in her preparation, or she had a shallow understanding of the subject-matter. I had no reason to believe that the latter was the more likely explanation since she was one of the two student-teachers in the class with the highest 'O' Level grade. Whatever the reason, it resulted in a restriction of the use of students' responses in developing the mathematical concepts and thus assessment was not effectively integrated with instruction according to its interpretation in this study.

However, through processes infused in the training program to assist student-teachers to apply and sustain initial application of IAI, like self-evaluations, class observations, practical assistance and conversations after lessons, Tina managed to make progress towards flexibility in both content and use of students' mathematical thinking. In particular, discussions of students' responses that focused on why they may have responded that way made her view ideas from different perspectives. These reflections enabled her to learn to view the situation from the students' perspective; the kind of reflection that Wood (2001) suggested to be essential for pedagogical reasoning. Her line of questioning gradually changed from the more controlling, 'what' type of questions to include more 'why' and reasoning type questions. In the last lesson that I observed, I noted an exchange between Tina and a student that reflected this change of questioning, as follows:

T: What do you think you are going to get?
S: Negative two.
T: How did you get that? You have to try a step-by-step approach.

I viewed this type of questioning as encouraging students to think and communicate their thinking rather than controlling their responses.

Tina also observed changes in students' motivation as a result of allowing them to express their thinking orally and this encouraged her to pose questions that enabled

everyone to say something. In one of the lessons, she based the development of the concepts on students' responses to the question "What have you observed?" Although she struggled to provide useful feedback to the students, it was clear that she wanted to make use of their responses to enhance their understanding. She viewed this as important, as reflected in her Teaching Practice report where she stated:

> *"As the lessons went on some lessons were conducted by questioning asking questions and the lessons are now interesting as they are well motivated. Also pupils are able to answer orally asked questions than written ones."*

The fact that Tina recognised how such assessments affected students' motivation and that she could use the situation to benefit the students made her pay more attention to how to sustain the situation.

It seemed that Tina's difficulties in applying IAI were rooted in inadequate lesson preparation during the initial stages. It appeared as though the emphasis on lesson planning during training was not done effectively for her to understand its importance. Though she persistently experienced difficulties with providing appropriate feedback, there were signs of improvement arising from the continuation of training through my active support during Teaching Practice.

Bowie

The most developed application of IAI in terms of lesson planning and the level of performance during the lesson was shown by Bowie. Lesson plans were detailed in terms of content, students' activities and the teacher's activities. It was evident that questioning was given consideration during planning just as had been recommended during training. The questions that he was to draw from were often stated in his lesson plans. For example:

> *"Some questions to be asked by the teacher: 1) What can you see in your reading that is common? 2) What do you think is the use of the decimal point?"*

From the first meeting Bowie exposed students to group work and to communicating their thinking to the rest of the class. He seemed to have internalised the assumption of active involvement by the students that IAI is based upon. The deliberate emphasis on the notion of learning from each other, including himself in that he was ready to learn from the students, can be associated with socio-cognitive theories of learning, that include ideas of 'learning from learners'. He achieved this purpose through posing questions such as "Can somebody explain what he said to me?" A working atmosphere in which students became free and keen to express themselves was established. In Bowie's lessons, students were observed posing questions and volunteering explanations to the class, unlike in other classes. This did not happen by chance, but because he created room for it through deliberate tactics to involve students, such as posing questions back to students, appropriate waiting time, and being honest about things he was not sure about, thus giving students confidence that

he could actually learn from them. Throughout his trials of these tactics, his reflections drew heavily from the training. In our conversations after his lessons, he often related students' experiences to his college experiences, particularly the struggles encountered in group work and benefits gained from discussions with other student-teachers. It is presumably this experience or the practical exposure provided by the training program that enabled him to try out ideas to motivate students to reveal their mathematical thinking freely. How he was taught during training seems to have had an influence on his teaching.

Good questioning skills was one of Bowie's strengths in the application of IAI. He used the type of questions recommended during training that were perceived to enable students of different abilities to come up with something to say, such as:

> *"What similarities can you observe? What is common among these readings?"*

Students' responses were commonly used to ask further questions that in some cases supported the acquired knowledge and sometimes led students towards the mathematical concept being developed. This can be seen in the question:

> *"The three is a fraction of a centimetre. Should we write mm or cm (written on the board) now that we have three over ten ($\frac{3}{10}$)?"*

Bowie's questions and the dialogue that followed bear similarities to that which Black and Wiliam (1998, p12) recommended, in stating that:

> The dialogue between pupils and a teacher should be thoughtful, reflective, focused to evoke and explore understanding, and conducted so that all pupils have an opportunity to think and to express their ideas.

Bowie employed a variety of assessment techniques such as observations to identify students' strategies that he then used in further instructional decisions. The observations of students' strategies served a meaningful purpose of exposing them to alternative strategies. They were not merely to check who was correct. In one lesson, the following strategies were identified through observations of students' work and were put up on the board for a class discussion:

(a) 12 x 10

H T U

1 2

↙ ↙

1 2 0

(b) 12 x 10

12

x10

00

12

120

(c) 12 x 10

12. 0

↘ 1 place to R

= 120

This exposure to alternative strategies was followed by questions that reinforced knowledge already acquired by the majority of the students, if not all;

> *"What observation have you made when you multiply by 10?"*

Another demanded thinking from a different perspective;

"What happens to the digits when the decimal point moves to the left?

The latter demonstrates how students' knowledge can be challenged by way of providing feedback in the form of further questioning without necessarily posing difficult questions. Bowie also used questions such as "What else is missing?" to stimulate students to think of more, and from different perspectives. To me this was a sign of his perceptions of students: that he saw them as capable of thinking beyond their current thinking, as people who are capable of thinking for themselves instead of being there to be 'filled' with knowledge.

Conclusion

The case studies reported in this paper show how moving from controlling to communicating was achieved by empowering student-teachers during a preservice training programme. Previous cohorts did not progress to communicating because they did not have the advantage of the training methods I devised for this programme. The case studies also emphasise how individual student-teachers' learning differences play a significant part in their progress, and illustrate the value of training programmes having a means of incorporating further training for some student-teachers within Teaching Practice. In the study being reported, this was achieved by making supervision of student-teachers' first Teaching Practice formative, rather than to serve the purpose of grading currently practised at TCE.

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