Confidence-based assessment in science: an illustrative case study

Evaluación confiable en ciencias: un estudio ilustrativo de caso

CHARLY RYAN

Faculty of Education, University of Winchester, SO22 4NR, UK, Charly.Ryan@winchester.ac.uk

Abstract

Assessment for learning has proven potential for development of learning in science. A study of the use of one approach to assessment for learning, confidence-based assessment, in initial primary teacher education for science shows the potential of this approach for science teacher education in particular, and for science education in general. Furthermore, the study shows how the approach can also be used as assessment as learning, as the assessment activity helps develop the students' learning. The development in confidence that the students felt has implications for other levels of science education. If school students were to be introduced to confidence based assessment it could help increase their confidence in their science knowledge and develop positive companion meanings for science

Key words*: confidence-based assessment, assessment for learning, teacher education*

Resumen

La evaluación para aprender tiene una potencialidad cierta para desarrollar el aprendizaje en ciencias. Éste es un estudio sobre el uso de una manera de hacer evaluación confiable para aprender, dentro de una formación inicial para profesores de escuelas básicas. Muestra las posibilidades de esta estrategia, sea en la formación del profesorado o enseñanza aprendizaje en las escuelas. El aumento de la confianza en los alumnos tiene implicaciones para otros niveles del sistema. Si los alumnos escolares encontraran una evaluación confiable, se podría aumentar su confianza en su aprendizaje en ciencias y desarrollar el significado positivo para su conocimiento científico.

Palabras clave*: evaluación confiable, evaluación para aprender, formación de profesores.*

INTRODUCTION

In the United Kingdom, where this study is set, there has been considerable work done on developing assessment in science. Traditionally, science teachers have been at the forefront of development of assessment of learning, what is it that the learners have learnt as a result of their science programmes (NIEDA, *et al.,* 2004). In the 1990s, there was considerable effort devoted to the concepts of formative and summative assessment and their particular roles in education. Summative assessment was seen as an assessment that established how much a student had learnt. This form of assessment is often used at the end of key stages of education, at transition points from one level to another. So, the results of examinations at the end of secondary school are generally used as an assessment for suitability for work or university. Formative assessment was seen as assessment that was carried out during student learning with a view to supporting that learning. However, detailed analysis of these two forms of assessment showed that the classification depended on the use to which the assessment was put (WILIAM & BLACK 1996). For instance, summative examination scores at the end of primary school could be used for supporting the student's learning in secondary school. What was a summative assessment, end of primary school examination scores, had now become a formative assessment, an assessment used to support the students' learning. In recent years, the emphasis has shifted away from summative and formative assessment, particularly to assessment ***for*** learning (Black et al. 2002) and assessment ***as*** learning (Learning and Teaching Scotland 2005). In assessment ***for*** learning, the role of the assessment is to promote learning and a number of reports have presented the outcomes of a range of assessment strategies that seem to help promote learning (AIAA, 2003; OECD, 2004). In the United Kingdom, teachers in schools are doing much of this research and development work (BLACK, *et al.,* 2003). Assessment as learning is an assessment that allows learners to reflect on their assessment experience. Such reflection develops their metacognitive skills as well as their science learning, and so becomes assessment as learning. Students are learning from the assessment procedure. The work presented here is an account of the use of a new strategy, the use of confidence-based assessment in science teaching. This will show how this strategy can be used as an assessment ***for*** learning as well as an assessment ***as*** learning.

CONTEXT

This study was carried out in a three-year course of initial teacher education. As part of this course, all students have to study modules on how to teach science in the primary school, which are for children from ages 4 to 11. At the time of the study, there were detailed descriptions of what it was that the student teachers should know, both subject content knowledge and pedagogical content knowledge (DfEE, 1998). While these requirements have since been modified (TTA, 2002), most teacher education establishments have carried on using the old criteria for specifying subject content knowledge. The level of this subject knowledge is roughly that of the end of secondary school science examinations. While this study was carried out in initial teacher education, the content level is that applicable to secondary school science teaching. To enter the programme of initial teacher education, all student teachers have to have successfully completed their secondary school science examinations. However to pass the secondary school examination, students do not have to have complete mastery of the material. They need the minimum required to pass. In England, the National Curriculum for science covers the same areas of science in cyclic fashion from the ages of 5 to 16. This means that intending teachers of primary school science have to master the science curriculum. The 1998 initial teacher education criteria required complete mastery of all science topics, with an expectation that all students who successfully completed their initial teacher education would score 100% in their science content examination. In current practice, most institutions have gone for a less demanding success criterion. In the course reported here, the university decided that the criterion for successful completion should be set at 70% mastery over all topics, with a requirement that student teachers should have a minimum score on each area of science of 60%.

However, many studies show that students who successfully complete secondary school science education still have a range of alternative ideas (e.g. DRIVER, *et al.*, 1985; DRIVER, 1988) and that this also applies to students in initial teacher education (e.g. ANDERSON & LIBARKIN, 2005). That means that it is a demanding task for students to develop the required level of knowledge and understanding of science.

The teacher education programme for science

This is a three-year programme for intending primary teachers, who will be teaching children, aged 5 to 11 years. They have a module on teaching primary science in each year of the programme. A module has 30 hours teaching and 95 hours of private study. Students have to complete the module successfully to be able to progress. There is also a period of teaching practice in each of the three years of the programme. In the first year students gradually take over the teaching of the class so that by the end they have two weeks when they are responsible for teaching the class. In year two, they have a six-week teaching practice. They are expected to build up to five weeks when they are in charge of the class for two thirds of the time. On their final practice in the third year, they are expected to take charge of the whole class and the whole curriculum for at least 80% of the time. They are expected to teach science on each of their practices, to be assessed on that teaching as well as appropriate knowledge and understanding of science and scientific investigation.

The science teaching module in the first semester deals with how we can support children to develop their investigative skills in science. As students arrive with reservations towards science as a school subject, we encourage our students to identify, reflect on, share and challenge these views at the early stage of their training. In line with principles of developing assessment **for** learning rather than assessment **of** learning (BLACK, *et al.*, 2002) the module uses formative and self-assessment (BRADSHAW, *et al*., 2005) and a range of approaches to professional development planning. In year 2, the module focuses on developing children's knowledge and understanding in science. Students are asked to complete an on-line audit and then identify an area of science knowledge and understanding they want to develop. They form study groups with about three other students who need to work on a similar area. They then have to run a workshop, about 15 minutes, for their peers to teach an aspect of science they have learnt. The outcomes of their audits are revisited in Year 3 and there is a different professional development activity. Students use an electronic (online) version of the University of Cambridge Local Examinations Syndicate (UCLES) Audit. This audit is a 73 item, multiple-choice test where there are four options for each question. The audit was developed by a professional team of test developers with the assistance of a team of teacher educators who trialled pilot versions of the audit and advised on appropriate developments. The outcomes of the audit help to decide science contexts, e.g. forces, to include within the module teaching, for instance about progression.

The intention was that the results of the audit would help the students to identify an area of science most in need of development and then work on that, to prepare the workshop for their peers. When we reviewed the audit with the student teachers, there were a number of students who said they scored highly, e.g. 72%, by guessing. Despite convincing them that guessing from a four item multiple choice test would lead to a mark of 25%, they still did not feel they were confident enough in their knowledge for teaching purposes. Consequently, some student teachers were choosing areas for development where the audit suggested they had good knowledge, areas such as 'Forces' that the students knew were important for their development as teachers, rather than as science learners. They seemed to be going against the rational planning approach to their development, where it would seem that the obvious strategy was to work on areas that had scored the lowest. The choices that the students were making reflected discussion in the literature on the relationship between confidence and competence and its impact on teaching (SHALLCROSS & SPINK, 2002). The student teachers felt that their scientific knowledge was not in a form that they could use in the primary classroom. They seemed to be appreciating that learning to teach science was not simply a matter of knowing the science they had to teach. Further investigation led to the adoption of confidence-based assessment of their science knowledge and understanding.

Confidence-based assessment of science knowledge

In confidence-based assessment, students answer the question and then they have to decide how confident they are that their answer is correct. In the on-line version that we use they are asked to answer using the scale of 'low', 'medium' or 'high'. They are presented with each item from the UCLES Audit and then have to say how confident they are that their answer is correct. GARDNER-MEDWIN and GAHAN (2003) argue that 'knowledge' depends on confidence in knowing. They argue that there is not a simple dichotomy between knowing and not knowing. They propose a spectrum of knowing that goes from 'knowledge', where the knower is certain they are correct, through 'uncertainty', 'ignorance', and 'misconception' to 'delusion'. This spectrum represents a decreasing level in what is true and the learner has an increasing confidence in what is false. To have an appropriate measure of knowledge we need to help learners make their confidence explicit. In this way, the measure that the assessment produces would be a more valid measure of knowledge, as we have helped the learner make explicit their confidence in their judgments. In fields such as theirs, medical education, and of concern to us, teacher education, being confident that you are right and yet are wrong has important consequences. As a teacher, if you are confident that you are right, but are in fact wrong, you are likely to teach inappropriate science to your pupils. If you are less confident that you are right, you may take steps to develop your knowledge and your confidence or you may teach in a way that reduces opportunities for your students (HARLEN, *et al.*, 1995). While errors may be more obviously evident in medical practice in the short term, in science education the consequences may be more insidious, hidden and longer term. Teachers who confidently teach a misconceived view of science may have a significant impact on the future scientific conceptual development of their pupils. If this is the case, then we need to ensure that student teachers are aware of their level of confidence of their knowledge. To help them achieve this, they have to be honest in their evaluation of their confidence, and so they must feel safe in the test-taking environment. Furthermore, the marking scheme must motivate them to be honest. We attempt to set the environment by working from the students at the start of their careers with the view that, as professionals, we are responsible for, and have a duty to take charge of our own professional development. We introduce the notions of assessment for learning from the start of their learning to teach science. We tell them of the impacts of prior experience on teaching and what we might do about it. Students seem to be frank in their self-assessments and in analysing their science experiences (BRADSHAW *et al*., 2005). They use the range of tasks to support them in deciding their own pathways for developing their science teaching and trust them to carry it through in an appropriate, professional fashion. Our experience to date is that they respond to this trust and our expectations.

The marking scheme of the confidence-based audit is made explicit to the students in sessions before they complete the audit. The scheme rewards answers that are correct and where the student has high confidence. Where the student's answer is correct but they have lower confidence, they receive a lower mark. The marking scheme is given in table 1. This marking scheme is made explicit to the student teachers and they see its logic. Where the answer is wrong and where the student has low confidence in their answer, they receive no marks. At the extreme where the student is wrong yet they have high confidence that they are correct, a situation that is likely to have a high negative impact on their own students learning, they are penalised heavily.

Table 1
Confidence-based mark scheme.

Confidence level	C=1 (low)	C=2	C=3 (high)	No reply
Mark if correct	1	2	3	0
If wrong	0	-2	-6	0

The audit is divided into sections dealing with the major areas of science curriculum such as forces, materials and their properties, inheritance and so on. Each of these sections is marked separately, the student teacher has feedback on their usual score, and their confidence based score. If the student teacher had every item correct and they were fairly confident they were right they would have a confidence based score of 100%. Because of high confidence being given a higher score student teachers who had everything correct and were certain they were right would score 150%. In the feedback, they are told how many items they had correct, what their level of confidence was and the consequences for their scoring. They are given advice about their level of confidence in their answers and whether they are under or over confident for their level of knowledge as shown by the audit score. They can also compare their outcomes with those of their peers. Based on their scores they can then chose an area that they think they need to develop. If they have scored highly yet are low in confidence, they would have a low confidence-based score so they could choose to work on that as part of their professional development.

Findings and discussion

The first group to trial this approach was a group of 28 students following a three year programme of initial teacher education. This group of students had originally completed the audit without the confidence-based assessment at the start of their second year of teaching. They completed the confidence based audit in the middle of their second year module and then again in the middle of their third year module. Thus, they were able to comment on the different approaches. The outcomes for the confidence-based audits are given in Fig 1. The data shows an increase in both the number of answers right and the confidence based score. The scores in the second year show that the actual score is higher than the confidence based score. This means that the average confidence rating for the student teachers' answers was less than 'fairly confident' towards 'not confident'. The data from the third year show that there has been an increase in the actual score and, more importantly, there has been an increase in their confidence-based score, which is also higher than their actual score. This means that by Year 3 they had between 'medium' and 'high' confidence in their answers. These data also suggest that the strategy taken to develop student teachers' knowledge and understanding, principally peer workshops, seems to be having a positive outcome. Watching these workshops, it is clear that for the majority of the student teachers they present their material in the context of their future roles of teachers, with parallels for

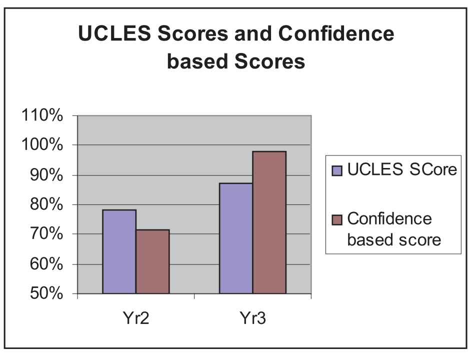

Figure 1. UCLES scores and confidence-based scores.

The pilot group completed a brief questionnaire on their views about the audits and the outcomes are in table 2. They seemed to be pleased with this development in their programme. At the start, I wondered about the impact of doubling the number of items to which they had to respond, the multiple-choice item and their confidence in their reply. For some students, they seemed to think that the new test was shorter than the previous version. It must be that it felt shorter, an unexpected outcome of the approach.

Table 2
Comments on New Confidence-based UCLES Audit

This audit gave you the correct answer if you got it wrong.
It was a reduced audit.
Confidence part was more useful + specific to each question.
The fact that it combined knowledge & confidence audit.
It combined knowledge and confidence in own knowledge
It gave me the opportunity to distinguish between the answers which I was definitely guessing at and those which I was sure of.
Seemed less daunting in its more colourful presentation.
It was in clear sections. You were able to re-take the test. There was no time pressure and it was multiple-choice.
It enabled you to judge your level of knowledge and areas I feel I need addition support in.
It made you aware of your confidence in a topic so you could revise something that you aren't too confident in.
Made you aware of how confident you were in parts although actually knowing answer.
It rated confidence as well as knowledge.
It told you the correct answer which was useful for revision purposes.
Clear layout-divided into sections-corrected errors. Scores by section
It told you the correct answer if you got it wrong. The questions and multiple choice answers were clear. Instant feedback.
It gave the correct answer if you got the question wrong.
The way you were asked how confident you were for each question.
Told you the correct answer if you got an answer wrong before moving onto the next one.
Gave correct answers so helped me to learn.
You could rate your actual confidence. Separate sections + results. Quick and easy.
The audit was split into sections which made it clearer to do.

In a group discussion about the audits, and the choice of topic for assignment, this group were vociferous in saying that they felt the original audit showed that 'You just knew a lot of stuff.' 'It's just a ragbag of bits and pieces.' They were starting to think about the audit, what it showed, about assessment and its purposes. It seemed to be an example of assessment **as** learning (LEARNING and TEACHING SCOTLAND, 2005). It was a very good way to raise the issue of knowledge versus understanding, on the roles of assessment in learning, and how they were learning from the process, and what might be the implications for their future pupils. The second area of debate was the nature of teacher knowledge and how different knowledge's relate to each other in teaching, a topic that can be difficult to broach in a meaningful way. They were starting to analyze in a thoughtful way the roles of different types of teacher knowledge. Their experiences with this audit showed that teaching was not a simple transmission of knowledge from them to their students; teaching and learning involves a range of other aspects including confidence.

CONCLUSIONS

The student teachers in this pilot group were pleased with this new form of assessment. They see it as an aid to learning, as assessment for learning. In discussions with the students, a number of them said that when the audit asked them to rate their confidence in their answer, they went back to their answer to decide whether they were right or not. This form of assessment was helping them to reflect on their learning. They also saw how the approach helped them to develop their knowledge and their confidence in their knowledge. This is a particular issue for this largely female group of students whose science experience has frequently been negative (RYAN, 2003). It shows how, with appropriate support, they can see that they can be successful learners of science, an attitude that may transfer to the classroom, as student teachers tend to do what their teachers have done.

The development in confidence that the students felt has implications for other levels of science education. There has been a range of studies showing how children's liking for science falls off as they go through school (e.g. TIMSS, 2003). Students learn science but do not see its relevance for their future lives as citizens and choose not to follow scientific careers. Part of this decline may be due to the science assessments that they experience (ASSESSMENT AND LEARNING REVIEW GROUP, 2004). A second contributor to the decline might be their knowing science material yet not being confident in their knowledge such that they see their science knowledge as irrelevant. If school students were to be introduced to confidence based assessment it could help increase their confidence in their science knowledge, just as it did with this group of student teachers. The companion meanings of assessment (ROBERTS & OESTMAN, 1998), the implicit learning that students take from activities, would be positive. As with this pilot group, the assessment can also act as assessment **for** learning as well as assessment **as** learning, leading to higher attainment. We might thus enter a virtuous cycle where increasing knowledge and confidence leads to increasing interest in being successful in science, a key aim of science education.

BIBLIOGRAPHY

AIAA *Self Assessment*, Durham, AAIA North East, 2001. At http://www.aaia.org.uk/pdf/AAIAformat4.pdf, accessed 30/11/05.

Anderson, D.J. & Libarkin, J.C. (2005). Digging into earth science, *Revista de Educación en Ciencias/Journal of Science Education,* **6** (2), 65-68.

Assessment and Learning Review Group, *A systematic review of the evidence of the impact on students, teachers and the curriculum of the process of using assessment by teachers for summative purposes*, London, EPPI Centre London Institute of Education, 2004.

Black, P.J.; Harrison, C.; Lee, C.; Marshall, B. & Wiliam, D. (2002). *Working inside the black box: assessment for learning in the classroom.* London, UK: King's College London School of Education.

Black, P.; Harrison, C.; Lee, C.; Marshall, B. & Wiliam, D. (2003). *Assessment for learning: putting it into practice*, Buckingham, UK: Open University Press.

Bradshaw, A.; Clarke, H.; Erricker, J.; Fletcher, L. & Ryan, C. (2005). Developing writing for understanding - primary teachers perceptions of science, *Science Teacher Education*, 43, 8-9.

DfEE, *High Status, High Standards*, London Department for Education and Employment, 1998.

Driver, R. (1988). Un enfoque constructivista para el desarrollo del currículo de ciencias. *Enseñanza de las Ciencias*, **4** (2), 109-120.

Gardner-Medwin, A.R. & Gahan, M. Formative and Summative Confidence-Based Assessment, *Proceedings of the 7th International Computer-Aided Assessment Conference*, Loughborough, UK, July 2003, 147-155 at www.ucl.ac.uk/~ucgbarg/tea/caa03.doc (Accessed 29/11/5).

Harlen, W.; Holroyd, C. & Byrne, M. (1995). *Confidence and understanding in teaching science and technology in primary schools*, Edinburgh, Scottish Council for Research in Education.

Driver, R.; Guesne, E. & Tiberghien, A. (1985). *Children's ideas in science*, Milton Keynes, Open University press.

Learning and Teaching Scotland, 2005. at http://www.ltscotland.org.uk/assess/ (accessed 29/11/05).

Nieda, J.; Cañas, A. & Martín-Díaz MaJ (2004). *Actividades para evaluar ciencias en secundaria,* Madrid, Universidad de Alcalá de Henares / OREALC/ Cátedra UNESCO / Libros López Machado.

OECD, Formative Assessment: Improving learning in secondary classrooms, Paris, 2004. Resumen en castellano: Evaluación formativa: mejora del aprendizaje en las aulas de secundaria, 2004, at http://www.oecdbookshop.org/oecd, accessed 30/11/05.

Roberts, D.A. & Oestman, L. (eds.). (1998). *Problems of meaning in science curriculu*m, New York, Teachers College Press.

Ryan, C. (2003). Becoming a teacher of primary science: integrating theory and practice. *Teachers and teaching: theory and practice*, **9**, (4), 333-349.

Shallcross, T. & Spink, E. (2002). How primary trainee teachers perceive the development of their own scientific knowledge: links between confidence, content and competence? *International Journal of Science Education,* **24** (12), 1293-1312.

TIMSS *International Student Achievement in Science*, Boston, TIMSS, 2003.

TTA, *Qualifying to teach: professional standards for qualified teacher status and requirements for initial teacher education*, London, DfES, 2002.

Wiliam, D. & Black, P. (1996). Meanings and consequences: a basis for distinguishing formative and summative functions of assessment, *British Educational Research Journal*, **22**, (4), 537-548.

Received: 14.08.2005/ Accepted: 3.04.2006