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The duality of coding assessment information

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The challenges and activities of outcomes-based education and very often the beauty of this 'new' approach are often overshadowed by the realities of the classroom and the difficulties of assessment. One of the greatest problems concerning outcomes that address knowledge, skills and values is to determine and qualify different types of assessment information. This article examines the dichotomy of determining or qualifying, i.e. grading or portraying assessment information. The article investigates, firstly, the setting of practical criteria and, secondly, the adequacy of assessment criteria in guiding the judgments of the assessor. A possible guide for coding assessment information is suggested with specific reference to mathematics as learning area.

Introduction

Assessment has become one of the hottest issues in recent developments in education. The challenges and activities of outcomes-based education (and in most instances the beauty of this 'new' approach in education) are overshadowed by the realities of the classroom and the difficulties of assessment. To assess knowledge and content is an easier exercise than to assess skills and values. In order to address the issue of assessing outcomes representing a broad range of skills, alternative assessment procedures have been introduced (NDE, 1997a, NDE, 1997b, NDE, 1998, C2005, 2000). These procedures may often lead to prescriptive assessment where learners must meet a predetermined set of outcomes which can only be demonstrated in a specific set of ways. Ecclestone (1999:37,45) argues that such a drive for greater transparency by means of elaborate specifications often results in criteria that are incomprehensible to all but those who debate and create them. Such procedures may exclude and marginalise other ways of thinking. The other extreme may also occur where outcomes are so broad and general that any open-ended response may suffice.

Purpose of the study

One of the greatest problems concerning outcomes that address knowledge, skills and values is to determine and qualify various types of assessment information. This article examines the dichotomy of determining (quantifiying) or qualifying, i.e. of grading or portraying assessment information with specific reference to mathematics.

Statement of the problem

A dichotomy may be observed in the assessing of fixed and exact knowledge versus assessing a broad range of skills. Answers are sought to the problem of how learners know the basis of their respective grades or results in the classroom. The following question is posed:

- How may assessment information be coded?

The problem deals with the setting of practical criteria as well as adequacy of assessment criteria in guiding the judgments of the assessor. This article investigates the problem of distinguishing between dimensions and tentatively suggests a possible assessment guide for coding. This problem is investigated against the background of mathematics as learning area.

Research methodology

Developments in educational assessment are investigated by means of literature, articles, newspapers and other media. A brief conceptual outline of assessment within an outcomes-based framework is presented followed by an analysis of some official guidelines laid down by education bodies. Certain assessment practices in the mathematics classroom are reviewed: mathematics examples are taken from a common standardised examination written by Grade 9 learners in the Free State (DEFS, 2000:2; 3). Three representative responses are used to illustrate patterns of engagement and problem solving. The subsequent discussion of the responses is used to analyse the stated problem and to provide insight into the argument of grading versus portraying. These practical mathematics examples are presented in an attempt to address issues of viable criteria as well as their adequacy. Possible applications are indicated and conclusions are drawn.

Conceptual framework

Certain assessment concepts need clarification in order to distinguish between grading and portraying. Concepts such as measurement, evaluation, standards and grading play an important role in our understanding of coding assessment information. Clarke (1996:328) argues that the role of assessment in teaching is to model, monitor and inform. These three functions emphasise an increasingly integrated function of assessment in instruction and learning. Modeling addresses the extent to which assessment serves as an effective model of valued performance and effective educational practice. These performances should be monitored by providing learners with adequate opportunities to display their capabilities. The information function concerns the effectiveness with which assessment provides information concerning the actions of all stakeholders in assessment.

Assessment is an encompassing term including measurement, testing, evaluation, standards and criteria according to McMillan (1997:8). Linn and Gronlund (1995:5) as well as Freeman and Lewis (1998:314) regard assessment as a comprehensive term which includes the full range of procedures used to gain information about student learning (e.g. observation, ratings of performances or projects, paper-and-pencil tests) as well as the formation of value judgments concerning learning progress. Measurement has traditionally been defined as a systematic process of assigning numbers to the results of tests or other types of performance (Cangelosi, 1990; Cangelosi, 1996; McMillan, 1997, Linn & Gronlund, 1995). It can also be used to determine how much of a trait, attribute or characteristic an individual possesses. McMillan (1997:9) adds an extra dimension when he argues that this differential attribute of measurement can either be quantitative or qualitative. He further argues that evaluation involves an interpretation or inference of results through measurement (McMillan, 1997:10). Evaluation therefore concerns the quality aspect of assessment: it is a value judgment regarding quality. In other words, to evaluate is to distinguish between traits in order to determine quality; to measure is to determine how much of a characteristic or trait is present in order to quantify results.

Standards are valued measurable results that indicate a specific level of performance (McMillan, 1997:10-28). Criteria are narrative descriptions of performances that address the factors used to judge performance (McMillan, 1997:217). The Draft Revised National Curriculum Statement (NDE, 2001a:22) describes assessment standards as the minimum level and depth and breadth of the demonstration of achievement of learning outcomes. The duality is obvious: assessment standards address the nature of the assessment process as well as the procedure as far as fluidity and versatility are concerned. However, broader assessment standards are recommended by the Draft Revised National Curriculum Statement (NDE, 2001a:22) in order to allow teachers greater flexibility in their interpretation of assessment while teaching. Consequently this flexibility must be reflected in the criteria used by the teacher to conclude that the learner does indeed satisfy expected learning outcomes. In the context of this article, standards may be called benchmarks (or blueprints) which reflect the nature of the evidence (meaning) required as well as the quality of the interaction (management) deemed appropriate.

A concluding activity of the assessment process is the translation of assessment information. Clarke (1996:353) argues that grading is a fairly simplistic form of coding assessment information where the emphasis is on simplistic and selective characteristics. Marking is an equivalent term for allocating 'marks' to any performance task (Conradie & Frith, 2001:226; 230; 232; CAT & EAT, 2001:2; 12). In the design of a coding system certain criteria must be related to such a system. A scale (quantity) must distinguish between levels of performance (quality). In other words, in terms of the above, depth and breadth indicate quality of achievement whereas level of performance indicates quantity. The inter-relatedness of measurement, scale and quantity (grading) on the one hand, and evaluation, performance levels and quality (portraying), on the other hand, is obvious. This emphasises the duality of coding assessment information.

Stiggins (2001:287) indicates the necessity of clear definitions of different levels of proficiency where coding is done in terms of quality. He argues that in the realm of subjective assessment appropriate scoring schemes must be devised. This is not an easy task. According to Ecclestone (1999:38) subjective assessment can be empowering or ensnaring. He warns that if outcomes are expressed as broad aims for teaching and learning, such broad aims may not be linked explicitly to considerations about how such aims might be assessed. He advocates more transparent and accessible forms of assessment as well as responsive, genuinely critical learning experiences for learners. Bassey (2001:9), however, refers to Forali's (1997) and Kosko's (1994) arguments in his appeal for the idea of 'fuzzy logic' in educational measurement to resolve the dilemma of allocating exact marks in ambiguous cases. Bassey advocates narrower ranges of marks or 'best-estimates-of-trustworthiness' as a viable solution to coding assessment information. This argument may perhaps address the problem of attempting to assess extensive outcomes. However, Hammersley (2001:223) argues that in most instances a multiple of interacting variables will always operate and users would have to draw on knowledge of the context, and on their practical experience in order to make informed decisions.

Despite clear definitions and guidelines or narrative descriptions, the process of coding different levels of performance in varying degrees of quality remains a complicated endeavor in classroom assessment. The above discussion reveals the following issues, underlining the complexity of coding systems and addressing at the same time the dilemma of quality and quantity.

Narrative descriptions for criteria may therefore imply that

- everything is a matter of degree, in other words, it is often difficult to distinguish fixed boundaries between categories;
- an infinite spectrum of options is possible which may complicate the coding of assessment information.

The question may be posed whether relatively standard cases should fall into the same grading scale in relation to more marginal ones that may possibly lie on the borderline of several categories. Another problem is the tendency to reduce qualitative coding systems to quantitative marking systems. Policy makers suggest conversions of quality to quantity (CAT & EAT, 2001:12). Provision is made to allocate marks to correspond with certain criteria. Hammersley (2001:219; 223) argues that truth itself may become a matter of degree if those criteria are not based on certain conditions and drawn on knowledge of the context. This emphasises the problem of providing adequate criteria in guiding the judgments of the assessor.

This study subsequently investigates a number of assessment practices in mathematics as learning area against the guidelines of the National Curriculum Statement (NDE, 2001a, NDE, 2001b).

Assessment practices

The National Curriculum Statement (NDE, 2001a) outlines assessment principles for implementation in the South African education and training system. The assessment framework of the National Curriculum Statement simplifies the assessment principles and procedures indicated in previous outcomes-based education models (NDE, 1997a; NDE, 1997b; NDE, 1998; C2005, 2000). The Draft Revised National Curriculum Statement (NDE, 2001a) attempts to consolidate assessment principles by means of less complicated terminology and more focused assessment standards for different grades. Assessment remains an integrated part of the instruction and learning process in every grade and learning area. Specific assessment standards address the expected levels of performance and range of performance indicators for each of the learning outcomes for each grade. Assessment standards, in other words, are narrative descriptions of performances within learning areas.

A major problem lies in the evaluation of performance once learners have completed the task or performance. The teacher is responsible for reviewing the responses constructed by learners and for making a professional judgment about the performance. The NDE (2001b:130-156) addresses the issue of coding in a very simplistic manner. The example (NDE, 2001b:131) in Table 1 illustrates assessment standards where a maximum of three options may be chosen:

Table 1 Coding example

Ass Std/s	Code			Comment for support
Ass Std	Yes		No	
Ass Std	✓		×	
Ass Std	Achieved		Not yet achieved	
Ass Std	A	B	C	
Ass Std	Not yet	Almost there	Achieved	
Ass Std	◗	●	■	

The example (NDE, 2001b:131) in Table 2 allows for only two options:

Table 2 Assessment codes

Learning Area/Programme		
Activity:		
Grade:	✓ satisfactory performance	
Coding (teacher's choice):	◙ Needs support	
Name of the learner	LO1, AS3 Evidence of estimation approaches	LO5, AS2 Evidence of knowledge of working with concepts and units of measurement
W. Learner	✓	✓
X. Learner	✓	◙ Cannot
Y. Learner	✓	◙ Cannot
Z. Learner	✓	✓

A national summative coding system is consequently recommended (or prescribed) to record learning outcomes specific to a grade (NDE, 2001b:132) (Figure 3).

The problem lies in the reminder (challenge?) of the authors of

Table 3 Coding system

	Learner's performance
A	**has far exceeded** the requirements of the learning outcome for the grade
B	**has exceeded** the requirements of the learning outcome for the grade
C	**has satisfied** the requirements of the learning outcome for the grade
D	**has not satisfied**, but is close to satisfying the requirements of the learning outcome for the grade
E	**is far below** the requirements of the learning outcome for the grade

this draft (NDE, 2001b:97-98,130) that the coding system does not represent marks or percentages, but is rather a management tool for the teacher to record the developmental progress of the learner. This implies that the teacher is responsible and accountable for designing and developing a means of justifying a coding system in any of the instructional stages in the classroom. Gruender (1996:27) advocates the need for designs that could supply a variety of techniques in various types of circumstances to learners and teachers.

How will teachers approach a coding system given these guidelines? The nature of the factors used to judge performance must first be analysed and coded by the teacher, i.e. learning outcomes and corresponding standards for each specific outcome. Marzano, Pickering and McTighe (1993) in McMillan (1997:217) argue that such value judgments should be a verifiable prediction that is entirely appropriate to the relevant facts, concepts or principles used to explain the assessment situation. The problem lies in the development and application of such criteria in the classroom.

Applications

A discussion of specific assessment criteria in mathematics follows. Sample learning outcomes and corresponding assessment standards are analysed in terms of mathematical content. Two different coding approaches are outlined in order to address the problem of assessment standards that may provide for the demonstration of knowledge and skills. A learning outcome is identified from mathematics as learning area, Grade 9 (NDE, 2001b:100):

> The learner is able to recognise, describe and represent patterns and relationships, and solve problems using algebraic language and skills.

An excerpt from one of the corresponding assessment standards (NDE, 2001b:101) for the mentioned learning outcome states:

> We know this when the learner:
> Constructs, uses and represents relationships between variables in a variety of ways including formulae, equations and expressions.

Learning outcomes identify the subject matter (e.g. algebra) whilst assessment standards analyse the subject matter (e.g. algebraic skills applicable to formulae, expressions and equations). This procedure has parallels with the traditional curriculum objectives and instructional objectives (Cangelosi, 1996:43-45).

The above learning outcome and related assessment standard will subsequently be contextualised within specific mathematical content. Two examples are taken from a common examination written by Grade 9s in the Free State (DEFS, 2000:2; 3). These examples address, *inter alia*, the learning outcome and assessment standard indicated above:

Example 1 Solve for x:

$$3(x-4) = 6(x-1) - 5(x-2)$$

Example 2 A farmer has a certain number of sheep. He sells all but 10 for R50 each. He receives R3 250 from the sale. How many sheep did he have?

The conventional method of grading is to allocate marks according to a predetermined marking system focusing mainly on knowledge and algorithmic skills. Freeman and Lewis (1998:181) argue that any well-designed question should have a set of acceptable answers to satisfy the need for consistency in assessment. A conventional grading system or the familiar memorandum will present no problem because such a mathematics memorandum provides for the required fixed procedures for simple linear equations of removing brackets, addition and subtraction of similar terms, solving the unknown variable and verifying the solution. Well-known familiar patterns, often acquired through rote learning, are easily assessed by means of a memorandum.

This quantitative form of assessment or traditional memorandum may have some drawbacks. How does a teacher evaluate an almost perfectly worked out solution with a single but fatal flaw? Is it worth almost all the marks for the question or none? Does such a mistake affect the nature of the learner's understanding and should the response be classified as 'completely wrong' or 'almost right'? The first example will present no obstacle. If the second problem, however, is graded in a similar way the comprehension component of assessing may be lost: understanding implies 'how' as well as 'why'. Markers with a conventional memorandum should keep an open mind because how may acceptable but unexpected responses such as the following be coded?

One learner (see Figure 1) has an intuitive grasp but is unable to use mathematical language in the response.

Although the problem is solved in the case in Figure 2, structure, and an adequate grasp of concepts are lacking.

In the case in Figure 3, there are severe misconceptions about the essence of the problem.

An alternative coding system is necessary to accommodate possibilities not provided for in a conventional memorandum. If the emphasis is on portrayal an outcomes-based qualitative coding system may be fluid and open to various interpretations. Such a coding system may be applicable to a wide spectrum of responses and may have a greater deal of validity and reliability. The criteria of a coding system should provide for a variety of responses such as correct answers without any demonstration of understanding, i.e. a lack of understanding may be discerned in the presentation of solutions, or wrong answers although understanding may be present in a learner's approach.

Subsequently coding systems are classified based on the two representative examples (DEFS, 2000:2; 3). Example 1 requires solving a simple linear algebraic equation algorithmically, while example two challenges learners to construct a simple linear algebraic equation, however, the problem now is to implement various reasoning patterns. Coding systems providing for a spectrum of responses as indicated above may be classified as indicated below. Table 4 compares the different characteristics of the two systems.

Table 4 Different coding systems

Grading (Example 1)	Portraying (Example 2)
Theory	Practice
Rigorous assessment criteria	Accessible assessment criteria
Answers *how*	Answers *why*
Fixed procedures	Holistic and reductionist
Quantity	Quality
Knowledge	Skills
Determinable	Inferences regarding deeper understanding

This leads to the question of how inferences for a deeper understanding can be developed by means of a coding system? A coding system must strengthen the critical abilities of learners. Stiggins (2001: 257; 266) identifies a vast number of reasoning patterns but reduces

Let the number of sheep be x.

$x \times R50 \div 3250$

$R3250 \div R50x$

$= 65$

$65 + 10 = 75$

He had 75 sheep.

Figure 1

Sheep $= x + 10$

$x - 10 = R50 \times x$

$R50 \times x = R3250$

$x = R3250 \div 50$

$x = 65$

$65 + 10 = 75$

He had 75 sheep.

Figure 2

10 sheep $= R500$

$R3250 - R500 = R2750$

 → x sheep

10 of $x = R50$.

$x + x - 10 = R2750$

$2x - 10 = R2750$

$2x = R2750 + 10$

$2x = 2760$

$x = 1380$

Figure 3

Table 5 A generic coding system

Standard	Emerging	Developing	Proficient	Exemplary
Conceptual knowledge (Classification and comparison)	Not able to use concepts or to classify	Lacks ability to use concepts or to classify	Adequate use of concepts and classification	Concepts are classified and used correctly
Understanding of Expectations (Application possibilities)	Several errors are found	Errors are common	Few errors made	Calculations are correct
Analysis and Synthesis (Relationship among separate and component parts)	No sense of relationships	Not a good grip on separate and component parts	Can apply analysis and synthesis	Applies various relationships effectively
Inductive and Deductive reasoning	Can scarcely distinguish between cause and effect	Struggles to implement inductive and deductive reasoning	Implements inductive and deductive reasoning sufficiently	Consistently implements inductive and deductive reasoning
Evaluation (Judgemental ability)	No sense of evaluative possibilities	Lacks a clear sense of evaluative ability	Sufficient demonstration of value judgments	Demonstrates ability to judge and evaluate

these patterns to drawing inferences by reasoning analytically, comparatively, or in an evaluative manner, synthesising, classifying, and reasoning inductively or deductively. These components are expanded below within the context of possible coding systems. The following components of reasoning may contribute towards the development of a suitable coding system:

- **Knowledge of concepts**, e.g. *x* as variable in a linear equation: can knowledge base be tapped from memory or reference possibilities such as co-operative learning groups, facilitator or textbook?
- **Understanding of expectations**, e.g. solution of linear equations: can reasoning expectations be achieved by means of algorithms as well as novel problem situations?
- **Analytical power**, e.g. how do separate parts relate to each other: can inferences be drawn about composite parts?
- **Synthesising**, e.g. why is a combination of ideas relevant in this context or how can ideas be structured into a set of generalisations?
- **Classification**, e.g. identification of properties: how can parameters and attributes be determined?
- **Comparative abilities**, e.g. recognition and contrasting: how can similarities and differences be distinguished?
- **Inductive reasoning**, e.g. application possibilities within a broader context: can conclusions be drawn from particular facts to general rules?
- **Deductive reasoning**, e.g. distillation of information: how can I proceed from the general to the specific?
- **Evaluative reasoning**, e.g. judging of capabilities: is the solution appropriate and applicable?

These patterns of reasoning are rarely used independently but they may assist learners to become problem solvers and lifelong assessors of the quality of their own learning.

A possible coding system in this context may include some of the aspects indicated above. Criteria should be explained and negotiated with learners so that learners may understand the nature of quality performance as well as the expectations in mathematics assessment. Learners infer the criteria for quality and the learning outcomes from assessment. Such criteria are communicated to learners by means of a coding system.

The coding system in Table 5 addresses the aspects under discussion. Table 4 compared the different approaches of grading and portraying. Table 5 addresses the development of a coding system indicating different levels and depth and breadth of demonstrating achievement. A coding system is subsequently suggested to portray the complexity of different patterns of reasoning. It may serve as a guide in evaluating different levels of performance in varying degrees of quality as reflected by the mathematics examples above. These criteria and levels may all be focused into the coding system in Table 6.

Due to the increase in sophistication of mathematics performances, such performances demand an increase in the sophistication of coding systems. Therefore the above coding system may address certain assessment issues and at the same time provide for some of the problems encountered in portraying various levels of mathematics mastery.

Table 6 Coding system to assess responses to reasoning proficiency

Criteria		Performances levels			
Evaluative criteria (Standards)	Performance criteria	Emerging Basic	Developing Commend-able	Proficient Good	Exemplary Exceptional
Knowledge	Does learner have access to essential facts via memory or reference materials?				
Conceptual under-standing	Do learner's inter-pretations reflect under-standing of concept relationships?				
Strategies and Critical Thinking	Is evidence provided that learner • proceeds from a plan • applies appropriate strategies • Follows a logical and verifiable reasoning process toward a solution, e.g. Analytical reasoning Synthesising Comparative reasoning Classifying Induction Deduction Evaluative reasoning				

Conclusion

Simple mathematics problems were used to illustrate the dichotomy between grading and portraying. Fixed procedures, e.g. solving simple linear equations algorithmically were contrasted with portraying assessment information by means of a coding system. The complexity of coding assessment information remains an issue. The dichotomy may be reduced to the duality of theory 'defining' general laws that explain features that are fixed and exact as opposed to the fluidity of practice. The latter concerns different outcomes which result from too many variables, often unnoted (acceptable but unexpected answers are possible even when questions have been carefully and meticulously posed). The former relates to fixed procedures, the latter portrays relatedness.

A number of implications have been explored:

- The dilemma of quantifying performances has been addressed. The uniqueness in responses has been underlined by the well-known constructivist principle of finding a solution not the solution (Von Glasersfeld, 1992:16).
- The problem of instrumental attitudes (quantification) versus generating more assessment specification (qualification) has been identified. If ranges in coding systems are narrowed down for best estimations the problem is simplified not solved. Eventually all possible outcomes are included but may conveniently be reduced to what is most easily measurable.
- The dilemma of accessible criteria has been explored. If learners infer the goals and outcomes of the curriculum, and the criteria for quality from assessment, assessment criteria must be more rigorous and accessible to learners to enable them to infer the criteria for excellence of performance.

Studies for future research might examine or partially replicate aspects of this investigation with additional variables such as the following:

- What assessment standards or narrative descriptions may allow learners to develop expected knowledge, skills and values?
- If criteria are communicated to learners by means of a coding system how may coding systems assist learners to develop a sound reasoning system in order to promote logic and to enhance reasoning abilities?
- What is the relationship between the learning strategies of learners and the way in which assessment is implemented?

In conclusion theoretical or exact procedures are more easily assessed by means of traditional memorandums or marking systems providing for assessing mastery of knowledge and algorithmic skills. This approach to assessment may lead to rote learning strategies with little accompanying understanding. This is most easily assessed in an analytic way where separate result(s) are provided for each dimension. Answers are sought to 'how'. An alternative to conventional assessment procedures is a more practical approach that may provide for many variables with good reasoning and application possibilities. In the latter case novel questions are posed which seek answers to 'why'.

No single coding approach in assessment is superior in all respects to others. Both coding approaches outlined above have strengths and weaknesses. Each coding approach may have certain merits depending on the particular setting, which in turn is determined by the structure, purpose, outcomes and contents of the course. A combination of approaches of assessment may provide the best guide for demonstrating understanding and mastery of subject matter.

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