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A Case Study in the Measurement of Educational Efficiency in Open and Distance Learning

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Open and distance learning (ODL) gives learners control of the time, place, and pace of learning, often being characterized as flexible learning. However, this flexibility goes hand-in-hand with procrastination and non-completion. As a result, the efficiency of the educational process is of importance to ODL providers, government funding agencies, and learners themselves. Despite its importance, measuring efficiency in ODL is problematic. This article presents a case study in measuring educational efficiency using a method which reflects the special characteristics of ODL. The article concludes with a discussion of the wider applicability of the measurement method in the context of lifelong learning.

Introduction

Educational efficiency, "the degree to which educational systems are successful in optimizing the educational input/output relationship" (UNESCO, 1995), is one of the quality indicators available to the various stakeholders in the educational process. Government agencies use data on educational efficiency to allocate funds to learning providers, such as universities (Yorke, 1998). Institutions use data on the educational inputs and outputs as factors in quality assessment systems (Burnett & Clarke, 1999; Rovai, 2003b). The rather limited information available to learners when deciding which study programme to follow (Simpson, 2004a) could be supplemented with efficiency data if it were more easily accessible. In addition, efficiency data may help to provide evidence for the success or failure of new educational technologies. The latter use of efficiency data is particularly relevant in the context

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of open and distance learning (ODL). When technology, applied to overcome distance, is combined with open entry policies, educational efficiency problems arise (Simpson, 2004b), and the underlying causes of this inefficiency in ODL have been the subject of several studies on non-completion, attrition, wastage, and drop-out (Cookson, 1990; Rovai, 2003a; Xenos, Pierrakeas, & Pintelas, 2002).

Given its importance as a measure of the quality of educational processes, educational efficiency requires clear definition and agreement on measurement methods (Reimann, 2004). This article presents the results of a case study on measuring educational efficiency in ODL. This article begins with a general definition of efficiency and progressively refines it for use in the ODL context. It then introduces a method of calculating efficiency based on this definition, before describing a case study of the application of the calculations in an ODL setting. The article concludes with a discussion of the issues surrounding the definition and measurement of educational efficiency in ODL with a view to the role of ODL in the wider context of lifelong learning.

Problems with the Definition and Calculation of Educational Efficiency

The UNESCO definition of educational efficiency cited above follows the standard definition of efficiency: the ratio of output to input (Rumble, 1997). Improvements to the input:output ratio can be made in two ways, and a distinction is drawn between technical efficiency—maximizing outputs from a given set of inputs—and cost efficiency—minimizing the costs of input (Hülsmann, 1997). Much of the work done to date on educational efficiency has addressed the latter (Moonen, 1997; Rumble, 2001). Our interest lies in the former: how to increase the number of learners who are successfully "output" from an educational process as a proportion of those who are "input" to the process (Jansen, 2004; Kettunen, 2003).

The educational processes upon which our work focuses are those associated with the modular study programmes offered by ODL providers. We draw on the approach described by Koper et al. (2005) in viewing these programmes as networks of modular units of learning[1] in a particular domain. Each unit of learning is associated with an assessment, the successful completion of which leads to a formal certification of the attainment of certain learning objectives. Learning providers specify combinations of units of learning, or routes, as requirements to be met for formal certification of a given level of competence in a domain, referred to as goals. To illustrate these concepts consider a masters degree in the domain of management sciences (a goal). Different institutes may offer different ways of attaining this goal, and a particular learning provider might offer a distance learning programme (a route), requiring the successful completion of 20 modules (20 units of learning).

Using this abstract approach to the notion of educational processes, our definition of educational efficiency in ODL is, with respect to a goal defined as a set of units of learning: the ratio of the number of learners successfully completing all required units of learning associated with the goal (the numerator) to the number of learners

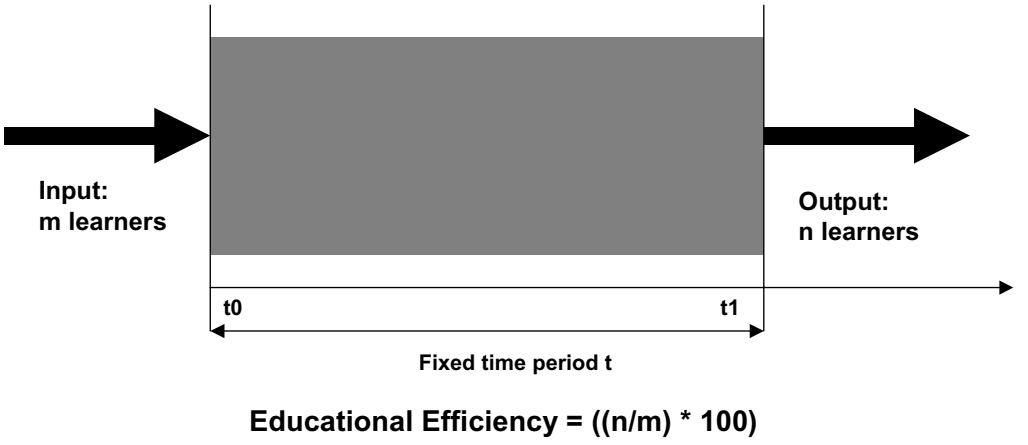

Figure 1. Calculating educational efficiency in a constrained setting

starting down the path towards the goal (the denominator), within a given time period.

In this approach we speak of educational efficiency with respect to a route (e.g. a particular bachelors or masters degree programme) rather than the efficiency of an ODL provider or of a goal. If other efficiency measures are required, aggregations can be made above the route level (e.g. average efficiency across all masters degree programmes) and across providers.

In non-ODL settings providers often require learners to enrol for a study programme, setting a date by which enrolment must have happened. The input side of the efficiency ratio is all, and only, those learners enrolled for the programme on this date. Furthermore, end dates are typically set, fixing the period within which learners must reach the programme's goal. In such constrained situations calculating educational efficiency is straightforward, since both input and output are clearly defined, as is the period over which efficiency is to be measured, as shown in Figure 1.

In contrast to the above situation, ODL offers learners freedom of time, place, and pace of learning. Flexibility of learning provision is seen as a powerful advantage by both learners and governments (Schellekens, Paas, & Van Merriënboer, 2003) but brings complexity to the educational efficiency ratio. Output remains relatively straightforward to calculate: since ODL providers are responsible for certifying learners' levels of competence, the output is those learners who are registered as having attained the required competency level for the goal. While this statement masks several layers of complexity in which assessments are constructed—learners attempt to demonstrate proficiency, logistical processes record the results of these attempts and determine whether or not a learner has reached the required level of competence—the process allows ODL providers to be able to identify, for a given route, how many learners have reached the goal (and when this happened).

However, other aspects of the definition are more problematic in the ODL world, as noted by Shale and Gomes (1998). Complicating factors include the following:

1. Learners are free to determine when to start a study programme, and are not constrained as to the time they may take to reach the goal. This removes the notion of a fixed period of time over which to calculate efficiency (Ashby, 2004).
2. Learners may suspend their learning for long periods of time (months and even years). This makes it problematic to differentiate between those suspending their learning process and those truly stopping (Yorke, 2004), with consequences for determining who should be included in the efficiency calculations for a particular time-frame. A further, related complicating factor is that the nature and content of study programmes change, so that after a period of time some learners may no longer be able to reach their original goal.
3. Learners are not required to enrol for a study programme and can opt instead to pursue a course-at-time approach (Woodley, 2004). This makes it difficult to know whether a learner successfully completing a unit of learning on a route is actually pursuing the goal associated with the route (and should be counted on the input side of the ratio) or was simply interested in the single unit of learning (and should not be counted).
4. Learners may enrol for a particular study programme but follow another without explicitly stating the switch. This can happen either immediately or at any time further down the line.
5. The increasing modularization of ODL (Reimann, 2004) means that units of learning are used in several study programmes, and learners completing a unit of learning may be pursuing one of a number of goals (for example, a statistics course may be used in mathematics, psychology, and computer science study programmes).

The factors listed above have four implications for the measurement of educational efficiency in ODL. First, a flexible approach is needed to the time-frame within which efficiency is calculated, and calculations should be periodically repeated. A "sliding measurement window" able to be widened and/or moved along a time axis would allow more appropriate calculations to be made. Using such an approach, other calculations could be made, such as efficiency since the introduction of a study programme, 7 years post-introduction efficiency, efficiency for the previous 3 years, etc., but also time required to achieve a given efficiency (e.g. how many years does it take to achieve 20% efficiency for a study programme?). The second implication is that an evidence-based approach to calculating efficiency is needed, using longitudinal data on the pathways of progression of learners (in terms of units of learning) along the lines described by Robinson (2004). The third implication is that those counted on the input side at a given instant (due to the available evidence at that time) may be excluded in a subsequent snapshot (and vice versa). The fourth implication is that the resulting calculations are unlikely to be 100% accurate, containing both false positives (those incorrectly counted as input) and false negatives (those incorrectly not counted as input).

Proposed Calculation Method

With these implications in mind, we propose the following steps to calculate educational efficiency for study programmes in ODL. The process is essentially one of successively reducing the set of all students associated with an institution to those associated with a particular route. Much of the process is dedicated to identifying, on the input side of the ratio, all and only those learners following a given route to a goal.

The following steps are designed to be carried out in a time-frame stipulating the dates between which efficiency will be computed:

Step 1. Specify the route for which efficiency calculations are to be made

This step requires a precise definition of the requirements to be met by learners, typically either by specifying points to be accumulated, perhaps using the European Credit Transfer System (ECTS) (European Commission, 2004), or by enumerating the units of learning associated with the goal.

Step 2a. Collect the set of all subjects who have enrolled, called "enrollers," for one or more of the units of learning in the route

All enrollers possibly associated with the route are collected in this step, to the exclusion of other enrollers at the institution. Note that this step refers to enrolment at the unit of learning level (which is mandatory since it typically involves payment by, and assessment of, an individual), rather than the study programme level, where enrolment is, as noted above, optional.

Step 2b. Reduce the set resulting from the previous step by excluding non-starters

As noted by Gibbs (2004), some enrollers for an ODL study programme have no intention of completing (this behaviour is also seen at the unit of learning level). Enrollers pay their fees and receive material, but decide to have no further participation in the unit of learning. This group is referred to as "non-starters" by Fritsch (1991) and our process excludes this (often numerically not insignificant) group by only including those enrollers who have made at least one attempt to complete a unit of learning from the route. Note that a non-starter, who has simply not yet shown evidence in a given measurement period (and so is excluded from the ratio), will be counted as an enroller in a measurement period subsequent to their first activity.

After completing Step 2b we are left with the set of learners who have (at least) attempted to complete part of the goal. However, this set contains learners who are on their way to different goals (due to the sharing of modular courses on different routes) and learners who are picking and mixing courses to suit a personal, rather than an institutionally defined, goal:

Step 2c. Reduce the set resulting from the previous step by only including learners showing evidence of pursuing the goal

This step exploits what we term learners' learning tracks: the (time-ordered) sequence of all units of learning successfully completed to date per learner, not restricted to those in the route set. With this sequence we are able to calculate the ratio of completed courses not on the route compared to all courses completed, known as the different goal indicator (DGI). A threshold is used, above which learners are considered to be on a

different route and pursuing a different goal. This threshold might be 50%, for example, meaning that when more than half of the units of learning successfully completed by a learner fall outside those included in the route he or she is considered to be pursuing a different goal and is excluded from the efficiency ratio. Experiences with the use of the DGI are presented below.

The set of learners remaining after this step is the input part of the efficiency equation (the denominator), which we refer to as students:

Step 3. Identify those students who have already satisfied the requirements associated with the goal (i.e. have completed the route)

This leads to a value for the output side of the ratio (the numerator of the efficiency ratio).

Step 4. Compute the educational efficiency for the time period

Once the input and output have been determined, the proportion of output to input can be computed straightforwardly.

Figure 2 illustrates the way in which the steps of the method successively refine the set of students considered in the efficiency equation.

Set A represents those persons who enrolled for a unit of learning associated with the route. Set B represents those learners who have attempted to complete one or more of the units of learning on the route (although this also includes learners

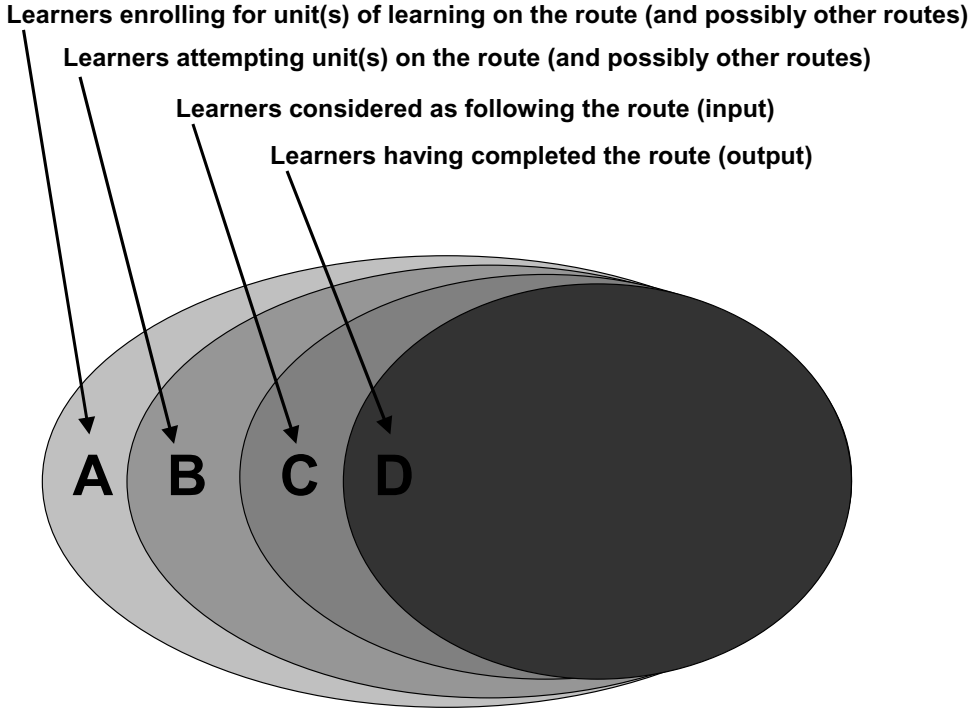

Figure 2. Successively refining the sets of learners involved in calculating the efficiency

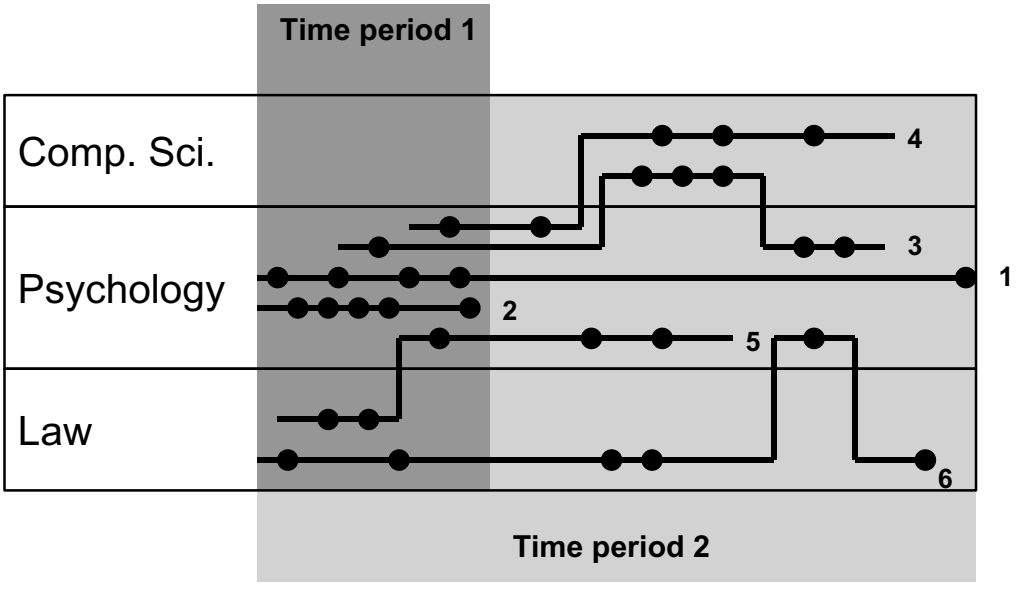

Figure 3. Possible paths in and between study programmes in two time periods

pursuing other routes which share units of learning with the route under consideration). Set C represents students whose learning tracks, in combination with the DGI, provide enough evidence to indicate they are following the route. Set D represents students who have completed the route. Non-starters can be found in the difference between sets A and B. The difference between sets B and C contains those learners pursuing other routes (towards other personal or institutional goals). Educational efficiency is calculated as the ratio of set D to set C.

To help illustrate the calculations, Figure 3 shows the paths of six typical learners through abstract study programmes in the domains computer science, psychology, and law. This simplified example assumes that learners show competence in a domain by completing five units of learning in the domain. The figure shows two time periods in which calculations might be made.

Assuming that the educational efficiency of the psychology route is under consideration, we can follow individual learners to determine whether they are included in the input and/or output side of the ratio in the two time periods:

- Subject 1 starts on the psychology route and pursues it to completion. In calculations for time period 1 the learner would be counted on the input side of the efficiency ratio for psychology, but not yet on the output side. Calculations over time period 2, however, would count learner 1 on both sides of the ratio.
- Learner 2 is also striving for the psychology goal and would be counted as both input and output in both time periods, having completed five courses.
- Learner 3 starts with psychology but also completes courses in computer science. However, the ratio of courses completed in the two domains (50:50) does not tilt

the balance towards computer science, leading to learner 3 being counted on the input side only for both time periods.

- Similarly, learner 4 starts with psychology but also completes computer science units of learning. In measurements for time period 1 the learner would be counted on the input side of the ratio. In time period 2 the learner would be considered to have "switched away" and so would be excluded from both input and output, since the DGI shows more than 50% of completed courses lie outside the route set.
- In contrast, learner 5 starts with law then switches to psychology. Calculations over time period 1 would exclude learner 5 from both input and output, but calculations over time period 2 would count the learner as being en route to the psychology goal (input but not yet output).
- Finally, even though evidence exists in time period 2 that learner 6 may have switched to pursue the psychology goal, the DGI still reveals a predominance of law courses on the learning track and would exclude learner 6 from psychology calculations.

The educational efficiency of the psychology study programme across time period 1 is then 25% (learner 2 has satisfied the requirements and is counted as both input and output, while learners 1, 3, and 4 are considered to be on the route and are counted as input). Measurements over time period 2 present a different educational efficiency, as learners 1 and 2 are counted as both input and output, learners 3 and 5 are also counted as input, but learners 4 and 6 are excluded from the calculations, leading to a value of 50%.

In order to further illustrate the workings of the method described above, we now present a case study using data from the Open University of The Netherlands (OUNL).

Case Study

The OUNL is a government funded ODL provider of higher education. It offers three forms of study: bachelor and master degree programmes (in law, economics, business and public administration, engineering, environmental science, cultural studies, and psychology); short programmes (vocational training courses, postgraduate courses, and short undergraduate programmes); individual courses (from a choice of over 400 modular courses).

The six bachelor and thirteen master degree programmes offered by OUNL comprise combinations of courses (i.e. units of learning). Each course ends with an examination which may take one of several forms: a final project or paper, a multiple choice test, an open essay test, or an oral examination. Courses comprise one or more modules, each with a nominal study load of 100 hours. A bachelors degree consists of 42 modules and is equivalent to 180 ECTS points, while a masters degree consists of 14 modules and is equivalent to 60 ECTS points. The 42 modules of a bachelors degree are divided into two phases, the propaedeutic phase[2] (14 modules) and the post-propaedeutic phase (28 modules).

Table 1. The courses making up the propaedeutic phase of the Bachelor of Psychology degree

Code	Course title	Modules
S12112	Introduction to Psychology	2
S09231	Social Psychology	1
S23212	Clinical Psychology 1: Personality Theories and Psychopathology	2
S13111	Research Practical: Quantitative Data Analysis	1
S11121	Introduction to Work and Organizational Psychology	1
S60311	Introduction to Health Psychology	1
S10121	Developmental Psychology	1
S35311	Intelligence and Social Competency	1
S04231	Research Practical: Introduction to Psychological Surveys	1
S09121	Cognitive and Biological Psychology	1
S25211	Introduction to Neuropsychology and Psychopharmacology	1
S22221	Research Practical: Literature Study	1

Our case study focuses on the propaedeutic phase of the OUNL bachelors degree programme in psychology. The goal of our study was determination of the competency level in the psychology domain associated with the propedeuse, the certificate issued upon successful completion of the 14 modules which make up the propaedeutic phase (the route).

Step 1 in our method of calculating educational efficiency requires us to specify the units of learning which make up the route. The 14 modules are contained in the 12 courses shown in Table 1.

Step 2, calculating the denominator of the ratio (input), comprises three substeps. Table 2 summarizes the results of these steps.

The difference between the results of steps 2a and 2b points to a high number of non-starters. Informal market research carried out at OUNL indicates that this may be due to a significant proportion of subjects enrolling solely in order to obtain OUNL study material, i.e. with no intent of completing the course module.

We note here that the results shown in step 2c reflect a more complex approach to computing the DGI than the 50% cut-off originally conceived. During analysis it became clear that a significant proportion of learners (around 1000) were pursuing

Table 2. Numbers of learners following the route

Step	Procedure	Set in Figure 1	No. of learners
2a	Subjects enrolling for one or more of the route courses	A	27,168
2b	Learners with one or more attempts to complete (non-starters excluded)	B	8,879
2c	Students who show evidence of following the route (i.e. excluding those with a different goal)	C	6,250

the propedeuse and bachelors routes in parallel and that a naive application of the 50% threshold would incorrectly exclude those learners who were actually following the propedeuse route from the efficiency equation. A different approach to the DGI calculation was adopted, which involved counting propedeuse courses, bachelors courses, and other courses separately (i.e. using three categories instead of two). Learners were considered to be following the propedeuse route as long as the number of propedeuse courses remained greater than or equal to either of the two categories, rather than to the sum of the other two categories, as is the case in the use of the simple 50% threshold.

The route shown in Table 1 could only be followed from 1997 onwards, although some units of learning from this route were used in earlier routes to the propedeuse. To focus our analysis on the route shown in Table 1, and to reduce bias and interference from earlier routes, we restrict the case study to report on efficiency in the period 1997/1998 up to March 2006. This restriction reduces set 2c to 5,392 from 6,250.

Step 3 identifies those learners who completed all the requirements associated with the goal in the time period under consideration. In our case study the numerator of the efficiency ratio (i.e. output) is 645. In other words, 645 learners started and completed the route to the goal in the time-frame under consideration without the application of exemptions.

Step 4 calculates the educational efficiency, and is summarized in Table 3, which distributes the totals across the years in the time-frame, showing, per year, the number of learners considered to be following the route and the subset of these learners who reached the goal in the measurement period.

The year shown in column 1 reflects the first year in which the criterion of step 2b were satisfied and the number of years taken to obtain the goal indicates the period from first enrolment (the criterion used for step 2a) up to successful completion of all 12 units of learning.

Table 3 shows that of the 5,392 learners identified as pursuing the goal since the academic year 1997/1998, 645 have reached their destination. This gives an overall educational efficiency of around 12% for the time period under consideration. This, of course, includes learners having recently started, and a more representative value for efficiency can be obtained by examining the initial years, such as 1997/1998, where a value of 22.9% can be seen.

Discussion

The method of defining and measuring educational efficiency in ODL outlined in this paper is based on longitudinal analysis of learner data. This approach was identified in response to complicating factors inherent in ODL's unique selling points of flexibility in pace, place, and time of study, which imply that a comprehensive picture of learner progression is needed over a longer time-frame than that required in traditional, restricted, cohort-based situations (Robinson, 2004).

The method is able to deal with the variations in start and end dates, route switching, and temporary suspension of learning. However, we can identify several short-

Table 3. Numbers of learners input and output in the time period under consideration

Year	Total (= input)	Goal not obtained	Goal obtained within given number of years (= output)						Output (efficiency value)
			0–3	3–4	4–5	5–6	6–7	>7	
1997/1998	706	544	55	26	29	21	19	12	22.9%
1998/1999	681	544	46	30	32	21	8		20.1%
1999/2000	576	470	43	27	24	12			18.4%
2000/2001	547	449	43	31	24				15.5%
2001/2002	633	551	56	26					13.0%
2002/2003	773	726	46	1					6.1%
2003/2004	646	636	10						1.5%
2004/2005	734	731	3						0.4%
2005/2006	96	96							
Total	5,392	4,747	302	141	109	54	27	12	12.0%

comings. First, the method introduces a significant amount of complexity into efficiency calculations and places requirements on ODL providers' data collection processes. Second, the method has a degree of inaccuracy, since, in a given time period, learners can be inappropriately included or excluded from calculations. Third, the method does not adequately address the dynamic nature of routes (substitution, splitting, and merging of units of learning, and provider termination of routes) and the associated implications for learners' abilities to follow a route to a goal (should learners who can no longer follow a route to its conclusion be included in calculations?). Additionally, the role of exemptions requires further investigation (should learners exempted from a significant proportion of a route's requirements be counted separately in the output?). Further work to address these issues is ongoing.

Although the method has only been applied to a single study programme at OUNL, validation is being pursued along three lines. Intra-study programme validation is being addressed by applying the method to the same psychology study programme on a half-yearly basis. As new student data becomes available the psychology faculty will be able to perform the same calculations to analyse efficiency levels and validate that the approach is sustainable over the long periods of data collection required in ODL (10–20 years). Furthermore, the method is being trialled in other study programmes at OUNL to verify its applicability in other contexts. Finally, in a third validation line we intend to cooperate with other ODL universities to apply the method, both to check the robustness of the approach and its utility under different educational systems. With respect to the utility of the method, wider application may well lead to a requirement to incorporate a cost efficiency component, so that for example, the costs per student can be calculated at the different steps of the method, or even a risk factor for the returns on investment (Simpson, 2005).

The difficulties of calculating ODL study programme level efficiencies led Yorke (2004) to propose abandoning their use in favour of measures at the unit of learning level, a proposal which has, in turn, been countered by Reimann (2004). Our belief is that there will continue to be increased pressure to report on and improve efficiency at the study programme level as a result of political initiatives in the lifelong learning arena (European Commission, 2003). Jongbloed (2002), exploring the implications of lifelong learning for institutes of higher education, noted that increased flexibility in the concept of a study programme will be needed, and ODL provides an approach to help increase levels of participation in lifelong learning.

Consideration of the lifelong learning context, however, exposes a single provider bias in the description of our approach to calculating efficiency. Fritsch's (1991) account of movement into and out of the German Open University and Woodley's (2004) more recent reference to the same phenomena in the UK Open University show that the true picture of lifelong learning is a multi-provider one, with learners moving within and between providers to suit their needs and circumstances. As a result, a more appropriate notion of routes in lifelong learning would see the involvement of more than one provider. While this possibility is not excluded by our definition and measurement method, it leads to questions of who defines routes, who assesses learners and who owns lifelong learner data which are not easily answered in today's educational landscape.

In summary, we emphasize that various stakeholders have an interest in data on the efficiency of educational processes, including funding bodies, providers, and learners. Although a body of research exists on educational efficiency, no recognized procedure for its measurement in ODL exists. The case study presented in this article provides an approach for dealing with the complexity of measuring educational efficiency in ODL.

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Notes

1. Units of Learning are equivalent to the Units of Study described by Robinson (2004). We give preference to the alternative term due to its prominence in the educational technology literature.
2. The propaedeutic phase reflects the two tier structure of Dutch higher education described by Jansen (2004), although the timing constraints mentioned in Jansen's article are not applicable in the ODL context of The Open University of The Netherlands.

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