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Construction and Application of SACMEQ School Resources: Portray of School Systems Based on the Rasch Scaling Technique

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Abstract

A School Resources Index (SRI) was constructed using the Rasch scaling technique. Data were from the pooled school resource items that were collected from pupils, teachers, and school heads derived from two sub-regional studies undertaken by Southern and Eastern Consortium for Monitoring Educational Quality (SACMEQ) in 1995 and 2000. Capitalizing on the possibility to link more items, the new scale provided a stronger positive correlation between the school resources and the pupils' achievement compared to using the initial variable containing the summation of school resource possessions. This SACMEQ SRI provided a reliable and valid instrument to compare the resource level among different school systems with varied levels of economic development. It also provided a meaningful tool to examine the changes in the school resources between two different time points. From the SACMEQ SRI, the hierarchical resource "profiles" were also established. The profiles could be used as a guideline of standard to identify more critical and relevant resource items at each progress level, for better budgetary planning, resource allocation, priority setting, and benchmarking.

Introduction

Policy concerns and research questions

The economic difficulties and financial constraint during the 1980s and 1990s pressured many policy makers to look into educational productivity encompassing more efficient use of educational resources. Specifically they are concerned about: (i) whether the school investment improves the educational quality; (ii) which resources are effective to education; and (iii) the minimum requirement on school resources.

These policy concerns were also the key issues of the educational policy research project undertaken by a consortium known as Southern and Eastern Africa Consortium for Monitoring Educational Quality (SACMEQ). SACMEQ has produced a data archive in 2004 (Ross et al. 2004) which contained data from two large scale sub-regional studies covering over 60,000 Grade 6 pupils and some 7,000 teachers in over 3,000 schools in Botswana, Kenya, Lesotho, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Swaziland, Tanzania Mainland, Uganda, Zambia, Zanzibar, and Zimbabwe.

In order to address these policy planning issues, it has been decided to measure the

pooled school resource items in a meaningful way. In this exploratory study, the major attempt has been made to establish an index of school resources that is valid across fifteen SACMEQ countries over time. In particular, the following six research questions are being addressed:

- Which school resource items constitute the SACMEQ SRI?
- What are the distinctive profiles of the schools at different resource levels on the scale?
- What is the breakdown of schools across the resource levels for each SACMEQ country?
- What is the mean school resources score for each SACMEQ country?
- What are the changes in the school resources between SACMEQ I and SACMEQ II; and
- What are the among-region and within-region variations of the school resources scores in each SACMEQ country?

To test the utility of the final scale, a further research question has been added:

- What is the relationship between school resources and pupils' achievement outcomes on reading and mathematics in SACMEQ countries?

Rational for constructing a School Resources Index

When measuring the resource level of a school, one particular resource item may not provide a reliable indicator, just as one single mathematics question is not sufficient to define a mathematical competence. In a typical School Survey Questionnaire, questions on school resources maybe inter-related. For example, a school library is associated with some books to borrow and bookshelves to hold books. Furthermore, some items are more difficult to fulfil than others. For instance, electricity is a condition for having electrical appliances.

A scale should be appropriate for the developmental level of a country. If a list of school resource items in a School Survey Questionnaire for an industrialized country was used in a developing country, it may be criticized for the contextual irrelevance and the magnitude. For example, a relevant question used in a developing country asking whether they have water at school may not well discriminate schools in an industrialized country. Likewise, while a question about computers in a developing country may not be relevant, a question which really discriminates schools in an industrialized country would be asking the magnitude of the item. It is therefore critical to combine these questions in order to measure countries with various development levels on a single continuum.

Scope and limitations

In this study, the Rasch measurement approach has been used to construct the SRI. Various research studies explore the uses of different Item Response Theory (IRT) models with two or three parameters on item characteristics (Write & Stone 1979). However, it is not the intention of the study to compare the Rasch model against other IRT models.

The focus of this study is the availability of materials and physical resources. Other

school variables were not included in this study. However, two areas of information require further clarification. First, the pupil- and the school-level questions about whether pupils can borrow library books were considered as availability of "borrowable" books. Secondly, questions on the distance from the school to facilities were regarded as "alternative access to goods" in the vicinity, because of the importance of this potentiality in developing countries (Griffin 2004a).

In the present study, the demonstrated relationship between school resources and pupil achievement does not adjust for the pupil input level. It is argued that the relationship between pupil achievement and the school resources using the newly established scale is stronger than using the existing derived composite variable as a result of the possibility of incorporating many more items. The aspect of measuring the impact of school resources on pupil achievement when controlling for the pupil home background shall be dealt with in other studies.

Literature Review

Rasch measurement model

With the classical testing method, as opposed to the IRT, it would be difficult for a given score to sufficiently have any substantial meaning as regards to the fulfilment ability of the respondents. This is attributed to the fact that the scores are dependent on the sample of respondents and the sample of items in an instrument. For example, an average respondent is expected to score high on an "easy" instrument and low on a "difficult" instrument (Woo 2005a).

The Rasch model is a probabilistic measurement model (Rasch 1980; Write & Stone 1979) that is the simplest and the most commonly used within the existing models of IRT. The Rasch model incorporates one parameter, namely item location, for modelling the item and respondents' behaviours. Using this model, the school resource item difficulty and the school's fulfilment ability for a school resource item can be placed on one single scale.

Given the school's resource location (ßv) and the resource difficulty (δi), the probability of a school (v) to fulfil a resource item (i) can be expressed as:

$$P_{vi} = \frac{e^{ß_v - \delta_1}}{1 + e^{\beta_v - \delta_i}}$$

A given score in the Rasch measurement can provide a probabilistic description of the resources that a school has. Given a total score of *r*, it is most likely that the *r* resource items a school has are the ones which are easiest on the scale.

In addition, in the Rasch approach, an assumption has been made in which the single scale that maps the schools and the resource items is sample-free, but not population-free (Griffin 2004b). That is, within a set of resources and a set of schools for which the model holds, subsets of resource items give the same relative school locations, but with different precision depending on the number of items. In this sense, the measure of school resources

is independent of the instrument used to measure the characteristics of the school. Thus on condition that the responses fit the model, it is possible to link inter-related subsets of items from different data collections to make a meaningful scale. Finally, some ordered response category items of the Likert form can be also identified with a meaningful hierarchy within the same scale (Andrich, de Jong & Sheridan 1997).

Based on the IEA Reading Literacy data on 9-year and 14-year old students, Siniscalco & Ross (1997) carried out an experiment to establish an international reading resources scale using IRT. They reported that it was possible to construct a meaningful resource scale in order to map 30 countries.

School resources

Research on the relationship between school inputs and pupils achievement has been controversial. At foremost, the Coleman study (Coleman et al. 1966) shocked the educational policy makers as it reported that the pupil's socio-economic background was more influential than the school inputs on the students' performance. Subsequently, Peaker (1971) concluded that student background and early learning do matter on the progress of achievement, not the school effect.

During the 1980s and 1990s, these findings were greatly challenged in a various studies in the context of non-industrialized countries. (Heyneman 1980; Heyneman & Loxley 1983; Fuller 1985; Fuller 1987; Hanushek 1995; Hanushek 1997). The conditions that were established prior to schooling in developing countries were not as influential determinants of achievement as in high-income countries. The researchers criticized that the variables that were often used in industrialized countries to measure student background were not appropriate in developing countries. Consequently, there was not much variation in these variables.

There exist a number of other studies conducted (Murimba et al. 1997; Varghese 1995; Fuller & Clarke 1994; Harbison & Hanushek 1992; World Bank 2004; Postlethwaite & Ross 1992). In general, these studies reported that facilities, textbooks, and writing materials had reasonable effect on the student performance in developing countries. In the Third International Mathematics and Science and Study (TIMSS), Martin et al. (1999) reported that the shortage of instructional materials would affect at a different magnitude in developing countries as opposed to in industrialized countries.

Methodology

Population and sample

The target population for SACMEQ studies was defined as "all pupils at the Grade 6 level during the data collection year at the eighth month of the school year who were attending registered government or non-government schools in the country". In some countries, small percentages of population were excluded due to schools affected by wars and natural hazards and schools using non-mainstream curriculum.

The sample was selected in two stages. At the first stage, a sample of schools was drawn with a probability proportional to the enrolment on Grade 6. The intra-class correlation (Rho) values obtained in the SACMEQ I study were used where possible. Otherwise, a Rho of 0.4 was used for SACMEQ II. The accuracy required for all school systems was set at the equivalent of a simple random sample of 400 pupils, which would yield a sampling error of 5 percent for a percentage and 0.10 of a standard deviation, with a confidence limit of 95 percent. At the second stage of sampling, a simple random sample of 20 pupils from all Grade 6 pupils was drawn within each selected school.

Sampling weights were applied in order to adjust for (i) discrepancies between the population at the time of sampling and the data collection; (ii) disproportion among strata, and (iii) differences between the planned and achieved samples within strata. The design effect obtained via the IIEP JACK (Ross & Leite 2000) demonstrated that the sample designs in SACMEQ I and II had satisfied the prior requirements of sampling accuracy, except for South Africa and Uganda, due to the under-estimation of the Rho value at the time of sampling.

A more detailed account of the sampling procedures used in the SACMEQ studies has been presented in the SACMEQ data archive (Ross et al. 2004).

Data preparation

(a) Item linkage

As shown in Table 1, the items concerning school resources included 64 SACMEQ I items (10 items from the Pupil Questionnaire, 15 items from the Teacher Questionnaire, and 39 items from the School Head Questionnaire) and 64 SACMEQ II items (13 items from Pupil Questionnaire, 15 items from the Teacher Questionnaire, and 36 items from the School Head Questionnaire). Out of the 77 total items, 51 items were common to both studies, which were used as “anchor items” linking the two studies.

(b) Data matrix

The Rasch Unidimensional Measurment Models (RUMM) software (RUMM Laboratory 2003) was used in order to calibrate the school resource items. The valid cases were aggregated at the school level. Overall, 2890 schools were used for the calibration process. The country, the school location, and the time were used as “factors”.

(c) Recoding of variables

Questions regarding the availability of items and questions on the quantity of items were recoded to have dichotomous values, i.e., “not available (0)” or “available (1)”. Questions on the distance to facilities have been recoded as “over 5 kilometres (0)” versus “up to 5 kilometres (1)”. The items with ordered response categories were recoded to have three categories. Specifically, the textbook questions were recoded as “no textbook (0)”, “share textbook (1)”, and “have own textbook (2)”. The question on building condition was recoded as “require rebuilding (0)”, “require some repairs (1)”, and “in good condition (2)”.

(d) Item calibration

With RUMM’s “conditional maximum likelihood” procedure, the school parameters were eliminated while estimating the resource parameters. Based on the resource parameter

Table 1. List of Variables Considered for the First Exploration of SACMEQ SRI

Questions		SACMEQ I	SACMEQ II
How many of the following items do you have this term?	- Exercise books	PQ22.1	PQ21.1
	- Notebooks	PQ22.2	PQ21.2
	- Pencils	PQ22.3	PQ21.3
	- Rulers	PQ22.4	PQ21.6
	- Pencil erasers	PQ22.5	PQ21.5
	- Ball point pens	PQ22.6	PQ21.7
	- Pencil sharpeners		PQ21.4
	- File folders		PQ21.8
How are the textbooks used in your classroom?	- Reading textbooks	PQ20	PQ35
	- Mathematics textbooks		PQ38
Are you allowed to take library books home from school?		PQ21	PQ20
What do you sit on in your classroom?		PQ24	PQ22
What writing place do you have in your classroom?		PQ25	PQ23
How many books do you have in your classroom library or book corner?		TQ8	TQ10
Which of the following are available in your classroom or teaching area?	- A usable writing board	TQ10.01	TQ12.1
	- Chalk	TQ10.02	TQ12.2
	- Wall chart	TQ10.03	TQ12.3
	- A map of your country	TQ10.04	
	- A map of Africa	TQ10.05	
	- A world map	TQ10.06	
	- Cupboard	TQ10.07	TQ12.4
	- Bookshelves	TQ10.08	TQ12.5
	- Classroom library, book corner or book box	TQ10.09	TQ12.6
	- A water tap	TQ10.10	
	- A teacher table	TQ10.11	TQ12.7
	- A teacher chair	TQ10.12	TQ12.8
	- An atlas	TQ10.13	
	- An English dictionary	TQ10.14	
Which of the following do you have access to in your school?	- A map		TQ13.1
	- An English dictionary		TQ13.2
	- Geometrical instruments		TQ13.3
	- Teacher's guide (English)		TQ13.4
	- Teacher's guide (Mathematics)		TQ13.5
What exactly have you used the education resource centre for during the academic year?			TQ24
How many kilometers is it by road from your school to:	- Health centre / clinic	SQ11.1	SQ13.1
	- Tarmac road	SQ11.2	SQ13.2
	- Public library	SQ11.3	SQ13.3
	- Book shop	SQ11.4	SQ13.4
	- Secondary school	SQ11.5	SQ13.5
	- Shopping centre or market		SQ13.6
How many teaching areas does your school have?	- Permanent classrooms	SQ27.1	SQ34.1
	- Temporary classrooms	SQ27.2	SQ34.2
	- Open-air teaching areas	SQ27.3	SQ34.3
What is the total inside area of all permanent and temporary classrooms in your school?	- Permanent	SQ28.1	SQ35.1
	- Temporary	SQ28.2	SQ35.2

Questions		SACMEQ I	SACMEQ II
What is the general condition of your school buildings?		SQ29	SQ36
How many toilets or latrines does your school have?		SQ30	SQ37
Which of the following does your school have?	- School library	SQ31.01	SQ38.01
	- School hall	SQ31.02	SQ38.02
	- Staff room	SQ31.03	SQ38.03
	- School Head's office	SQ31.04	SQ38.04
	- Secretary's office	SQ31.05	
	- Store room	SQ31.06	SQ38.05
	- First aid kit	SQ31.07	SQ38.06
	- Sports ground	SQ31.08	SQ38.07
	- Playground	SQ31.09	
	- Piped water	SQ31.10	
	- Well or borehole	SQ31.11	
	- Electricity	SQ31.12	SQ38.09
	- Telephone	SQ31.13	SQ38.10
	- Fax machine	SQ31.14	SQ38.11
	- Garden	SQ31.15	SQ38.12
	- Typewriter	SQ31.16	SQ38.13
	- Duplicator	SQ31.17	SQ38.14
	- Radio	SQ31.18	SQ38.15
	- Tape recorder	SQ31.19	SQ38.16
	- Overhead projector	SQ31.20	SQ38.17
	- TV set	SQ31.21	SQ38.18
	- Film projector	SQ31.22	
	- Video cassette recorder (VCR)	SQ31.23	SQ38.19
	- Photocopier	SQ31.24	SQ38.20
	- Computer	SQ31.25	SQ38.21
	- Cafeteria	SQ31.26	SQ38.23
	- Fence or hedge around school borders		SQ38.22
	- Piped water / water tank / borehole / spring		SQ38.08
How many books are there in your school library?		SQ32	
How many books were added to your school library last year?		SQ33	
Can pupil borrow books from the school library to take them to their home?		SQ34	SQ39
How many times have one or more members of the staff of the education resource centre visit your school during this school year?			SQ26

Note: PQ= Pupil Questionnaire; TQ = Teacher Questionnaire; SQ = School Head Questionnaire

estimates, the school parameters were estimated using a “direct maximum likelihood” procedure (Andrich & Luo 2003). One of the fit statistics generated was a standardized residual with a theoretical mean of 0 and standard deviation which approaches 1. It was provided for both schools and resources.

Several calibration runs were executed in order to come to the final two versions of the school resource scale: one with 72 items and another with 68 items. Table 2 shows the summary. A more detailed account of the item calibration procedures has been presented in Saito (2005).

(e) Scoring all schools using the item parameters

All the schools that have participated in SACMEQ I and/or SACMEQ II were scored using the calibrated item parameters. This was undertaken by RUMM’s “person measure” procedure. The school estimates were scored using both the 72 item-scale and the 68-item scale. The scores were then merged back to the original combined pupil-level data file for further analyses. The correlation coefficient between the 72-item scale and 68-item scale was 0.991. The results shown below were based on the 72-item scale.

Table 2. Summary of Calibrations

Run #	# items	Observations	Actions
1	77	4 items with a fit residual >10	These items are to be deleted from the next run.
2	73	3 items with Differential Item Functioning	These items are to be split in the next run.
3	76	Out of the split items, only urban items worked.	The 3 non-fit items are to be deleted from the next run
4	73	One item with technical difference between SACMEQ I and II	This item is to be split to be considered two different items.
5	74	These split items behaved similarly. Two distance questions may not fit conceptually (tarmac road; secondary school).	These two distance questions are to be eliminated from the next run.
6	72	There are four other distance questions, but they are conceptually fit.	Two versions of scaling would be made (72-item scale and 68-item scale).
7	68	The reliability would go down.	

Results

School resource scale from the sample schools in the calibration

The reliability on the person separation index with the 72-item scale was 0.901, providing the power of test-of-fit rating as "Excellent". While the mean of the item location was fixed as 0 by definition, the mean of the school location was 0.133, and the standard deviation was 1.058. The mean of 0.133 indicates that the average school in SACMEQ countries was more "able" than the "difficulty" level of the average resource item.

A response made by a school to each item can be considered as a function of two forces: (1) the intensity of an item; and (2) the fulfillment of a school. The probability that a school has a given school resource is a function of the level of "resource power" of the item and of the level of "resource fulfillment" of the school (Siniscalco and Ross 1997). It must be noted, however, that this generalization is a "probabilistic" one.

In Figure 1, the individual resource items' thresholds and the distribution of schools according to their resource level have been placed on the 72-item scale. A resource item appearing at a higher level would exist in fewer schools than the item appearing at a lower level. For example, a duplicator (location 1.131) is likely to exist in fewer schools than a school library (location 0.071) would. On the other hand, a teacher table (location -0.945) would exist in more schools than a school library would.

Also shown in Figure 1 is the school position in relation to the individual resource items. For example, an average school in Seychelles (location 2.104) is likely to have everything except some "high-tech" equipment (location above 2.216). There is a 50-50 chance of having school buildings in good condition (location 2.19). On the other hand, an average school in Malawi (location -0.871) is likely to fulfil all the lower items up to a teacher table (below -0.945) and have a 50-50 chance of fulfilling "the distance from the school to the nearest market within 5 kilometres" (location -0.849).

Portrait of six school resource levels

Using the information in Figure 1, it was possible to develop a portrait of six typical schools with increasing levels of school resources. These were based on the identification of the common characteristics in groups as well as the evaluation of the location estimates and the overall distribution. Some systematic hierarchy from independent questions appeared in the levels. For example, a form of water appeared in Level 2, piped water in Level 3, and water in classroom in Level 6. Electricity showed up in Level 4, simple appliances in Levels 4 and 5, and high-tech appliances in Level 6.

(i) Level 1: Insufficient School Resources

A school at this level has a playground. Buildings require repairs. Classes take place in an open-air class. There is a writing board and chalk. Pupils have or share sitting/writing places. However they share textbooks. Pupils have at least an exercise book, a ballpoint pen, and a pencil.

Figure 1. Item Map for SACMEQ School Resources

Location	Schools	School Resource Items					
4							
		Film proj					
	o						
3		Fax					
	o	OHP					
	o						
	o	computer					
SEY	oo	VCR	Bldg G cond	Photo C.			
2	ooo	cafeteria	TV				
	oooooo	2m2/pup	Sch hall				
MAU	ooooo	Sec office					
	oooooo						
	oooooo	1+clbk	file	Tape rec.	bkshelf	1+slibk	
1	ooooooo	duplicator	water in class				
SOU	ooooooo	P-lib near	Bkshop near				
BOT	oooooooo						
NAM	ooooooooo	Cl. Lib.	Add S.L book	Telephone	typewriter	First aid kit	Allow Pborrow
SWA	oooooooooo	Own M-txt	Own R-txt	Cupboard	Pborrow-s+c	Electricity	Radio
KEN	ooooooooooo	W-map in cl	Map Af. in cl	Sch Lib.	sharpener		
ZIM	oooooooooooooo	Pborrow-s	Acc.G-inst.				
0 LES	ooooooooooooooooo	Acc. M-guide	Piped wtr	Staff room	fence		
MOZ	oooooooooooooooooo	Store room	Wall chart	Toilet 60-	Atlas in class	Eraser	
UGA	ooooooooooooooooo	Acc.E-guide	Notebook	Acc. any map	E-dict in class	Map C in cl	
TAN	oooooooooooooo	Clinic near	T table	Market near	Perm. Str.		
ZAM	ooooooooo	AccE-dict	S-ground	SH office	Ruler	T chair	
ZAN	oooooo						
MAL	oo	Any water	Closed str.				
	oo	BP pen	Pencil				
-2	o						
		P-ground	Bldg.rpr.	Share/haveWri			
		Share/haveSit					
-3		Wtg.bd	Ex.book	ShareMTxt			
		Chalk	ShareRTxt				
-4							
	o = 15 Schools						

(ii) Level 2: Limited School Resources

In addition to the above resources, a school has a clinic and a market within 5 km from the school. It has a sports ground and non-piped water. Classroom has a temporary and/or permanent structure. The school head has his/her office. In the classroom, there is a chair and a table for the teacher. Teachers have an access to an English dictionary in school. Pupils have rulers.

(iii) Level 3: Basic School Resources

In addition to the above resources, a school has a fence, a store room, and a staff room. Water is piped, and a toilet is used by less than 60 pupils. In the classroom, there is a wall chart. Teachers have access to a map and teaching guides. They have at hand English dictionary, map of a country, and an atlas. Pupils have at least a notebook and an eraser.

(iv) Level 4: Comfortable School Resources

In addition to the above resources, a school has electricity and a school library, a classroom library, and a first aid kit. It has a radio, telephone, and a typewriter. In the classroom, there is a cupboard. Teachers have world map, map of Africa at hand in the classroom, and they also have an access to geometric instruments. Pupils have their own textbooks, and sharpeners. The school purchases library books every year, and books can be borrowed.

(v) Level 5: Affluent School Resources

In addition to the above resources, a school is located within 5 km from a public library and a bookshop. A water tap can be found in a classroom. A school has a duplicator and a tape recorder. In the classroom, there are bookshelves. At least one book per pupil is available for both class and school libraries. Pupils have file folders.

(vi) Level 6: Prosperous School Resources

In addition to the above resources, a school has a secretary's office; a school hall and a cafeteria. School buildings are in good condition. The teaching space is at least $2m^2$ per pupil. The school has a TV, a VCR, a photocopier, a computer, an overhead projector, a fax machine, and a film projector.

Distribution across the hierarchical SACMEQ school resource levels

The percentages of Grade 6 pupils who were in schools with different resource levels along with the standard errors of sampling (SE) have been presented in Table 3. It is shown that the distribution was negatively skewed in Mauritius and Seychelles (SACMEQ II). On the other hand, large percentages were found on lower levels for Malawi and Zanzibar (SACMEQ I). On the whole, the category which yielded the highest percentage for SACMEQ I was Level 2 (31 percent) where as for SACMEQ II, it was Levels 3 and 4 (28 percent).

Table 3. Percentage and Sample Error for Each School Resources Level

School Systems	Level 1 Insufficient		Level 2 Limited		Level 3 Basic		Level 4 Comfortable		Level 5 Affluent		Level 6 Prosperous	
	%	SE	%	SE	%	SE	%	SE	%	SE	%	SE
Kenya	2.5	1.52	26.4	4.07	43.9	4.49	22.7	3.73	3.9	1.28	0.6	0.28
Malawi	21.0	3.35	55.4	4.11	18.9	3.11	4.8	1.77	0.0	0.00	0.0	0.00
Mauritius	0.0	0.00	0.0	0.00	0.0	0.00	10.8	2.64	51.1	4.28	38.1	4.14
Namibia	3.2	1.64	29.5	3.80	26.3	3.72	21.2	3.26	10.7	2.14	9.0	2.09
Zambia	12.9	2.65	29.2	3.84	32.4	3.98	22.5	3.60	3.0	1.48	0.0	0.00
Zanzibar	14.8	0.00	53.6	0.00	23.9	0.00	6.0	0.00	1.7	0.00	0.0	0.00
Zimbabwe	0.6	0.65	23.1	3.44	38.9	3.89	22.0	3.38	12.7	2.33	2.7	1.34
SACMEQ I	7.9		31.0		26.3		15.7		11.9		7.2	
Botswana	0.0	0.00	1.3	0.74	6.8	1.96	68.4	3.59	19.8	3.04	3.8	1.44
Kenya	0.0	0.00	11.4	2.66	41.7	4.13	38.6	4.11	6.5	1.72	1.9	1.20
Lesotho	0.0	0.00	9.2	2.46	49.0	4.15	40.5	4.14	1.3	0.80	0.0	0.00
Malawi	1.0	0.78	61.6	4.43	30.1	4.21	7.3	2.18	0.0	0.00	0.0	0.00
Mauritius	0.0	0.00	0.0	0.00	0.0	0.00	14.2	2.95	52.8	4.17	32.9	3.96
Mozambique	3.1	1.44	24.8	3.20	32.5	3.61	32.9	3.01	6.7	1.66	0.0	0.00
Namibia	0.0	0.00	12.9	2.31	33.8	3.04	30.4	3.04	10.6	1.55	12.3	1.60
Seychelles	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	28.8	0.00	71.2	0.00
South Africa	1.0	0.99	14.9	2.92	19.7	3.24	30.2	3.98	14.0	2.78	20.3	3.75
Swaziland	0.0	0.00	3.5	1.43	29.3	3.54	51.8	3.89	13.1	2.63	2.3	1.16
Tanzania	1.4	0.80	30.6	3.60	45.5	4.24	22.5	3.90	0.0	0.00	0.0	0.00
Uganda	3.6	1.75	32.6	4.31	40.6	4.49	19.1	3.41	3.5	1.40	0.7	0.68
Zambia	4.6	1.61	37.0	4.27	30.6	3.73	25.0	5.14	2.0	1.32	0.8	0.83
Zanzibar	2.0	0.00	40.5	0.00	39.0	0.00	17.7	0.00	0.0	0.00	0.9	0.00
SACMEQ II	1.2		20.0		28.5		28.4		11.5		10.5	

Mean school resources

Each school has been given an estimate of a school resource score. When merged back to the pupil-level original data file, the mean school resource score (at pupil level) was -0.09215172409658 and its standard deviation was 0.960755343058. The mean school resource should be interpreted as the school resource level that pupils have access to. A standardized school resource score (ZSRESLOC) has been calculated making the SACMEQ II mean as 500 and the standard deviation as 100 as shown in the following formula:

$$ZSRESLOC = 100 \times \frac{Estimate + 0.09215172409658}{0.9420927535299} + 500$$

Where Estimate is the individual school resource score calculated at pupil level.

In Table 4, the means and standard errors of sampling for the school resources for each country using the standardized score have been presented. For SACMEQ I, the overall mean school resource score was 464.8. The mean ranged from 379.3 in Malawi to 630.8 in

Table 4. Mean and Sample Error for School Resource Scale

School Systems	SACMEQ I		SACMEQ II		
	Mean	SE	Mean	SE	
Botswana	NA	NA	544.6	4.59	
Kenya	454.9	4.96	485.5	4.92	**
Lesotho	NA	NA	475.0	3.72	
Malawi	379.3	4.97	409.7	3.99	**
Mauritius	630.8	3.97	629.0	4.01	
Mozambique	NA	NA	461.3	4.26	
Namibia	481.1	6.06	513.9	4.18	**
Seychelles	NA	NA	675.2	0.00	
South Africa	NA	NA	541.4	9.04	
Swaziland	NA	NA	510.9	4.96	
Tanzania	NA	NA	439.8	4.37	
Uganda	NA	NA	437.6	5.88	
Zambia	430.6	6.63	443.2	8.42	
Zanzibar	399.2	0.00	432.9	0.00	**
Zimbabwe	477.9	5.68	NA	NA	
Overall	464.8		500.0		

** Significant at 95 % confidence

Mauritius. For SACMEQ II, the country with the highest mean was Seychelles (675.2), and the lowest mean school resource score was 409.7 in Malawi.These results were consistent with the level of GDP per capita (World Bank 2003).

Changes in the school resource level between SACMEQ I and SACMEQ II

Also shown in Table 4 are the differences between two studies. The standard error of the difference was calculated by taking the square root of the sum of the variances for each mean. In order for the difference to be significant at the 95 percent confidence level, the difference must be greater than or equal to two standard errors.

All the countries except Mauritius increased the school resources. The increased values varied from 12.6 points in Zambia to 32.8 points in Namibia. The changes in Kenya, Malawi, Namibia, and Zanzibar were statistically significant at the 95 percent confidence level taking into consideration the size of the standard errors.

Among-region and between-region variations

The distribution equity was examined using the allocation patterns of the school resources. In Table 5, the variation among and within regions on the school resources have been presented for each school system. The variations among regions (ARV) were calculated using the F statistics obtained from the ANOVA analyses conducted at the school-level data file. The following formula was used:

$$ARV = \frac{F - 1}{F + \frac{m}{n} - 1}$$

Where m = number of schools; n = number of regions

For SACMEQ I, Malawi, Mauritius, and Zambia showed small variations among regions (less than 0.1). However, in Kenya and Namibia, these figures exceeded 0.45. For SACMEQ II in Mauritius and Uganda, the calculated variations among regions were negative, which were treated as no variation among regions. In contrast, in Namibia and Zanzibar, the variation among regions yielded large figures. When comparing SACMEQ I and II, in Kenya the variation among regions reduced by 0.14 points where as in Namibia and Zanzibar, they increased by about 0.11 or 0.13 points.

Table 5. Variation Among and Within Regions

School Systems	SACMEQ I		SACMEQ II	
	Variation Among Regions	Variation Within Regions	Variation Among Regions	Variation Within Regions
Botswana	NA	NA	0.11	0.89
Kenya	0.47	0.53	0.33	0.67
Lesotho	NA	NA	0.02	0.98
Malawi	0.06	0.94	0.03	0.97
Mauritius	0.06	0.94	0.00	1.00
Mozambique	NA	NA	0.18	0.82
Namibia	0.45	0.55	0.56	0.44
Seychelles	NA	NA	0.01	0.99
South Africa	NA	NA	0.39	0.61
Swaziland	NA	NA	0.05	0.95
Tanzania	NA	NA	0.04	0.96
Uganda	NA	NA	0.00	1.00
Zambia	0.08	0.92	0.16	0.84
Zanzibar	0.29	0.71	0.41	0.59
Zimbabwe	0.21	0.79	NA	NA

Correlation between the SACMEQ school resource scale score and the achievement scores

The SACMEQ Reading and Mathematics scores in the SACMEQ archive had been established using the Rasch scaling method (Ross et al. 1994; Andrich et al. in press), and standardized to have a mean of 500 and standard deviation of 100 for SACMEQ II. It should be noted that the overall correlation between the existing simple resource index (summation of 22 items) and the aggregated achievement scores at school level for SACMEQ II were .446 and .388 for Reading and Mathematics respectively. However, when using the newly-established resource scale, the correlation improved to .490 and .437 respectively. This was due to the fact that the Rasch model enabled more items to be incorporated to build the scale.

The coefficients of correlation between the SACMEQ school resources score and Reading and Mathematics scores for each country have been presented in Table 6. In general, the achievement scores in both subjects were positively related to the school resources score with statistical significance. This finding was consistent with the conclusion of Siniscalco and Ross (1997). The magnitude of the correlation coefficient was particularly high in Kenya, Namibia, and Zimbabwe (SACMEQ I), and Botswana, Namibia, and South Africa (SACMEQ II).

In order to put perspective to the magnitude of these correlation coefficient, it should be noted that the Reading Literacy Study conducted by the IEA reported the school-level correlation coefficient between school resources and achievement ranging from -0.03 to +0.14 (Ross & Postlethwaite 1994).

However, these relationships were not adjusted for the pupil input. Further studies need to be carried out in order to determine the veritable relationship.

Table 6. Coefficient of Correlation between SACMEQ SRI and Reading and Mathematics Scores of Pupils in the SACMEQ I and SACMEQ I

School Systems	SACMEQ I		SACMEQ II			
	School Resources x Reading		School Resources x Reading		School Resources x Mathematics	
Botswana	NA		0.60	**	0.60	**
Kenya	0.61	**	0.55	**	0.46	**
Lesotho	NA		0.42	**	0.29	**
Malawi	0.20	**	0.21	**	0.06	
Mauritius	0.22	**	0.14		0.12	
Mozambique	NA		0.20	**	0.05	
Namibia	0.75	**	0.77	**	0.77	**
Seychelles	NA		0.44	**	0.42	**
South Africa	NA		0.78	**	0.73	**
Swaziland	NA		0.55	**	0.39	**
Tanzania	NA		0.23	**	0.20	**
Uganda	NA		0.44	**	0.24	**
Zambia	0.12		0.59	**	0.39	**
Zanzibar	0.21	**	0.26	**	0.12	
Zimbabwe	0.65	**	NA	**	NA	
Overall	0.51	**	0.49	**	0.44	**

** Significant at 95 % confidence

Conclusion and Discussion

The established SACMEQ SRI satisfied criteria of an "ideal" scale (Woo 2005b). First of all, the SACMEQ SRI exhibited an "excellent" reliability index of 0.901, indicating that the scale is internally consistent and is separating the schools on this variable. The high reliability could be due to the dependency of items within the scale. For example, many high-tech items were dependent on the availability of the electricity. Using the Rasch model, it would be worthwhile to re-examine the reliability and the fit of the scale by converting the dependent items to a single item with a greater total score with minimized redundancy.

Secondly, a given score of a school on the school resource scale was not merely a quantitative measure. It provided a qualitative description of the resource items that are likely to be available in a school. These profiles could be used as a guideline to identify critical and relevant resource items at each progress level.

Thirdly, the SACMEQ SRI had a correlation coefficient of 0.490 and 0.437 with the school aggregates of pupil Reading and Mathematics scores respectively, suggesting that the scale can be used as a predictor of school achievement as well as an indicator of a school's developmental level. This was achieved by a careful selection of the resource items that were meaningful in developing countries. A similar approach would be required in order to validly measure the socio-economic status of pupils in this context (Dolata 2005). This would shed light on the long-lasting debate regarding the interaction between school effect and the pupil background on achievement.

Finally, using the linked common items between SACMEQ I and SACMEQ II, countries that only participated in one of the studies were also placed on the same scale as those that participated in both studies. However, interchanging totally one set of items for another set would significantly alter the nature of the resource list. That is, very different subsets of school resources would mean different qualitatively different functioning in schools. The situation can be accepted if each item on the resource instrument is taken to represent the universe of that type of resources. For example, a blackboard is an item representative of all possible types of blackboard, and a copier is a representative of copiers, etc. Such an assumption does not allow that the copier item is exchanged for a blackboard. Such a change in the instrument would shift the meaning of the overall resource allocation and would make the measure of resources dependent on which items were used on the instrument and would violate the assumption of specific objectivity. However, if only a few of the resource items are different among the schools, then depending on which ones they are, they might be exchangeable in the above sense. This notion of exchangeability may require further exploration in order to justify the use of Rasch in the domain of school resources.

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