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# A Comparative Study Between Saudi Arabian and Glasgow Science Textbooks for 10-Year-Old Students on the Coverage of Basic Science Process Skills

**Hanan Fawzi Aljarallah**
Lecturer of Curriculum and Instruction, Education Faculty, King Saud University, KSA
hanan.alj@gmail.com

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**Abstract:** The study aimed at determining how well basic science process skills are promoted in Saudi Arabian science textbook activities compare to those covered by the Glasgow Science Program booklet activities. The textbooks selected for examination in this study were the science textbooks that have been taught to 10-year-old students and used by schools in Saudi Arabia, as well as the science booklets used by schools in Glasgow. A total of 31 scientific activities covered in the Saudi Arabian textbooks and 18 scientific activities covered in the Glasgow Science Program booklets were analysed according to a modification of Tamir and Lunetta's (1978) task analysis instrument (LAI). Results showed that there were considerable differences in the coverage of science basic process skills between both books. The major conclusions of the study were that (a) the basic skills, covered within Saudi Arabian textbooks in comparison with Glasgow science booklets, are restricted to observation, communication and inference process skills, whereas few opportunities were provided to practice measurement, classification and prediction process skills; (b) the absence of an extension level for the activities is the main cause of this inequality; (c) increasing the number of science activities in Saudi Arabian science texts does not improve students' acquisition of basic science process skills while an extension level for these activities is not provided; and (d) there are relationships between some integrated skills, in that pupils' performance in them are poor, and the low frequency of certain basic skills in both books (i.e. prediction and classification).

***Keywords:*** *textbooks; Basic Science; Glasgow; Saudi Arabian.*

## 1. Introduction

As a result of living in a rapidly developing, scientifically rich world, a great emphasis has been placed on science curricula and teaching methods, particularly for children. This emphasis is due to many reasons, as Mechling and Oliver (1983) point out. Examples of these benefits are helping young students to understand the natural phenomena around them, helping them learn authentic scientific concepts and, therefore, avoid misconceptions. Moreover, science educators bear a greater responsibility toward the next generation to be critical thinkers, well-informed decision makers, curious learners, problem solvers and scientifically literate citizens.

Therefore, investigations of the best way of science teaching and learning are continuously conducted. These studies and investigations could not confirm that one single method is the best way to achieve in science. However, most science researchers agree on the fact that there are two aspects of the discipline that are very important and strongly related to each other: knowledge of science and the process of doing science (Woolnough, 1989). Thus, an emphasis on scientific knowledge alone is limited; although the process of science alone is not science, it leads to the establishment of new scientific knowledge and principles. Thus, science knowledge and process skills in science education are inseparable.

Although issues related to learning scientific knowledge have long been investigated, this study is concerned with the practical part of science, or 'science process skills. The term 'science process skills' was introduced in the curriculum project, which is called Science-A Process Approach (SAPA). This project was introduced by the Commission on Science Education of the American Association for the Advancement of Science (AAAS) in 1965. After introducing this approach in science teaching, science process skills learning has been given great importance (Mattheis and Nakayama, 1988; Harlen, 1999; Tamir, 1985; Germann, Haskins and Auls, 1996). Furthermore, a major goal of science instruction which has been included in many recently developed science curricula emphasized teaching the science process skills (Ruddock and Sainsbury, 2008).

Science process skills are the skills scientists use to conduct science which form the foundation for scientific methods. The acquisition and frequent use of these skills can better equip students to solve problems, learn on their own, and appreciate science (Millar, 1989). These processes include observing, inferring, predicting, classifying, measuring, communicating, transforming data, controlling variables and defining operationally. These skills have a distinct importance for many reasons. One of the reasons given in support of the science process is that it develops skills that pupils will use in the future in every area of their lives. Moreover, science process skills build critical thinking and problem-solving skills which can be used in other academic areas. According to Rillero (1998: 3), science process skills can also help students 'read, write, and do social studies and mathematics'

Last but not least, successfully integrating the science process skills with classroom lessons and field investigations will make the learning experiences richer and more meaningful for students because they will be actively engaged with the science they are learning. This active engagement with science is more likely to lead to students becoming more interested in and have more positive attitudes towards science (Blumenfeld et al, 2006).

## 2. Literature Review

- **Previous related studies**

After searching within the previous studies in the framework of science textbook analysis, the researcher found that for many years researchers and educators have been concerned with science process skills. For example, Tamir and Lunetta (1978) analysed the laboratory inquiries of a selected biology textbook called *BSCS Yellow Version* (BSCS, 1973). These inquiries were analysed according to the laboratory analysis instrument LAI, which has been developed by the researchers for their project. They found that prediction and communication process skills are promoted infrequently, although observation and inference process skills are promoted in all inquiries. Following this, they used the instrument for a comparative analysis study between the *BSCS Yellow Version* and a physics project (Lunetta and Tamir, 1979). It was followed by a study that analysed eight selected science laboratory manuals (Tamir and Lunetta, 1981).

In addition, a number of other well-known researchers have used the LAI instrument. For example, Furhman, Lunetta and Novick (1982) report the analysis of several chemistry manuals. Lumpe and Scharmann (1991) carried out a comparative study between *Modern Biology Laboratories* (1989) and *Biological Science: An ecological approach* (BSCS, 1987). Seven years later, Gerrnann, Haskins and Auls (1996) modified the LAI instrument to be appropriate for their analysis purpose, which was determining how well the selected *Nine High School Biology Laboratory Manuals* promote scientific skills.

Moreover, Anderson (1992) analysed two science activities that were included in selected textbooks for elementary and middle schools. He aimed to examine the 'quality' of the written texts as well as the 'integrity' of the science contents stated in both activities. The methodology of this study was qualitative, in which the researchers evaluated and compared the two activities based on their perspectives. This study concluded that the function, procedures and design of both activities were inadequate. However, the basic science process skills covered in these textbooks' laboratory manuals were not analyzed.

Ruddock and Sainsbury (2008) compared mathematics, science and literacy curricula in England with those of other prosperous countries. With regard to Singapore's science curricula, the country being known for its proficiency in education, it demonstrated that science process skills should be practiced through scientific activities: 'In science process teaching and learning, teachers should teach each of the basic process skills explicitly through the use of appropriate activities and then meaningfully infuse the teaching of these skills in their lessons' (174).

Beaumont-Walters and Soyibo (2001) carried out another study concerned with the same issue, i.e. students' poor performance in science skills. However, they investigated whether social factors such as school type, student type, socio-economic background, student gender and grade influenced these skills (Beaumont-Walters and Soyibo, 2001). They found that school type has a remarkable influence on students' science skills performance, although student type and grade level had little effect.

Although there have been studies analyzing science activities in major secondary and high school science textbooks in the United State, the United Kingdom and Israel, and studies from other countries that have investigated the relation between students' performance in integrated process skills and their gender, grade level, school type and socio-economic background (Beaumont-Walters and Soyibo, 2001), no research has yet been undertaken to investigate the relation between students' performance in integrated process skills and the coverage of basic process skills in the primary school texts they were taught. Therefore, this study focuses on the coverage of basic process skills in primary school science texts in the KSA and Scotland.

- **Basic and integrated process skills**

Most researchers agree that there is a two-level hierarchy (basic and integrated) of process skills (Padilla 1990; Yager, 1996). According to Padilla (1990), the SAPA curriculum project reported that observing, classifying, communicating, measuring, inferring and predicting are basic process skills. It is very important that these basic skills are acquired at the earliest grades. Furthermore, practicing these basic skills will lead to the accomplishment of more advanced process skills. As this study is concerned with the basic process skills, a discussion of each basic skill is provided.

**Observing (process skill):** to observe and learn information directly through the senses or instruments (Padilla, 1990). The observed knowledge is confirmed and is difficult to argue (Wolfinger, 1984). It is claimed that observing is an obvious process and does not need to be taught. However, teaching this skill to children helps them in carrying out close observations and noticing details (Millar, 1989).

**Classifying (process skill):** to classify and place objects into groups by their similarities and differences or other classifying criteria (Padilla, 1990). This is an important step towards a better understanding of the different objects and events in the world.

**Measuring (process skill):** To quantify or compare objects using proper measuring instruments and valid units of measure (Padilla, 1990). A measurement statement contains two parts: a number to tell us how much or how many; and a name for the unit to tell us how much of what.

**Communicating (process skills):** To present or communicate any learned knowledge with pupils (Padilla, 1990). Students can communicate their observations verbally, in writing, or by drawing pictures. Other methods of communication that are often used in science include graphs, charts, maps, diagrams, and visual demonstrations.

**Inferring (process skill):** To interpret phenomena based on past experiences or direct observation of the event (Padilla, 1990). Thus, unlike observations, which are direct evidence gathered about an object, inferences are explanations or interpretations that follow from the observations (Millar, 1989). Inferences link what has been observed with what is already known from previous experience. We use our past experiences to help us interpret our observations.

**Predicting (process skill):** To anticipate or estimate a future event based on prior observations and experiences (Padilla, 1990). So, like inferences, predictions are also based on both direct observation and the mental model that pupils build up from their past experiences.

## 3. Research questions and aims

My intention is to ascertain whether the scientific inquiries included in Saudi Arabian textbooks for students who are aged 10 promote the basic process skills, and to then compare these process skills with the skills promoted in the equivalent Scottish textbooks. More specifically, the present study is set the task of answering these detailed questions:

1. How many, and which kinds of science activities are included in science textbooks of the fourth grade in KSA and Scotland?
2. To what extent are basic science process skills included in the scientific activities of the fourth-grade science textbooks?
3. How are the science process skills supported in the science activities in these two textbooks?
4. What are the differences, if any, between Saudi Arabian and Scottish textbooks, both in terms of the relative frequency of basic process skills and the way in which these are presented and used?

## 4. Research hypothesis

The major hypothesis in this research is that the deficiency in students' acquisition of integrated process skills might be due to a deficiency in primary textbooks in supporting the basic process skills through scientific activities. This hypothesis is built from two sub-hypotheses: 1) many integrated process skills that are poorly achieved by high school students rely on particular basic process skills; 2) high school students who have performed poorly in integrated skills did not practice particular basic process skills at early stages (i. e. primary school) because they were not covered in these science textbooks.

## 5. Significance and rationale for the study

A review of the previous related studies revealed that this study is the first of its kind in the KSA, therefore, it will establish the foundations for further research in the field of Saudi Arabian science textbook analysis. In addition to the contribution of this research in KSA, the modified instruments used in this study and findings can help authors, teachers, and other persons of interest to select the most suitable books in this genre of science education. This is a recognised advantage of science textbook analysis research (Tamir and Lunetta, 1978; Tamir, 1985; Fraenkel and Wallen, 2000). Furthermore, this research provides knowledge of basic process skills and their inclusion in science textbooks which I hope will contribute to the literature of science process skills teaching.

### The KSA education system

As this study is concerned primarily with Saudi Arabian and Glasgow curricula, it is worth clarifying the distinctions between the two systems. First, in the KSA the curriculum is national, in which all schools in the country teach the same texts. Secondly, the first stage in the education system, which is called the basic stage, consists of six grades: the first three grades are called the lower basic stage while the fourth, fifth and sixth grades are known as the upper basic stage. Finally, it is important to clarify that students begin school at 6-7 years of age, and graduate at the age of 17-18. Thus, students' age in the fourth grade, which is the focus of this study, is 10-11 years.

### The Glasgow Science Programme

In contrast to the Saudi Arabian curricula, Scottish school textbooks are not national, i.e. different schools in the country teach different texts. Nevertheless, the Glasgow 5-14 Science Programme is widely used in Glasgow schools, as suggested by one of the experts in the field from the Education faculty at the University of Glasgow. This programme provides a clear framework of what should be covered at each stage to ensure progression and continuity in pupils' learning. This programme is designed for pupils aged 5-14 years old. Therefore, students are expected to be 10-11 years of age in primary six, which is equal to Saudi Arabian students' ages in primary four. Topics covered in the programme range across all science disciplines. Two booklets from the series of books in the programme should be covered.

## 6. Methodology

- **Research design and method**

Since the aim of the research is to evaluate science textbooks, the positivist research paradigm would be able to provide precise and valid data which can be verified by other researchers. Under the umbrella of the positivist approach, science process skills evaluation can be carried out using different research methods, such as class observation or content analysis. Considerable numbers of studies have been conducted to evaluate students' acquisition of science process skills by class observation methods. Thus, the researcher observes the actual use of textbooks in classrooms.

It is necessary to offer a basic description of a textbook as well as to identify which particular science activity is more supportive for basic process skills. If more detail is needed, it might then be useful to conduct class observations and personal interviews.

- **Data collection**

**The sample**

The sample includes a primary 4 science textbook in the KSA as well as the Glasgow science texts which are equivalent to primary 4 in the KSA. The Glasgow 5-14 science programme booklets which are equivalent to primary 4 texts in the KSA were included in the sample. All the activities in the selected textbooks were analysed. The number of activities that have been analysed (and hence my sample) is as follows: first, 31 science activities that are included in the Saudi Arabian text. Second, 18 science activities covered in the Glasgow texts.

**The instrument**

The laboratory task inventory was largely taken from the Tamir and Lunetta inventory LAI (1978). This instrument has two main sections: a) the first section analyses laboratory tasks and consists of 16 inquiry skills categories (Table 1), which were used in this research; b) the second section consists of 4 categories to examine laboratory organisation, although it was not used in this research because its purpose differs from that of this research (Tamir and Lunetta, 1978). This is a reliable and valid instrument that has been checked for reliability and validity (Fisher et al, 1998). The first use of LAI was by the developers of these instrument, Tamir and Lunetta, in 1978. It has since been used by many science researchers and educators to examine the structure and levels of inquiry for many science textbooks.

I prepared a table that presents the basic process skills, their descriptions and examples of instructions or statements that support these skills. The descriptions were taken from Padilla (1990), while the examples were taken from Padilla (1990) and Tamir and Lunetta (1978) to provide a variety of examples that might help the coders to identify which process skill is covered by each statement, thus increasing the validity of the research data.

**Table (1): The categories of the task analysis instrument LAI and examples taken from *BSCS Yellow Version* (Third Edition)**

| Categories | Examples |
|---|---|
| Recognise and define problems | Your task will be to learn as much as you can about organs in the frog.... Pretend that you are the first person ever to dissect a frog.... Now you are on your own [15-2]. |
| Formulate hypotheses | On the basis of your observations, what hypothesis can you make about the possible functions of cork in the living tree [3-1]? |
| Predict | Will starch alone react with Biuret reagent [4-1]?<br>If a glycerinated muscle fibre is exposed to salts as before and then ATP is added drop by drop, what will happen [6-4]? |
| Design observation and measurement procedures | Use your knowledge of living processes and make what observations you can that will throw light on your hypotheses [9-2].<br>What control would you suggest for this inquiry [13-1]? |
| Design experiments | Devise an experiment to test tolerance of vinegar eels to pH changes [16-1]. |
| Carry out observations, measurements and experiments | Observe it in a drop of 5 percent solution with the microscope [6-2].<br>How do the abdomens compare in shape [27-1]?<br>How many were in F, generation [27-2]?<br>If you carry out the following experiments you will discover some ways in which plants respond to light [19-3]. |
| Record results, describe | What is the effect of temperature on the rate of heartbeat [ 11-2]?<br>What do you observe on the paper [21-2]? |
| Transform results to a standard form | Using graph paper, make a graph of the data [11-2].<br>Draw in your notebook a simplified outline of Paramecium as you see its appearance through the microscope. Add within the outline all the parts of the animal that you observe [9-1]. |
| Explain | What explanations can you give for the different cork cell shapes in your preparation [3-1]? |
| Make inferences, draw conclusions | What is the significance of this observation [17-3]?<br>What can you conclude [17-3]?<br>What do changes in each tube indicate [17-4]? |
| Formulate generalisations or models | On the basis of your inquiries into the nature of cells, prepare a statement about your model's investigation of the cell theory [3-3].<br>What are some characteristics of a frog that make it a good experimental animal for water balance studies [13-1]? |
| Define limitations or assumptions | Is Benedict's solution a test for all of these sugars [4-1]?<br>What assumptions are you going to make about the use of hydrogen peroxide in this inquiry [4-2]?<br>Is an identification of a spot on a chromatogram such as this sure proof that it is the same as one of the known amino acids [5-1]? |
| Learn techniques | Run iodine under the cover glass in the following way [3-2].<br>Construct the calorimeter using Figure 5-9 as a guide [5-3].<br>A technique for staining bacteria [22-3].<br>You can demonstrate the rate of transpiration in plants with a simple piece of equipment, the potometer [18-3]. |
| Perform quantitative work | What is the total temperature change that occurred in the reaction chamber [4-2]?<br>Make a graph of the relation of this movement to time [18-3].<br>What is the dilution of the source material in tube 1 [23-1]?<br>From the backcrosses, what percentage of the offspring of each backcross has a mutant trait [27-2]? |
| Perform "dry" laboratories | Five experiments will be described. On the basis of these, you should be able to provide answers to the following questions [19-4]. |
| Work according to own design | There will be few directions - you must explore and interpret what you find in terms of what you already know.... Now you are on your own [15-2]. |
| The figures in brackets represent the numbers assigned to specific laboratory inquiries in the text (BSCS, 1973). | |

For this study, the first section of LAI was adopted and modified to meet the needs of this research. In other words, four items of the LAI that analyse the basic process skills were taken. The items used as presented in the original instrument are as follows: predict and make inferences. In addition, the category 'carry out observations and measurements' were divided into two separate items in line with the basic process skills identified by (Padilla, 1990), yielding two subcategories: carry out observation and measurement. Furthermore, one category has been added to analyse the final basic process skill of interest to the researcher, namely the 'classification' process skills. Thus, the modified instrument consists of six categories that represent the basic process skills.

These examples might help clarify the nature of each skill and consequently become easier for the coders to use. Furthermore, the modified instrument uses examples from two different sources to provide different ways of supporting these skills in science texts and, therefore, the validity of the instrument will increase.

**Data analysis**

The modified instrument was used to code all task instructions presented in the textbooks (the process is described in detail below). The manifest as well as the latent content of the science activities were coded. Latent content refers to 'the meaning underlying what is said or shown' (Fraenkel and Wallen, 2000: 476). Whereas, the manifest content refers to the words that clearly represent the process skills. This method has an advantage because it investigates the more obvious as well as the underlying concepts of the science activities' instructions (Fraenkel and Wallen, 2000).

The analysis was carried out by the researcher and another Saudi Arabian science teacher; not only do both hold graduate degrees in science, they also have additional research experience. The researcher considered the ethical issues and made an effort to avoid any unethical procedures. Participation in the research project took the form of a second coder, who helped to transform the raw data (the textbooks themselves) into a form of material that was usable for this project. The involvement of a second coder was considered important in order to verify the reliability and validity of the research.

Therefore, a formal letter was sent to the science teacher who participated in the research. The letter explained to her the nature of the research and requested her permission to analyse science textbook activities. After obtaining agreement from her to participate in this research, she was provided with a number of studies, research results, and books in the field of science process skills to enhance her familiarity in the topic. Both coders then discussed the use of the modified coding scheme and were trained in its use. Text analysis procedures were then conducted and each stage of the analysis procedures will now be discussed.

**Science textbook analysis procedures**

The first step in the analysis procedures was counting the number of scientific activities included in the textbook. Both the researcher and other Saudi Arabian teacher counted these laboratory manuals before comparing the results. Both found that the Saudi science textbook for the fourth grade promotes 31 scientific inquiries, whereas Glasgow books for the 6th grade promotes 18 science activities.

**Core analysis**

Both the researcher and the Saudi Arabian teacher analysed these activities in separate conditions. In order to analyse the science activities, every sentence in the instructions for the scientific inquiries were carefully read then re-read by both coders until they felt comfortable with coding the results in order to establish whether a particular skill fits any of the categories of the instrument. When a particular skill is covered in one sentence, a (+) is recorded. If the same skill appears more than once, more than one (+) is recorded, and the number of (+) recorded will then be equivalent to the number of skills covered in one activity. Table 2 presents an example of the coding for the six basic skills covered by activity number (4) in the Saudi Arabian text.

**Table (2): Analysis sheet of the fourth science activity covered in the primary 4 science textbook in KSA**

| Basic process skills | The analysis of the 4th science activity |
|---|---|
| Observation | + + + |
| Classification | 0 |
| Inference | + |
| Prediction | 0 |
| Measurement | 0 |
| Communication | + + |
| Total | 6 |

- **Discussion of the results**

To identify the differences, if any, between the researchers' analysis and the rational explanation of these differences, a precise review across the analysis for all the activities was carried out. When any differences were found through the comparison, an explanation of the way in which a sentence in the activity's instructions had been analysed was discussed. After this discussion, I was convinced by the teacher's argument regarding the analysis of the two activities. Therefore, few changes were made to my analysis results.

- **Establishing the reliability of the analysis**

Several ways to estimate research reliability have been proposed. In the case of this research, linearly weighted kappa was used instead of simple kappa. The use of linearly weighted kappa to estimate the reliability of this research is due to two reasons. First, using this measurement was suggested by one of the statisticians from the Department of Statistics in the University of Glasgow. Second, using simple kappa is meaningful if the categories are nominal, as it treats all disagreements equally. In the case of this research, the categories are ordinal i.e. category 2 represents more skills than category 1; similarly, category 1 represents more skills than category 0. Therefore, it is useful to weight the near misses between raters.

To calculate the kappa coefficients, new tables were created. These tables aimed to compare the analysis of each skill throughout each activity between coders. When a particular skill is not covered in the activity, a (0) is recorded. However, when a particular skill is covered once, a (+) is recorded. Finally, if a particular skill is covered twice or more, (++) is recorded. These steps were carried out for each activity and for the two coders' results. In other words, three categories were used for each rater: zero occurrences of the skill, one occurrence, two or more occurrences. This data compression was carried out on the advice of the research statisticians to enhance the statistical power of the test.

The formula for the linearly weighted kappa is: Kw = (Po-Pe)/(1-Pe). Po refers to the proportion of weighted observed agreement, while Pe is the proportion of weighted chance agreement (Altman, 1991). An online calculator, provided by Lowry (2009), was used to carry out the calculations.

The value of the research depends largely on its reliability (Fraenkel and Wallen, 2000). Therefore, I attempted to formulate the tables and record the data precisely and accurately, before revising the original data and the new tables.

- **Findings**

Before presenting the findings, it is important to justify the extent to which this research is reliable. The kappa coefficient is in the range between 0.74 and 1, which indicates that there is a high rate of agreement between the two analysts and, therefore, the results are reliable. There is no absolute value for an excellent inter-rater agreement, although values above 0.81 are usually considered to indicate very good inter-rater agreement; values between 0.61 and 0.80 representing moderate agreement; whereas kappa values below 0.5 indicate poor agreement (Altman, 1991: 405). Of the X kappa statistics calculated, Y were above 0.81.

The following are the results of the textbook analysis. They are divided into three sections: 1) related to the Saudi Arabian textbook; 2) related to the Glasgow textbooks; and 3) a summary and overview of the differences between the texts.

**1. Analysis of the Saudi Arabian textbook**

The analysis shows unbalanced coverage of the basic process skills. In other words, the number of science inquiries varies from topic to topic, which could be due to the differences between topics and the nature of the knowledge they promote. The study shows that in general the scientific activities are highly structured and promote step-by-step instructions. In addition, the basic process skills are distributed across these inquiries.

The total number of basic process skills covered within all scientific activities is 136 skills. Considerable differences were found between basic process skills in the text. Observation was the most frequently-used skill (n = 85; 62.50%). Next in magnitude was the inference process skill (n = 29; 21.32%), followed by the measurement process skill (n = 9; 6.62%), communication process skill (n = 7; 5.15%), and, finally, classification and prediction process skills (n = 3; 2.21%) were at a lower level of frequency.

**2. Analysis of the Scottish textbooks**

In relation to the Scottish texts, the Fairground Electricity and Sound and Light topic books were analysed. These are the books that are taught to 10-year-old students. The total number of activities covered in these books is 18: nine of them relate to Fairground Electricity topics, while the other nine are covered in the Sound and Light booklet. The study shows that in general the scientific activities are highly structured and promote step-by-step instructions. In addition, photographs and diagrams are provided to simplify the activities for pupils. The basic process skills are distributed over these activities.

The total number of basic process skills covered within all scientific activities is 81 skills. Considerable differences were observed between skills. Observation was the most frequently-used skill (n = 48; 59.26%). Next in magnitude was the communication process skill (n = 17; 20.99%), followed by the inference process skill (n =

6; 7.41 %), prediction process skill (n = 4; 4.94%). Finally, classification and measurement process skills (n = 3; 3.70%) produced a lower level of frequency.

**3. Summary and overview of the differences between the textbooks**

According to the findings, the main differences between the Saudi Arabian and Scottish science textbooks can be summarised as follows:

- The number of science activities which provide step-by-step instructions as well as places for pupils to write their responses to the questions (i.e. worksheets) for 10-year-old Scottish pupils is demonstrably fewer than for the scientific activities included in the Saudi Arabian science texts. The reason for this is explained by the Glasgow 5-14 Science Programme as promoting an enquiry-based approach to learning characterised by first-hand experience.
- The comparison between the number of science activities included in the Saudi Arabian and Glasgow texts shows that the Glasgow booklets contain approximately one-half of the number of activities in the Saudi Arabian texts. In addition, precise analysis of the basic skills revealed that the number of basic skills covered in the Glasgow booklets is one-half of those in the Saudi Arabian texts (81: 136), as Table 3 indicates. However, the classification skill is promoted three times in both texts, in spite of the remarkable differences between the number of science activities that support these skills in the texts for both countries.
- The six basic process skills can be divided into two groups: high frequency skills are considered to be one group and low frequency skills the second. Without repeating the details here, the analysis revealed that in general all basic process skills are covered within the scientific activities that are included in both textbooks. Nevertheless, both countries rarely involve process skills for classifying and predicting. Finally, the emphasis on measurement and inference process skills is high in Saudi Arabian texts, while they fulfil a low frequency in the Scottish textbook's analysis. By contrast, the emphasis on communication skills is high in Glasgow science texts, while it attains a low frequency skill in Saudi Arabian text analysis.
- Three important claims regarding observation and prediction skills can also be noted: 1) most observational tasks require qualitative rather than quantitative observations; 2) the observational tasks do not cover a particularly broad spectrum of the senses (or at least not all senses for textbooks from either country); 3) predictions tend to be transfer tasks with only vague predictions required, and quantitative prediction was not supported in the texts at all.

**Table (3): Comparison between the coverage of basic process skills through science activities across Saudi Arabian and Glasgow science texts for 10-year-old students**

| Basic process skills | Saudi Arabia | Glasgow |
|---|---|---|
| Observation | 85 | 48 |
| Classification | 3 | 3 |
| Communication | 7 | 17 |
| Measurement | 9 | 3 |
| Inference | 29 | 6 |
| Prediction | 3 | 4 |
| Total | 136 | 81 |

## 7. Discussion

Four significant findings emerged from the comparative analysis between Saudi Arabian and Glasgow science texts for 10-year-old students. A discussion of each finding is provided, although the discussion as well as the implications are mostly related to the Saudi Arabian text. The high frequency skills in the Saudi Arabian text are observation, inference and measurement; the three low frequency process skills are classification, communication and prediction process skills.

**The initial finding:**

The first significant finding to emerge from this study is that there is a link between the low frequency skills covered in the Saudi Arabian texts and the absence of an extension level of inquiry. This argument is built on the Germann et al (1996) classification of science activity levels. They divided the laboratory activities into seven levels, the final level, called the 'extension level', is further divided into two groups. According to Germann et al (1996), an instance of the first group is when students examine or investigate a number of examples in an activity by using the procedures learned in the same activity. After conducting this step, classifying these examples is important, thus the extension level of inquiry promotes classification process skills. The second group of the extension level of inquiry exists, for example, when pupils are asked to use the results of an activity to predict new outcomes, which clearly supports prediction skills (Germann et al, 1996).

Due to the fact that these two basic skills, i.e. classification and prediction, which are the main skills in the extension level of an activity, are the skills of the lowest frequency in both texts, I could argue that by omitting an extension level for the activities considerable opportunities to support these two skills are missed. If an extension level is added to the science activities, most of the low frequency skills could be promoted.

**The second finding:**

It has been found that although both texts are taught to 10-year-old students, there was a great deal of variance in the number of science activities covered by these books. Whereas 31 activities were covered in the Saudi Arabian book, there were only 18 activities included in the Glasgow booklets. The second issue is that there is no activity in the Saudi Arabian text which supported more than three basic skills. In the Glasgow Science Programme booklets, however, there were a few activities that covered more than three basic skills. Thus, overall, the coverage of basic skills in the Saudi Arabian text appears to be insufficient.

I might argue that as a result of the Saudi Arabian government's concern with the development of science education, more activities were added to this version of the science textbook compared to previous texts. However, this research finding shows that some process skills are supported by a large number of activities, while others by very few. Therefore, it seems likely that in attempting to improve the written texts, it would be necessary to replace some of the activities that cover the popular skills with activities that support those skills that remain unsupported, in order to offer students a range of experiences.

**The third finding:**

The third finding related to the hypothesis proposed earlier in this research. In the present study, it was assumed that the deficiency in students' acquisition of integrated process skills might be due to the shortcomings of elementary textbooks in supporting the basic process skills through scientific activities. The analysis of the low frequency skills indicates that some of the poorly performed integrated skills are related to the low frequency of basic skills that this study has reported. These skills are prediction, classification and communication process skills.

**Discussion of the low frequency process skills**

- **Prediction process skill**

The analysis of this process skill revealed that opportunities for practising this skill in Saudi Arabian and Glasgow texts are few. Predictions tend to be transfer tasks with only loose predictions required, and quantitative prediction was not supported in the texts at all.

Moreover, in the few cases where students are asked to predict the results, they are not asked to explain why these predictions took place or to consider the evidence for these predictions. It is very important for these predictions to be compared with the evidence in order to draw an inference and finally reach a conclusion. The benefit of this approach is explained by Germann et al (1996: 495), in that the explicit engagement in science process skills leads to the successful performance of a scientific inquiry, as it enhances pupils' awareness as well as encouraging them to practise the metacognitive skills that are important to conducting a scientific inquiry successfully. Therefore, based on the prediction analysis of both texts, it can be concluded that the coverage of prediction skills does not support the practice of this skill in a way that helps students predict and justify their predictions in the later school stages.

- **Classification process skill**

The analysis shows that only limited opportunities are provided in the selected science texts for practising classification skills. All too often, when Saudi Arabian students are asked to classify objects, the classification procedures and data tables are provided for them, without offering students the opportunity to identify the variables and classify objects based on their own criteria. Researchers clarified that the main aim of practising classification skills does not concern the process of classifying itself, rather the linking of information and classification purposes (Millar, 1989). Thus, if the instructions for textbook activities do not consider the main purpose of the classification skills, pupils will not be able to practise this skill in a way that will help them classify objects in more advanced experiments. Therefore, the findings from this research supports its hypothesis, that the deficiency in students' acquisition of integrated process skills might be due to elementary level textbook deficiencies in supporting the basic process skills through scientific activities.

In addition, the Saudi Arabian text approach in covering the classification skills can be described as follows. The classification tables, procedures and objectives that should be classified in textbook activities are provided. Pupils' opportunities to decide the variables and to classify objects based on their own criteria are missed. This approach has negative effects, as pupils do not have the opportunities to make choices and, therefore, they do not have the opportunities to practise autonomy. Thus, it is important for pupils to practise autonomy through scientific activities, which might be achieved by allowing students to make decisions about planning the way in which to classify the objects included in the activities.

The second feature of the Saudi Arabian text in the coverage of this skill is that only two classifying criteria are supported, those of similarities and differences. The basic classification skill is not concerned with the process of classifying, so much as linking information and classification purposes (Millar, 1989). It is known that the relations between objects are not confined to similarity and difference, and that there are many other classifying criteria that might help pupils in the acquisition of classification skills. Examples of these relations are contradiction and direct correlation.

- **Communication process skill**

The analysis of this skill in both texts clearly shows that opportunities for practising communication skills in the Saudi Arabian text are comparatively few. While there are 31 science activities throughout the units, the communication skill was only applied seven time and a number of activities take place without students communicating their ideas with their classmates. Thus, the numerous advantages of one aspect of collaborative work, which is communicating and sharing ideas between students, are missed. Examples of these benefits are that students will be in a situation requiring competence, which improves learning (Blumenfeld et al, 2006); another important psychological fact is that if students communicate their knowledge with others, they will learn more effectively (Sawyer, 2006).

In addition, no questions or instructions asked students to use graph-drawing skills in the Saudi Arabian texts, while they are provided in the Glasgow booklets. From a practical perspective, it is important to know that communicating knowledge through drawing a graph is a skill distinctive from interpreting a graph or drawing as an illustration, which has to be taught in its own right. Therefore, science activities should be required to provide opportunities that support each of the skills.

**The fourth finding**

The fourth important finding in this study related to the high frequency skills, which might be seen as a positive aspect of the text. Supporting one primary science text with a great deal of observation, measurement and inference skill is widely acknowledged. However, the precise analysis of these skills indicated that these skills were supported by stable format questions which only activate a few dimensions of these skills. To explain this argument, the high frequency skills of observation and measurement are discussed.

**Discussion of the high frequency process skills**

- **Observation process skill**

Students are often asked to perform observation skills in the activities of both texts. It is not surprising that many activities are structured to encourage pupils to observe scientific phenomena because children are keen observers of the world around them.

Observation has special significance for this subject because it is central to the way in which young children learn science, hypothesise, measure, classify, research and discuss. Through such means, opportunities arise to infer, predict and communicate important issues. Characteristics such as curiosity, attention to detail and perseverance are also encouraged. However, the observation analysis indicates the following: first, the emphasis on conducting observation practise through the sense of sight and taste was considerably higher than for the other senses; second, more emphasis was placed on qualitative than on quantitative observations. I would argue that if pupils are not encouraged to practise quantitative observation, their abilities to observe quantitatively in experiments carried out during later stages of education will be less. As an example of an advanced quantitative observation that students are likely to be asked to perform at a later school stage is performing and recording data. Pupils' performance in integrated skills tests have proved that many American pupils are poor in practising this integrated skill (Germann and Aram, 1996). Furthermore, the study by Germann and Aram (1996) on pupils' performance in integrated skills reveals that their ability to provide confirmed evidence for their conclusion is insufficient. This evidence can be stated if pupils focus on numerical data, which is now doubly important in supporting conclusions. Hence, I could argue that the low coverage of quantitative observation in primary texts and the reduced opportunities to practise them, results in insufficient outcomes being reported in integrated skills tests.

In addition to the quantitative observation deficiency in the Saudi Arabian text, an emphasis on attention to detail is also lacking, which is an important feature of reliable observation (Millar, 1989). The analysis of this skill indicates that much of this observation is facile and unfocused. However, the observation skill should be sharpened and focused and considered as one of the details to help pupils practise observation skills for a purpose and with precision. As a consequence, students' observations will be more selective and useful to the implementation of other skills.

These findings ascertain that although this process skill is highly supported, it is restricted to qualitative observation that is observed through the senses of sight and taste. Thus, it can be suggested that by making the observation more focused, improving pupils' attention to detailed observation, making use of all senses, and requiring quantitative as well as qualitative observation, pupils' performance in integrated skills would be improved.

- **Measurement process skill**

Although the measurement process skill is the third most frequently used skill in the scientific activities included in the Saudi Arabian texts, more attention should be given to this skill. The analysis of this skill in the Saudi Arabian text revealed that, as a result of the confinement of measurement procedures to two stages (i.e. before and after conducting the activity), pupils miss the benefit of the repeated trials that verify results. Another such missed opportunity is the texts not ask students to compare data with others or with other groups and discussing the similarities and differences and the reasons for them. Missing these measurement practices leads to a decrease in pupils' abilities to practise more complex measurement activities, such as acquiring data from an experiment, which is one of the integrated skills in which American pupils perform poorly (Germann and Aram, 1996).

The conclusion that can be drawn from the high frequency process skills analysis is that each of the skills is covered many times by using the same techniques or strategies and they are generally covered within the same unit. This evidence supports my argument that the major cause of students' lacking some basic skills is that these scientific activities ask pupils to follow instructions which might support the same basic skills, whereas other basic skills are dismissed. Therefore, the solution that was proposed earlier might be the most effective, which is that two or more sets of instructions for activities should be mixed in one activity and, at the same time, specific instructions added to cover the low frequency skills.

## 8. Conclusion

This research revealed three main findings. First, the number of some process skills in the KSA texts is greater than in the Glasgow texts. These skills are observation, inference and measurement. However, they were supported by stable format questions which improved only limited dimensions of these skills. Secondly, the number of prediction and classification skills is quite similar in both texts in spite of the differences between their numbers of tasks. These skills are usually supported in the extension level of science activities. Third, this research indicated that there are relationships between some integrated skills, in that pupils' performance in them are poor, and the low frequency of certain basic skills in both books (i.e. prediction and classification). Therefore, it is believed that supporting these basic skills in primary texts will lead to an improvement in pupils' performance in some of the integrated skills in which pupils have previously performed poorly.

### Further research needs

This study initiates an effort to justify the reasons for students' low performance in integrated process skills tests and has yielded some answers. Nevertheless, many areas are open for further research. For example, it might be replicated and expanded upon using other criteria and other coders to establish whether the results correspond. Moreover, the present research has been conducted on texts for only one grade. However, further reinforcement of the research results will undoubtedly be gained if it is applied to other activities in different primary grade texts as well as on the texts for different countries.

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# مدى تضمين مهارات عمليات العلم الأساسية في كتب العلوم التي تدرس للطلاب بعمر ١٠ سنوات في المملكة العربية السعودية ومدينة جلاسكو ( دراسة مقارنة)

**حنان بنت فوزي الجارالله**
محاضر المناهج وطرق التدريس- كلية التربية- جامعة الملك سعود- المملكة العربية السعودية
hanan.alj@gmail.com

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**الملخص:**
تهدف الدراسة إلى تحديد مدى تضمين الأنشطة العلمية في مقرر العلوم في المملكة العربية السعودية لمهارات عمليات العلم الأساسية مقارنة بتلك التي تضمينها في كتب العلوم في مدينة غلاسكو بسكوتلاند. الكتب المدرسية التي تم تحليلها في هذه الدراسة هي كتب العلوم التي تدرس في المملكة العربية السعودية وفي مدينة غلاسكو للطلاب الذين يبلغون من العمر ١٠ سنوات .عدد الانشطة العلمية التي تم تحليلها هو : ٣١ نشاطًا علميًا في كتب العلوم بالمملكة العربية السعودية، و ١٨ نشاطًا علميًا في كتب العلوم بغلاسكو. تم تحليل الأنشطة وفقا لأداة تحليل المهام (LAI) التي تم تطويرها من دراسة تامير ولونيتا (١٩٧٨) لتناسب هذا البحث. أظهرت النتائج وجود فروق ذات دلالة إحصائية بين كتب مقرر العلوم في البلدين في مستوى تضمين مهارات عمليات العلم الأساسية. أما النتائج الرئيسية للدراسة فهي: (أ) تتضمن كتب العلوم في المملكة العربية السعودية مهارات الملاحظة والاتصال والاستنتاج في حين تم توفير فرص قليلة لممارسة مهارات القياس والتصنيف والتنبؤ؛ (ب) السبب الرئيس في عدم تساوي مدى توافر مهارات عمليات العلم الأساسية الستة في محتوى كتب العلوم هو قصر النشاط العلمي وبساطته وعدم امتداده لمستوى أعلى؛ (ج) زيادة عدد الأنشطة العلمية في كتاب العلوم في المملكة العربية السعودية لا يحسن اكتساب الطلاب لمهارات عملية العلم الأساسية إن لم يتم توفير مستوى إضافي لهذه الأنشطة بشكل يحفز عمليات العلم الأساسية جميعها؛ (د) توجد علاقة بين ضعف أداء التلاميذ لبعض مهارات عمليات العلم التكاملية وعدم تضمين بعض مهارات عمليات العلم الأساسية مثل التنبؤ والتصنيف في الأنشطة العلمية في الكتب الدراسية للمراحل الأولية.

**الكلمات المفتاحية:** الكتب المدرسية؛ العلوم الأساسية؛ غلاسكو؛ السعودية.