ABSTRACT. This paper examines form two students’ understanding of ‘right angle’, words commonly used in secondary school mathematics syllabus. 48 students participated in this study. Participants were asked to identify a right angle among four plane figures given. Past research has indicated that words have specific meaning in mathematics but their meanings in other contexts may be diverse and pose a challenge to students learning mathematics. Results of this research suggested that many students have limited understanding of a right angle. This study recommends teaching of mathematics vocabulary together with symbolic notations to facilitate conceptual understanding.

KEY WORDS: Mathematics register, ordinary words, technical words, symbolic notation, conceptual understanding

INTRODUCTION

Perhaps more than any other subject, teaching and learning Mathematics depends on language. Orton (2005) defines language as a means of communication that consists of words, which are labels for ideas that may suggest different meanings to different people. Hence words acquire meaning within a particular discourse community of people without which every individual has to form their own meaning from the environment. The learning of Mathematics is concerned with acquisition of concepts, which in most cases are stated in the learning objectives. Raiker (2002) notes that learning of concepts, however short or long it may take, is infused in words or phrases such as ‘origin’ and ‘volume scale factor’. Raiker further notes that while these words or phrases have specific meanings in Mathematics, their meanings in other contexts may be diverse. The author demonstrated the variance in meanings using the word ‘origin’ which in Mathematics means the point of intersection between horizontal and vertical axes whereas in non-mathematical contexts it is used as in ‘the origin of the species’ (p. 45) which refers to the ‘beginning’ or ‘genesis’. Raiker established that the problems in the teaching and learning of mathematical concepts partly arise from and are aggravated by the spoken language involved. This suggests that inappropriate or imprecise use of spoken language could play a role in the formation of imperfect knowledge and even misconceptions in Mathematics. This calls for need to distinguish use of language in Mathematics from its use in lay-talk. When a subset of a language is used for a particular purpose or in a particular setting, it forms a register. For instance, we have legal register, medical register and Mathematics register. This study which sought to investigate students’ awareness of and use of Mathematics register, in part, established instances of misunderstanding and misconceptions.
The importance of language in learning cannot be overemphasised. Orlich, Harder, Callahan, Trevisan and Brown (2007) state that "language is the vehicle for most learning and communication in a classroom" (p.46). Therefore, if teachers and educators on one hand and the learners on the other fail to use appropriate language of Mathematics conceptual understanding will suffer. Veel (1999) notes that language is a critical issue since most of the content is relayed through oral language. He argues that students do not derive a significant portion of their knowledge from reading text books, and teachers do the majority of talking in classrooms. Veel does not explain why students do not derive most of their mathematical knowledge from text books yet text books constitute a vital resource in learning Mathematics. If students can comprehend the language used in text books then they should be able to do most of the learning on their own. Ron (1999) observes that the dilemma facing students is the overlap between ordinary language and the language of Mathematics. She notes that Mathematics language is used to convey concepts that have little relevance or no correlation with lay-talk. She points out that learning Mathematics language is a challenge to students since it can only be learned in schools. This paper sought to find out students' understanding of 'right angle'.

As already argued above, the purpose of language is to communicate. Cuevas (1984) asserts that learning can take place in the learner's first language or second language. Schleppegrell (2007) outlined a variety of features of Mathematics language which include technical vocabulary, written and spoken language, symbolic notation, visual displays such as graphs; and grammatical features including complex noun phrases. Schleppegrell suggests that a focus on language is critical for student learning in the classroom, that both students and teachers should use Mathematics language, and that instruction should assist students to move from everyday language to the more formal register of Mathematics. However, the second language learners face a double challenge of first learning the language of instruction then the Mathematics language (Kgomotso, 2007). In the same line, Larger (2006) investigated the linguistic challenges of algebra problems. He assessed 221 middle school students, both native speakers and ESL learners, comparing the correctness of their responses to other data, including terms they highlighted as being confusing. He found that some of the words that caused problems were not the ones that are generally considered to be part of Mathematics register, for example, 'extension' and 'previous'. Cuevas comments that the complexity of learning Mathematics requires a variety of linguistic skills the second language learners may not have mastered, hence a certain level of proficiency in the language of instruction is necessary. The students who participated in the study were expected to have the pre-requisite proficiency in English to learn Mathematics at this level. However, where this was not the case, it was reflected in their performance on the exercise given.

Freeman (2008) citing American Educational Research Association (2004) defines proficiency as academic language which includes vocabulary used beyond social conversations and includes vocabulary required to communicate effectively and comprehend materials in academic content area. Guerrero (2004) argues that academic language is the language of communication in the classroom which takes place at the level of discourse and that the discourse associated with different subject areas has unique features that an L2 learner must come to use and understand. Solomon and Rhodes
(1995), for instance, maintain that academic language must be understood as a special register associated with various content areas at the level of discourse. Consequently, the Mathematics register entails linguistic aspects such as grammatical and textual levels that may differ from the registers in other disciplines. There is, therefore, need for learners to learn and use every register appropriately. Guerrero argues that the academic language is acquired faster by older learners since they have a more fully developed first language than younger learners do, they can use this knowledge to grasp how the new language works. In Mathematics, Guerrero's argument holds true especially in the use of lexical words such as more, less and previous. However, some ordinary words take different meanings when used in Mathematics and may cause confusion to both native speakers and English language learners. A study by Samo (2009) on students' perceptions about the symbols, letters and signs in algebra and how these affect their learning of algebra, found that secondary school students transferred the meaning of 'as many' from Urdu language to Mathematics to mean 'greater than'. The students were required to write in symbolic form the statement: 'There are six times as many students as professors.' Taking s to represent students and p professors, some students wrote $6s > p$ instead of $s = 6p$, $p < s$ or $s \leq p$, which is a misconception. The students developed algebraic equations and expressions by phrase to phrase translation of the given word problem. This is a typical case of the challenge of understanding mathematical statements due to a combination of lack of proficiency in the language of instruction and problems of forming algebraic statements. The study explored how students interpret 'right angle', a phrase comprising ordinary word (right) and technical word (angle) together with symbolic forms to communicate mathematical meaning. In this study, students displayed confusion in interpretation of 'right angle' with symbolic notation.

Ordinary language is a means of communication from which Mathematics draws its register. Mathematics register comprises words, expressions and meanings that differ from those of lay-talk (Cuevas, 1984; Edwards, 2007; Hill, 2005; Secada, 1991 in Gutierrez, 2002). Cuevas (1984) notes that the meanings of terms are much narrower in mathematics register than in the natural language. To make connections between everyday language and Mathematics register, some familiar everyday words are used with new meanings when talking about Mathematics (Thompson & Rubenstein, 2000).

Freeman (2008) classifies Mathematics register into two groups: Language of words and language of symbols. Cuevas (1984) further puts the language of words into three categories namely: technical words such as parabola, polygon, hypotenuse, ordinary words for instance even, difference, points, power; and styles of meaning and ways of presenting arguments in Mathematics. From this point of view, learning Mathematics involves relating meaning to symbols, words and oral sounds (Orton & Frobisher, 2005). Symbols are part and parcel of Mathematics and Mathematics register (Schleppegrell, 2007). Schleppegrell makes a connection between Mathematics symbolic notation and language. She notes that language provides the context of the real life situation while the Mathematics symbolism makes relationships between entities, and sometimes a diagram to provide a connection between the real life situation and the mathematical processes that are construed in the problem, a connection that is formulated in either written or oral language.
METHODOLOGY

Setting and research location
This study was carried out in a public secondary school in Kenya. The study explored the manner in which students use Mathematics register, which is a specialised language within a medium of instruction (English). Therefore, a public secondary school in Kenya, whose minimum entry marks to form one is 250 out of 500, was appropriate for this study. In Kenya, English is a compulsory subject in primary and secondary schools besides being the medium of instruction in upper primary and in secondary schools (Nzomo, et al., 2002). Primary education takes eight years hence an average performance in the KCPE\textsuperscript{1} examinations implies that the student understood and used English appropriately, a prerequisite for this study. Proficiency in the language of instruction was necessary in this study to guard against the danger of associating difficulty in understanding and using Mathematics register, to problems of understanding and using the language of instruction.

Sample
The population of this study consisted of a form three class, whose age ranged between 16 and 17 years, in a co-educational public secondary school in a rural area in Kenya. At this level, students had completed learning the form two curriculum from which eight topics were selected to determine their familiarity with and use of Mathematics register. The form three stream that was the sample for this study had 55 students. All students except three had form one entry marks of at least 250 out of 500. The three unique cases had 247, 243 and 238 marks. Seven students were absent during data collection therefore 48 students, 29 boys and 19 girls, participated in the written exercise out of which ten were picked for interview. The ten students constituted four top achievers, three middle achievers and three lower achievers according to the results of end of term one examinations, 2009. The top category had two boys and two girls, the middle two boys and one girl and the lower two girls and one boy.

By the time of this study, this class had covered only the first topic in form three: Quadratic Equations and Expressions. It is, therefore, safe to assume that these participants were form two students in form three as far as Mathematics learning is concerned.

Instruments
The larger study from which this paper is extracted employed several instruments including interview schedules, document summary forms, students’ exercise scripts and voice recorder. The exercise comprised ten items that aimed at investigating students’ knowledge of selected mathematical vocabulary and symbols used in specified form two topics in nine out of ten questions while question 5 investigated their knowledge of language patterns associated with mathematical vocabulary. Since this was a small scale study, the researcher could not use all vocabulary in form two syllabus. Eight topics were

\textsuperscript{1} Kenya Certificate of Primary Education
chosen at random from the syllabus namely: Indices and Logarithms, Area of a triangle, Area of quadrilaterals and other polygons, Linear inequalities, Vectors (1), Angle properties of a circle, Similarity and enlargement and Trigonometry. This paper reports on the item four, relating specifically to students’ understanding of a right angle.

**FINDINGS AND INTERPRETATIONS**

The student's exercise investigated students’ knowledge of selected mathematical vocabulary items and symbolic notations used in form two Mathematics syllabus. Item four required students to identify a right angle in the following diagrams.

(A).                               (B).                             (C).                                   (D).

Results were interesting. Eighteen students (18) chose A, none chose B, fourteen(14) chose C, eight (8) D and seven (7) chose both C and D. Both C and D are right angles so a student who understood the concept selected both. It was a striking point that a majority of students selected A! None, including the eighteen who selected A chose B. In terms of Properties, there is no difference between shape A and shape B, hence a student picking either of the shape and not both implies lack of mathematical understanding of ‘right angle.’ The same interpretation applies to figures C and D. There was no precision in meaning as expected in mathematical concepts. Gibbs and Orton (1994) state that students form their conceptions in Mathematics based on what they see rather than mathematical properties. This arises when a vocabulary item is associated with one illustration or explanation or category among many other options. This study did not investigate further due to its scope and time.

Upon probing students’ understanding of a right angle, the responses contradicted the earlier results of students’ exercise as illustrated in the following excerpt.

R: What is a right angle?
S1: An angle which is 90°
R: What is a right angled-triangle?
S5: A triangle in which one of the triangles must be 90° but others must be 90° with different angles so that when you add you get 180°
S3: A triangle where the summation of the square of the base and the square of the height equals the square of the hypotenuse

(Students' group interview, on 1st April, 2009)

Even though the study could not conclude that all students knew a right angle from definition since only nine participated in the interview. There is a possibility of miss link between students’ understanding of words and visual representation (symbolic language). Lemke (2003) argues that Mathematics understanding is lost if Mathematics is not taught as a co-entity with words and visual representation in explaining a phenomenon.
Conclusions

The trends identified in students’ understanding of ‘right angle’ mirror many of the trends delineated in past research. These students lacked precision in understanding of a right angle. This study recommends future research to investigate how students form meaning that contradict mathematical concepts.

REFERENCES


