

Teacher Education and the Teaching of Subitizing in Early Childhood Centers in Lusaka Urban, Zambia

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Abstract

The aim of the study was to examine the extent to which early childhood teacher education Mathematics programmes prepare early childhood teachers for teaching subitizing to young children in Early Childhood Education centers in Lusaka urban in Zambia. Using both qualitative and quantitative approach a description study was conducted. Semi-structured Key Informant Interviews (KIIs), Focus Group Discussion (FGD) meetings, questionnaires and documents and records analysis were designed and used to collect data.

The findings from the study revealed that the Zambia National Curriculum Framework and the National Numeracy Framework in Zambia do not state the topic or term subitizing. These national documents start with topic number and notation. Under this topic counting is covered first. All text books and reference materials used at teacher educational level and ECE teachers in ECE centers do not mention the term subitizing. The understanding of the concept of subitizing was found to be poor, insufficient in coverage and inadequate in content. The Key Informant Interviews revealed that both lecturers and ECE teachers thought subitizing and counting were one and the same thing. The questionnaires, focus group discussion meeting and document analysis revealed that the topic was not planned for and had no time allocation.

In order for all colleges of education to improve the performance of ECE students in teaching subitizing in ECE centers, it is recommended that the content of the mathematics curriculum, all text books, reference materials and the National Numeracy Framework should include and start with the concept of subitizing.

Keywords: *Subitizing, early childhood teachers, curriculum, mathematics programme, colleges of education, early childhood center.*

Introduction

The Government of the Republic of Zambia (GRZ)'s policies and legislation are guided by the National Instrument 'Vision 2030' which sets the country's long-term objectives and targets to make Zambia a middle-income country by 2030. The Seventh National Development Plan (7NDP) is a five-year medium-term plan spanning 2017-2022, The Seventh National Development Plan departs from sectoral-based planning to an integrated (multi-sectoral) development approach under the theme "Accelerating development efforts towards the Vision 2030 without leaving anyone behind". The bottom line is poverty alleviation for the Zambian people. The 7NDP under the education chapter has aligned its goals with the National Policy on Education (NPE), the Education For All (EFA) goals and the Millennium Development Goals (MDGs) and the United Nation Convention of the Rights of the Child (UNCRC) among others. In order to achieve the EFA Goals, Government was expected, among other education aspects, to provide Early Childhood Education (ECE) services to all children despite their backgrounds, gender and abilities by 2015 (UNESCO, 2006).

Zambia made the Education for All goals a fundamental and repetitive feature in all comprehensive policy frameworks starting with the Focus on Learning of the early 1990s. A dominant feature of Educating Our Future Policy document of 1996 was the domestication of the EFA Goals notably on universal provision and access of primary education for all, bridging of gender gaps in access and participation as well as addressing the challenges of education quality and relevance. Additionally, to the educational policy have been other specific policy interventions meant to address specific challenges

in the attainment of EFA and educational policy goals such as the declarations of Free and Compulsory Primary Education in 2002.

Acknowledging the importance of early childhood education in improving children's performance later on in education and in terms of more broad social outcomes such as good health, a stable family life, higher chances of employment and lower crime rates, Goal One adopted by the Education for All World Education Forum in Dakar Senegal in the 2000 was designed as follows: "Expanding and improving comprehensive early childhood care and education, especially for the most vulnerable and disadvantaged children". However, Gove and Cvelich (2010) note that a large proportion of the 615 million children who are in school in developing countries, are performing poorly in literacy, numeracy and essential life skills.

There has been recognition by the Ministry of General Education (MoGE) of continuous poor performance in mathematics in the country, and as a result, the ministry came up with strategies to address it. In the education policy document, *Educating Our Future* (1996), the Ministry of General Education acknowledged the fact that development of basic numeracy and problem-solving skills as early as early childhood is a panacea for improving performance not only in numeracy and mathematics but in all other aspects of learning and living. Despite the priority placed on numeracy and a lot of interventions put in place, the performance has continued to be mediocre.

The Southern Africa Consortium for Monitoring Educational Quality (SACMEQ) was officially launched in Harare, Zimbabwe, in February 1995. The main aim of SACMEQ is to provide policy advice to key decision makers on educational quality issues considered as high priority by their respective ministries of education. It was awarded continuing long-term assistance through the generous aid of the Government of the Netherlands. Later it changed the name to the Southern and Eastern Africa Consortium for Monitoring Educational Quality (SEACMEQ). Currently, SEACMEQ consists of 15 Ministries of Education in Eastern and Southern Africa: Botswana, Kenya, Lesotho, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Swaziland, Tanzania, Uganda, Zambia, Zanzibar and Zimbabwe (Ministry of Education, 2010). It is an international non-profit developmental organization of 15 Ministries of Education in Southern and Eastern Africa that decided to work together to share experiences and expertise in developing the capacities of educational planners to apply scientific methods to monitor and evaluate the conditions of schooling and the quality of education.

Since then SEACMEQ has been releasing results of pupil performance in Mathematics and Literacy and member countries are ranked according to the performance of the pupils in the member countries. From the year 1999, successive National Assessment Surveys on learning achievement and SEACMEQ reports continue to show that performance in numeracy had remained at below the desirable level of 40percent in Zambia. Furthermore, the results published in 2015 by SEACMEQ showed that Zambia was ranked the lowest in the mean performance in mathematics among a group of 15 countries.

Mathematics proficiency is an academic and economic driver for any country, especially Zambia. It provides a crucial foundation for accomplishing other academic and career goals (Baroody, Lai, & Mix, 2006; Jordan, Hanich, & Uberti, 2003). Building roads, houses, running, and traffic control or cooking, all need the understanding of numbers. Mathematics skills develop in a cumulative manner with early skills forming the foundation for the acquisition of later skills (Aunola, Leskinen, Lerkkanen, & Nurmi, 2004). This is why it is known as a science of a hierarchy of abstractions. It has been observed too that even before children enter grade one, the individual differences in performance in numeracy and pre-mathematics are visible (Berch, 2005; Stevenson et al., 1990), and are predictive of later mathematics achievement and school achievement in general (Duncan et al., 2007; Ginsburg, Klein, & Starkey, 1998; Locuniak & Jordan, 2008; Mazzocco & Thompson, 2005). This eventually affects national development. Children who lag in mathematics in their early years, usually continue to lag in their entire learning and academic trajectory than their more advanced classmates (Aunola et al., 2004). This calls for swift intervention as early as possible.

Basic number concepts and skills (numeracy) generally emerge before entry into school. Children's numeracy knowledge is obvious in their developing counting skills. It is also evident in their capacity to compare, share, order, estimate and calculate different quantities. Fundamental skills in recognising and responding to numerical cues are apparent in infancy (Wynn, 1995a; Xu, Spelke, & Goddard, 2005). Children show these skills in many everyday problem-solving situations involving numbers and

measurement. For instance, they may reason about who has more or less, devise strategies for creating equal shares of countable objects or amounts, or use counting in a range of situations to reason about a single group of objects or to compare two groups. It is therefore, important to promote the development of these competencies in young children and to know the best learning methods to use. These skills are often predictive of children's future school achievement. The extent to which children grasp numeracy skills in the early years is highly dependent on the ability of early childhood teachers to devise teaching strategies that foster the acquisition of numeracy skills, especially the ability to subitize.

According to Geist (2004), immediately after birth infants are surrounded by an environment that is filled with opportunities for leaning mathematics. As infants grow older, and enter pre-school, they engage in activities where they could have mathematics experiences. During play, young children sort, count, compare, classify, put together (add), and take away (subtract). When playing with sand and water, they receive not only sensory pleasure but also acquire concepts of measurement for example capacity, volume, temperature, mass and even time. Numbers and Mathematics are all over the place and are integrated into the children's everyday life. When children are standing in a line in readiness to go out doors or wash hands (ordinal numbers) or buy something from the tuck shop (counting money), they repeatedly come across mathematics opportunities. Ginsburg (2006) says the world of children is full of mathematics opportunities.

Children cultivate a significant understanding of numerous aspects of mathematics including numerosity. A number of researches suggest that young children develop significant mathematics proficiency early in their lives. According to Gelman and Gallistel (1978), young children as young as 2, 3, and 4 years can recognise numbers of items under four. This is called subitizing (Clement 1999). Canfield and Smith (1996) found that even infants have capacity to notice abstract number information. They indicated that five-month-old infants used visual expectation to show the ability to distinguish three pictures presented in one location from two pictures in another location. This shows that infants as young as five months could count up to three. Starkey (1992) also found that young children have the capacity to reason numerically. Children actively create mathematics knowledge through their day-to-day experiences and have the ability to understand this knowledge spontaneously (Baroody, 2000). In order to take advantage of this ability early childhood teachers should be equipped with strategies to use as they teach during their pre-service training.

According to Clements (1999), subitizing is "instantly seeing how many." The Wikitionary indicates that the term originates from a Latin word meaning "suddenly". Subitizing is the direct perceptual apprehension of the numerosity of a group. In the first half of the 20th century, researchers believed that counting did not imply a true understanding of number but that subitizing did (e.g., Douglass [1925]). Many saw the role of subitizing as a developmental prerequisite to counting. Freeman (1912) stated that although measurement focused on the whole and counting focused on the unit, only subitizing focused on both the whole and the unit and for this reason, subitizing underlay number ideas.

Carper (1942) suggests that subitizing was more accurate than counting and more effective in abstract situations. In the second half of the 20th century, both researchers and educators developed several models of subitizing and counting. They based some models on the same notion that subitizing was a more "basic" skill than counting (Klahr and Wallace, 1976; Schaeffer, Eggleston, and Scott, 1974). One of the main reasons for this was that children can subitize directly through interactions with the environment, without social interactions. Backing up this point of view, Fitzhugh (1978) established that some children could subitize sets of one or two but were not able to count them. However, these very children could not count any sets that they could not subitize. It was concluded that subitizing is a necessary precursor to counting.

Performance in mathematics and science subjects in many African countries has been poor and Zambia is among the worst examples recently (GRZ Grade 12 Mathematics results, 2017). The importance of having a solid background in numeracy is well recognized as it serves as a gateway to future professions in a variety of fields. In other words, numeracy competence is an essential component in preparing numerate citizens for employment and it is needed to ensure the continued production of highly skilled persons required by industry, science and technology. Despite the importance of numeracy in all aspects of life, there are still challenges to foster numeracy and more specifically subitizing in early childhood owing to the inability of early childhood teachers to employ teaching

strategies rich in numerosity and subitizing. Unless there is an investigation into the strategies early childhood teachers employ to foster subitizing and numerosity and their ability to organise numeracy corners, the level of numeracy in early years will continue dwindling and this will have an impact on the future mathematics prowess in adult life in Zambia. This study was undertaken to examine the teaching of subitizing in colleges of education which has an impact on how subitizing is taught in ECE centers. It is why I strongly feel, there is need to carry out a research study on how early childhood teachers teach subitizing in early childhood centers in order to enhance numerosity. More specifically to establish whether there is a relationship between teaching subitizing in colleges of education and ECE centers. It is for this reason that this study was undertaken to examine the extent to which colleges of education prepare ECE teachers to teach subitizing to children in ECE centers.

The reviewed literature shows that subitizing is a foundation concept and skill for numeracy and numerocity and as such teaching it to trainee ECE teachers has a bearing on the quality and content of activities ECE teachers organize for the children in their classes. Literature also indicates that subitizing can be taught using games and play activities. The implication of this literature review is that a gap exists in the programming of mathematics in Zambia. In an effort to remove this gap, this research was conducted to examine the position of the topic subitizing in national curriculum and text books used in colleges of education and also establish how graduate ECE teachers from colleges of education working in ECE center plan for and teach subitizing.

Purpose of the study

The purpose of this study is to examine the position of subitizing in the national mathematics documents of Zambian including the text books and reference materials used both in colleges of education and ECE centers. It also focused on establishing how it is taught in colleges of education and in early childhood centers in Lusaka Urban, Zambia.

Research questions

- a) How does early childhood teacher education Mathematics programme effect the teaching of subitizing to children in early childhood?
- b) What is the role of the National Numeracy Framework and the National Curriculum Framework in teaching subitizing?
- c) Is the time allocated for teaching subitizing sufficient for the acquisition of the skill of subitizing by pre-school children?

Methodology

In order to answer the research questions, quantitative and qualitative research approaches were used. The questionnaires used to collect quantitative data were: questionnaire for teacher educators; and 2) a questionnaire for ECE teachers. The second instrument used to collect data was the interview. The interview was in three forms; that is Key Informant Interviews (KIIs), semi-structured personal interview, an interview in a form of focus group discussion meeting. The FGD was recorded and later transcribed and main themes categorised. Third, in order to examine the curriculum content and its implementation, document analysis was conducted. The different methods of data collection were used in order to triangulate the information obtained.

Data analysis

A mixed approach which involved a simultaneous triangulation of methodological and data sources was used during data analysis. Consequently, both quantitative and qualitative data analysis procedures were used. The data obtained through interviews, documents and records and focus group discussion meetings were analysed thematically using content analysis. Additionally, thematic connections obtained formed the basis for data grouping. The measures suggested by Braun and Clarke's guide to the 6 phases of conducting thematic analysis (2006) was used to analyse the data based on the connections recognized and come up with the major themes from the study. Quantitative data from questionnaires were first coded, entered into the computer and later analysed statistically using the Scientific Package for Social Sciences (SPSS) software version 16.0. This was aimed at generating

simple descriptive statistics in form of frequencies, tables and graphs. While the two data types were analysed separately, they were triangulated for easy interpretation. This was done by looking for key themes in both the qualitative and quantitative data, which could be put together into single categories.

Results

Effective teaching is guided by a good curriculum. Curriculum includes the content of courses (the syllabus), the methods used (strategies), and other aspects, like norms and values, which relate to the way a learning institution is organised. In order to establish whether the curriculum was appropriate for imparting knowledge and skills of subitizing to trainee ECE teachers, which could in turn affect their teaching of the concept of subitizing and care of children in their classes, the following aspects were analysed: the content of the curriculum, the methods of teaching, strategies of teaching, and the allocation of time for classroom instruction, practical work and field experience. The teaching resources and equipment were also analysed.

Position of subitizing in the Mathematics curriculum

Studies (Clements & Sarama, 2009; Hartman, Jung, & Conderman, 2012) show that teachers can help children acquire the concept of number and quantity by including subitizing activities in the mathematics curriculum. Many teachers and teacher educators, text books do not include subitizing activities even though it plays a very important role in the development of number sense. Subitizing supports numerous mathematics skills.

According to Palomares and Egeth (2010), many studies on enumeration have established a gap between counting small and large numbers, which has been taken to reveal two distinct cognitive mechanisms. Counting four or fewer elements is fast and exact, and has been termed as “subsidization” (Kaufman, Lord, Reese, & Volkmann, 1949). On the other hand enumerating five or more elements has been termed as counting or estimating. This therefore means that if there is sufficient time, participants may count each item slowly and serially; if not, they may quickly and imprecisely estimate the number of items in parallel (Dehaene, 1992). This study focuses on subitizing.

In order to find out where the concept of subitizing is positioned in the National Numeracy Framework of Zambia (2016) and the National Curriculum Framework, the respondents were asked to indicate the position of the concept of subitizing and the responses are found in Table 1, which show that 70 percent of the respondents indicated that subitizing is covered under Number notation while 30 percent indicated different locations including the factor that it was not there at all. This is because subitizing has not been separated from counting, a concept covered under number and notation.

Document analysis

Document analysis revealed that subitizing is not mentioned in the teacher education curriculum and lecturers do not plan for teaching the concept. The topic Number Notation reflects a sub-topic counting but not subitizing. Analysis of documents in ECE centers revealed that teachers do plan for counting but none of the records (syllabus, schemes of work, records of work, weekly forecast and lessons plans) mention the term subitizing. The term subitizing does not appear in any of the documents reviewed.

Key informant interviews (KIIs)

The chairperson of Zambia Association of Mathematics Educators (ZAME) had this to say:

“Subitizing can impact almost the entire primary curriculum and impact the later secondary education. The simple flashing of a collection of dots can massively enhance students' number sense. The best part of this is that students love it and I hear it if we have to miss subitizing in our daily routine”. (The chairperson of ZAME is a mathematics teacher at Hill Crest Technical School in Livingstone).

“The concept of subitizing was omitted from the curriculum and ECE syllabus because it falls under counting” (Continuous Professional Development coordinator [CPD])

“There is nothing wrong by omitting subitizing since children can count”. (Grade level team leader)

Subitizing, the national curriculum framework and national numeracy framework

Understanding the use numbers, ability to think and work with numbers is what is referred to as number sense. There is still debate (Conderman et al., 2014) on whether subitizing is a skill that comes before counting, it is however, and evident that subitizing can and should be taught. It has been established that subitizing has a strong and positive impact on the development of number sense skills, which is the most basic and foundational of all mathematics skills. More and more research are supporting the fact that subitizing should be taught

While the National Numeracy Framework of Zambia (2015) gives general guidelines on the sequence of topics, teachers are left to decide which specific skills in number and quantity should be emphasized. Counting is emphasized but ECE teachers should also focus on representation, relating and operating whole numbers, starting with grouping of objects. The ECE Syllabus (2015) emphasizes that teaching numeracy to young children should help children understand numbers, ways of representing numbers, relationships among numbers and number systems. Consequently, representing numbers and understanding their relationships (e.g., 4 is 2 more than 2) are two critical elements in early mathematics instruction. The foundation lies in the ability to subitize numbers.

Clements and Sarama (2009) stated that early numerical development depends on four interconnected fundamentals: (a) subitizing, (b) counting with conventional number words in a stable order, (c) enumerating collections of objects, and (d) numbering skills. Children move from acquiring this essential knowledge of number, to understanding relations between numbers, to operating with numbers (Clements and Sarama, 2007; National Research Council, 2009). In this study, the results presented in Table 8 show that almost all (97.5 percent) ECE the teachers think that subitizing should be taught both at college and ECE level.

Coverage of the concept of subitizing in colleges of education

To establish the coverage of the concept of subitizing during the teacher education programme at college, the respondents were asked to rate the coverage of the concept of subitizing and the responses are presented in Figure 1. Figure 1 shows that most (72.5 percent) of the teachers thought the coverage of the concept of subitizing was not adequate during training at the college of education.

Document analysis

The curriculum for diploma in ECE, the syllabi, schemes of work, weekly forecast and lecture notes were analyzed in order to answer this question. This analysis revealed that subitizing did not appear in any of them.

Interviews

From the interviews conducted with ECE teachers and on this particular subject, it was revealed that coverage of the topic of subitizing was almost zero as the concept was never used during training except for the concept of counting. The difference between counting and subitizing was not explained. All (100 percent) interviewees agreed that they had never heard of the concept of subitizing before. This shows that subitizing as a concept was not covered during training in colleges of training.

KIIs revealed that the concept is consider as counting and that they do not view it as an omission in the syllabus or in teachers' planning.

Time allocated for practicing subitizing by trainee ECE teachers

Subitizing is taught by exposing learners to number patterns that they can immediately recognize. The brain is trained to see organized groups of numbers. When students can successfully subitize, they are able to mentally compose (bring together) and decompose (break apart) numbers. They are able to quickly add numbers together without counting one by one (Reid, 2016). The more learners are exposed to differently arranged objects the quicker they will be able say the number of objects presented either in pictorial or real format.

In order to establish the adequacy of time set aside for teaching subitizing in colleges of education and ECE centers, respondents were asked to indicate the number of hours. The result revealed a lot of variations and contradictions among the respondents. This could have been as a result of vague

understanding of what concept of subitizing was and their inability to differentiate it from counting. The documents analyzed revealed that there was time set aside for Number and Notation, under which the topic of counting falls but there is nothing or no specific time set aside for subitizing as a stand-alone concept.

Over and above, the time set aside ranged from 1 hour to 15 hours. The truth of the matter is that subitizing continues to be used by children and teacher right through the primary years. Since the concept was not very clear to ECE teachers, they could not apportion time to it but they did apportion time for teaching counting to young children.

Document analysis

Document analysis was used to establish how much time was set aside for teaching subitizing in the Government of the Republic of Zambia National Curriculum Framework (2013) and the National Numeracy Framework (2015) under ECE section. These documents did not allocate time for teaching subitizing in all colleges of education reached. The other materials written and used by lecturers were also analyzed and no allocation of time for teaching subitizing was found. These analyses revealed that there was no time set aside specifically for teaching subitizing. The lecturers had no schemes of work that indicated allocation of time for teaching subitizing. There was however, time for teaching number notation and counting in particular.

Teaching subitizing in colleges of education and ECE centers

The results indicate that 80 percent of the respondents agree with the statement that there is a relationship between what trainee ECE teachers are taught in colleges of education affect the way they will teach subitizing upon graduation.

Results from interviews

During the interviews conducted with the ECE teachers, all (100 percent) respondents indicated that there was a relationship between colleges teaching the subitizing concept and the ability of ECE teachers to teach it to young children. The reason forwarded being “You cannot teach what you have not been taught”. Other respondents indicated that the books they were referred to during college did not mention the concept of subitizing so they had “no idea it was supposed to be taught”.

Conclusion

The following major conclusions were drawn from this study:

a) Colleges of education do not prepare ECE teachers to teach or enhance subitizing in ECE centers. The document analysis, KIIs, Interviews and questionnaires confirm the absence and lack of familiarity with the concept of subitizing. The argument that it comes under counting does not justify its exclusion as it is psychologically a very different process and a different concept. The implication for ECE teachers is that they leave college not having heard of subitizing and continue teaching rote counting and feeling they have covered all numeracy skills that children in early childhood need. This creates a gap in the acquisition of numbers sense. The gap continues into primary school. Additionally, the KIIs revealed that college ECE student learn only pure mathematics and not what and how to teach children in ECE.

b) The mathematics curriculum in colleges of education and the National Numeracy Framework, all mathematics textbooks and core reference materials do not mention the term subitizing or how it could be taught to children in early childhood. This means that even if a student was interested in learning more on what should be taught from books they would not come across text books that talk about subitizing and the role it plays in helping children become numerate and develop numerosity. Some books however, do talk about principles of numbers and counting. The principle of one-to-one correspondence is there in text book but is not presented as a principle of subitizing.

Based on the findings of the study, the following recommendations are made. Of great importance is the fact that there is an urgent need to intervene in the teaching of subitizing, numeracy and mathematics in general both at College of Education and ECE levels in Zambia. The fact that the

curriculum, lecturers and ECE teachers lack theoretical knowledge and skills in teaching subitizing has implications on the quality of service they provide to learners in general in the acquisition of numeracy skills by the learners they teach. This is reflected in the annual results in mathematics at different educational level in the country.

Subitizing being a foundation to numerosity should be well taught and skills well cemented in the learners in order change the results in mathematics in the country.

The following are the recommendations arising from the study:

- a) In order for all colleges of education and universities to improve performance of ECE students in mathematics, it is recommended that the government reflects on the content of the mathematics curriculum and the National Numeracy Framework to include subitizing;
- b) Since all text books and major reference materials used in colleges of education and ECE centers at the moment have no units or chapters on subitizing. It is recommended that a unit or chapter on subitizing be added and;
- c) The teaching/learning aids are inadequate and inappropriate for teaching subitizing in both colleges of education and ECE centers. It is therefore recommended that both the lecturers in colleges of education and ECE teachers should be trained on how to produce cheap teaching/learning materials that could be used to teach children subitizing in a play manner.

Tables

Table 1. Unit in the curriculum under which subitizing is found

	Frequency	Percent	Valid Percent	Cumulative Percent
Number notation	7	70%	70%	70%
Other	3	30%	30%	100%
Total	10	100%	100%	

Figures

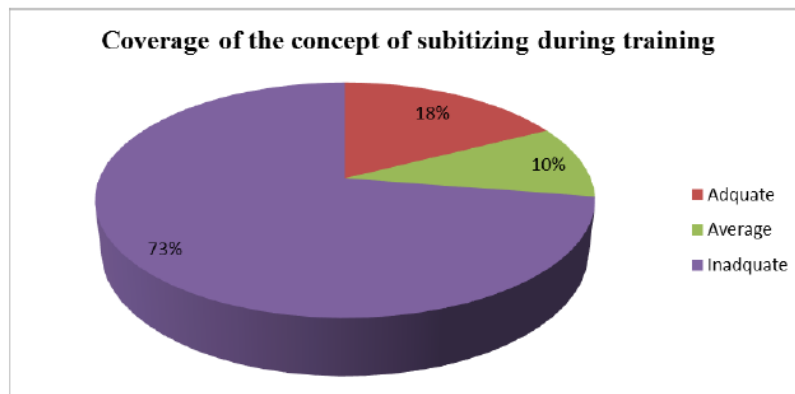


Figure 1. Rating the adequacy of the coverage of the concept of subitizing

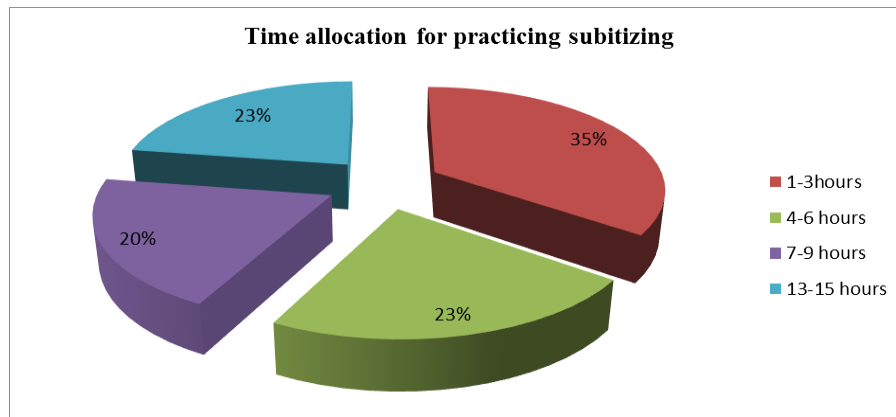


Figure 2. Time allocation for practicing subitizing

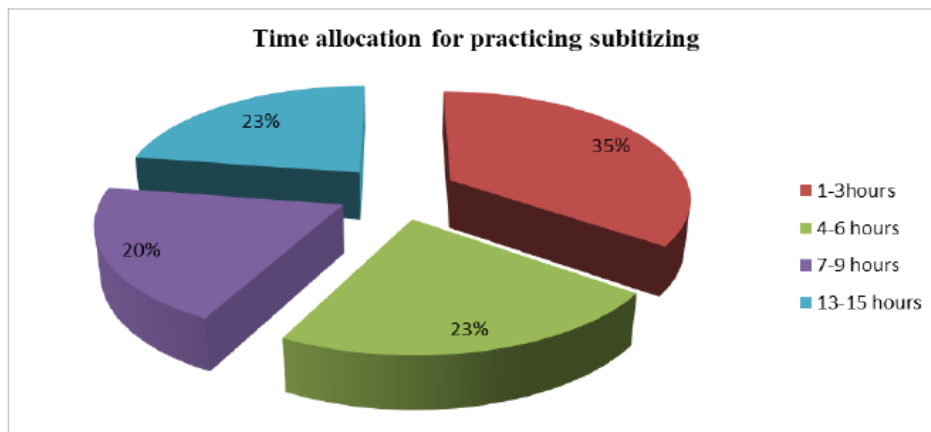


Figure 3. Teaching subitizing in colleges of education and ECE centers

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