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DEVELOPING AN INSTRUMENT TO ANALYZE THE QUALITY OF THE SECONDARY LEVEL MATHEMATICS TEXTBOOKS TO PROMOTE BILINGUAL EDUCATION IN SRI LANKA

Abstract:

Bilingual Education (BE) was introduced to Sri Lankan education system in 2001. BE refers to an educational programme in which both native language and a second language are taught as subject matter and used as media of instruction while teaching non language subjects. The research conducted by the National Institute of Education (NIE) reveals the need of scientifically designed text books to promote BE in Sri Lanka, because they are the only resource for most of the Sri Lankan bilingual learners (74.4%) (NIE, 2007). Therefore, a scientifically designed instrument to analyze the quality of text books prepared for bilingual learners is utmost important. However, there is a paucity of knowledge in this area. The present research attempts to develop an instrument to assess the quality of the secondary level mathematics text books for bilingual learners. Do Coyle's 4C model, (2010) (Content, Communication, Cognition and Culture) was selected as the suitable theoretical framework for this purpose. The four main components of the model were used to identify the indicators of the quality in addition to some other research findings. Draft items which were prepared as indicators were reviewed by bilingual education experts (5), mathematics educators (4) and curricular developers (5) and experienced mathematics teachers (5). Fuzzy Delphi technique was employed to establish the consensus among experts regarding these indicators. The instrument will be useful for researchers, text book writers and educational managers in the field of BE.

Keywords:

Bilingual Education, Mathematics, text book analysis tool, Do Coyle's 4C model

Introduction

Bilingual Education (BE) refers to an educational programme in which both native language and a second language are taught as subject matter and used as media of instruction while teaching non language subjects (NIE,2007). BE was started in Sri Lankan school system in 2001, in limited number of schools, the programme has made significant achievement in terms of number of schools practicing BE and student enrolment. At the beginning of this programme, there were about 100 schools and at present the number of schools has risen to 1,000 including national schools, provincial schools and government assisted private schools. According to the school census, there are 57,340 students studying in the BE stream (MoE, 2014 ,p51).

Bilingual Education is a new paradigm in the learning teaching process. It is dual focused; in one hand it is targeted at the achievement of non language subjects and on the other hand, the target language (i.e., in Sri Lankan situation English language). Dual focused nature of BE calls for appropriate learning materials. In Sri Lankan context, mathematics text book is considered to be one of the most important learning materials.

However, there has been no study conducted in Sri Lanka to assess the quality of mathematics text books used in the BE context. The lack of scientifically designed instrument for this purpose is a long felt need and it needs to be addressed. The present study is designed to identify criteria to develop an instrument for this purpose.

Literature Review

There is no universally accepted definition for BE and different scholars have made different definitions. Some of these definitions are closely related with the needs of particular country. Recent report of the Ministry of Education, stressed the nature of BE Programme relevant to Sri Lankan context as follows.

> BE can be defined as an educational programme using English as the medium of instruction in a few selected subjects in the secondary level through a content and language integrated learning framework (CLILF) approach without jeopardising the position of the first language as some subjects in the curriculum will continue to be taught in Sinhala and Tamil accepting the principle of balanced bilingualism (MoE, 2014, p51).

According to this definition, it is clear that theoretical framework of BE is the Content and Language Integrated Learning Frame work (CLILF). Content and Language

Integrated Learning (CLIL) is an approach to foreign language learning that requires the use of a foreign language to practice Content (Zarobe, 2007).

According to Met (1998) there are many different types of CLIL programmes operating in the world. The author further says that these programmes can be viewed as a continuum where in one end there is total immersion programmes which are content driven. In the other end is the formal language classes which are language driven and in between these two extremes there are number of other .programmes including Partial immersion programmes, Sheltered courses and Adjunct programmes with different degrees of content and language focus. In any of these approaches, learning materials is utmost important to achieve the added advantages of CLIL.

Theoretical Framework

One of the most widespread theoretical model is the Do Coyle's 4C model (Coyle, 2009).This model was selected as the theoretical framework for the present study due to two reasons. First, the model is flexible and therefore, it can be applied to the BE needs of Sri Lanka, in other words, balanced BE. The second reason is that the accumulated body of empirical evidence suggesting the significant number of success stories as a result of using this model (Puffer,n.d).

Do Coyle's 4C Model

The Coyle's model has been named as 4C model and the 4Cs stands for ***Content, Cognition, Communication and Culture***. According to Coyle,

> "Any satisfactory CLIL model should be based on these four parameters. The 4Cs framework for CLIL starts with content (such as subject matter, themes, cross-curricular approaches) and focuses on the interrelationship between content (subject matter), communication (language), cognition (thinking) and culture (awareness of self and 'otherness') to build on the synergies of integrating learning (content and cognition) and language learning (communication and cultures)"(Coyle,2009).

According to the author, it unites learning theories, language learning theories and intercultural understanding in which the content is the most important. Healthy relationships with other parameters (Cognition, Communication and Culture) may determine the success or otherwise of the CLIL programme" (Coyle, 2009).

Learning materials

There has been a growing body of research evidence in the literature on developing learning materials appropriate for CLIL contexts. According to Meyer (2010, p13) three main criteria can be used to select appropriate learning materials for any successful CLIL programme: Materials should be *Meaningful, challenging and Authentic*. The author further points out that classroom "content should be meaningful in a sense that it focus on global problems mankind faces while connecting with the daily lives of our students and their areas of interest" (p13).

Mehisto, (2012) states that "Quality learning materials foster the creation of relational links between intended learning, students' lives, the community, and various school subjects. They help students understand how learning is and can be applied in and outside of school. They seek to build intrinsic motivation to problem-solve and learn.
Quality learning materials guide students in seeking out and using other resources (sources) for learning."(p16). They help students understand how learning is and can be applied in and outside of school.

According these authors, learning tasks should be meaningful in a sense that students are made to understand the connection of what they learn in and outside the school. For example, in their family life, purchasing can be a day to day activity. Mathematical content such as percentages can be made meaningful by providing examples / word problems / assignments / projects etc involving family purchasing in the text book. According to Meyer, it should also focus on global problems mankind face. If these, two aspects are fulfilled with arousing students' interest, that mathematical content can be considered as meaningful.

Bilingual Education in Sri Lanka

National institute of education, (2007) conducted a need analysis on BE in Sri Lanka. In this survey, 48 schools roughly 10 percent of the schools in the total of 501 schools where BE was in practice, at that time, were selected. The results shows that the vast majority of schools was not from urban areas, but from rural and sub urban areas (rural 40.9 % & suburban 30.5%) where there are fewer resources for English language acquisition.

In the same survey, information regarding number of children learning in the BE stream in a family had been collected. According to the results, in most families only one child was learning in the BE stream where the family members are not proficient in the target language. Therefore, it can be argued that most bilingual students are from an environment with limited family support for their education. This situation leads the child to depend on the school for his/her educational needs. The research further suggested

the need of scientifically designed text books to promote BE in Sri Lanka, because they are the only resource for most of the Sri Lankan bilingual learners (74.4%) (NIE, 2007).

Although, mathematics text book becomes an utmost important Learning material for Bilingual students, according to the education policy in Sri Lanka, it is not possible to publish two different textbooks for monolingual and bilingual students. All the students have to study the same mathematics content prescribed in the curriculum regardless of the medium of instruction. In general, mathematics text books are prepared in Sinhala language first and later, they are translated in to Tamil and English languages. Bilingual students use the English medium text book while Monolingual students use text books in their mother tongue.

There are different views among different stakeholders, for example, mathematics educators, Bilingual experts, curricular developers, In Service Advisors (ISAs), teachers regarding the mathematics text book. It is natural that Mathematics educators concentrate more on content and the processes of mathematics while Bilingual education experts concentrate more on how the mathematics can be used to improve students' target language skills. Then, the problem arise is "how to cater the unique needs BE students regarding the mathematics text book while adhering to the education policy in Sri Lanka assuring equity in Education for all students?"

Research problem

The overarching research problem is "what criteria can be used to assess the quality of mathematics text books to be used in Sri Lankan BE contexts assuring equity in education for all students?

This broad problem has two main parts: what are the criteria suggested in the literature and to what extent these criteria can be applied to prepare text books for bilingual students in Sri Lankan contexts

Therefore, the specific research questions can be stated as follows

1) What criteria are suggested in the literature that can be used to assess the quality of mathematics text books to be used in BE context, in general?

2) What are the levels of consensus among experts on these criteria suggested in the literature, specifically applicable to Sri Lankan BE context?

Methodology

The two research questions were addressed in two stages. First stage was to review relevant literature to identify criteria that can be used to assess the quality of mathematical text books appropriate for BE contexts. The second stage was accomplished through the Fuzzy Delphi technique to obtain expert consensus (local) on

the criteria suggested in the literature. The following sections describe the two stages of the study.

Stage 1

Adopting the Do Coyle's 4C model as the theoretical lens, thirty two (32) criteria were gathered through reviewing relevant literature as potential criteria that can be employed to assess the quality of Mathematics text books appropriate for Sri Lankan BE context. For example, the following table shows the criteria of meaningful content as suggested in the literature

Table No 1: Indicators suggested in the Literature

No	**Criteria -** Connecting mathematics content to:
1.1	Student's Daily Family life/Students Experience (SDFL)
1.2	Students' Past Learning(SPL)
1.3	Regional and National Level Problems / issues(RNLP)
1.4	GlobalProblems mankind face(GP)
1.5	Other Mathematical Concepts /Other Subjects (OMC).

Criteria for other three dimensions (i.e. Communication, Cognition and Culture) of the model were also developed. The output of this stage was the list of 32 criteria and they were used as the inputs for the stage two of the study.

Stage 2

Sri Lankan context is different from most other countries and our target is Balanced Bilingualism (MoE, 2013, p51). As discussed in the previous section, BE has to be in compatible with the education policy of Sri Lanka. That means Sri Lankan BE needs are different and therefore, what Literature review suggested may not be equally applicable to Sri Lankan context. Moreover, BE is a new educational approach and most mathematics educators, curricular developers have different views on it. Therefore, to build a set of criteria that can be used for this purpose should involve a collective decision making process with all those experts who involve in BE as well as the mathematics education. The most suitable research tool for this purpose is the Fuzzy Delphi technique. The following section describes how the technique was employed in this research.

Fuzzy Delphi technique

Fuzzy Delphi technique was developed by Kaufman and Gupta (1988). This method is a blend of traditional Delphi technique and Fuzzy set theory. Traditional Delphi technique is scientific way of achieving experts' consensus which requires several rounds. In this technique respondents' verbal expressions are used to measure their views. These verbal expressions have limitations to reflect fully respondents mental latencies (Habibi,Jahantigh, & Sarafrazi, 2015). According to the authors, although the experts' competence and mental abilities are used for decision-making, the quantification of experts'opinions cannot completely reflect the human thinking style. Using fuzzy sets is more consistent with human linguistic and sometimes vague descriptions and it is better to make decisions in the real world by applying fuzzy numbers.

Delphi technique with fuzzy approach can be used for determining the importance of criteria and screening key criteria(Habibi,Jahantigh, & Sarafrazi, 2015). One of the major advantages of the fuzzy Delphi technique compared to the traditional Delphi technique to screen criteria is that a round can be used for summarizing and sorting items. The following sections describes how this technique was used in the present research.

I. Gathering experts' opinions

The criteria gathered through the review of literature were organized in Likert type items where 1 indicates the criteria is "Not at all important" and 5 indicating the criteria is "very important". For example, there were six criteria related to the content dimension of the Do Coyle's 4C model. The Likert type questionnaire was administered to a sample of 19 experts. These experts included bilingual education experts (5), mathematics educators (4) and curricular developers (5) and experienced mathematics teachers (5). According literature, Number of experts can vary between 10- 50 (Habibi,Jahantigh, & Sarafrazi, 2015).

II. Fuzzification of linguistic expressions of experts

After obtaining the opinions of experts, the values were fuzzified. Fuzzy spectrum was prepared for the fuzzification of these linguistic expressions. For that purpose triangular fuzzy spectrum was employed as shown in the following table 1. According to this method, each linguistic expression has three values: The lowest (l), most probable (m) and the highest (h) values. For example, a respondent who marks the linguistic expression "Connecting mathematics content to students daily family life " as "very important" the fuzzified values are 0.75(the lowest), 1(most probable) and the 1(highest). Likewise, Five point Likert scale linguistic expressions were fuzzified as given the following table no: 2.

Table2.Triangular fuzzy numbers of five-point Likert scale

Very Unimportant	*Not at all important*	*Moderately Important*	*Important*	*Very Important*
(0, 0, 0.25)	(0, 0.25, 0.5)	(0.25, 0.5, 0.75)	(0.5, 0.75, 1)	(0.75, 1, 1)

III. Defuzzification and ranking

Fuzzified linguistic expressions were entered in an excel worksheet. Each criterion will have three columns: Lowest value (L), Most probable value (M) and the highest value(H) The following table is a section of the excel work sheet in which fuzzified values of experts comments were entered. In the last two rows show the Defuzzified values and the ranking according to the defuzzified value.

Table 3. Excel sheet

Respondent	Criterian 1			Criterian 2		
	L	M	H	L	M	H
Mathematics Educator	0.75	1	1	0.5	0.75	1
Mathematics Educator	0.5	0.75	1	0.5	0.75	1
Mathematics Educator	0.5	0.75	1	0.5	0.75	1
Mathematics Educator	0.75	1	1	0.75	1	1
Bilingual Expert	0.75	1	1	0.5	0.75	1
Bilingual Expert	0.75	1	1	0.5	0.75	1
Bilingual Expert	0.75	1	1	0.25	0.5	0.75
Bilingual Expert	0.75	1	1	0.75	1	1
Bilingual Expert	0.5	0.75	1	0.75	1	1
Curricular developer	0.5	0.75	1	0.25	0.5	0.75
Curricular developer	0.5	0.75	1	0.5	0.75	1
Curricular developer	0.75	1	1	0.5	0.75	1
Curricular developer	0.5	0.75	1	0.5	0.75	1
Curricular developer	0.75	1	1	0.75	1	1
Experienced Teacher	0.5	0.75	1	0.5	0.75	1
Experienced Teacher	0.5	0.75	1	0.5	0.75	1
Experienced Teacher	0.5	0.75	1	0.5	0.75	1
Experienced Teacher	0.75	1	1	0.75	1	1
Aggregated Fuzzy value	0.625	0.875	1	0.54	0.79	0.97
Defuzzification value		0.833			0.767	
Rank		1			2	

Key L- Lower value; M-Most probable value; H- Highest value

Fuzzified values were defuzzified by taking the simple average of aggregated values. In the above example, defuzzified value for Criterian 1 was calculated as follows.

Defuzzification = ((1/3)*(0.625+0.875+1)=0.833

If the defuzzified value was above the cutoff point (0.8) that criteria was selected. For example, in the above example defuzzified value is 0.833 and this value exceeds the cutoff point (0.8) and hence, it was selected a criteria for the instrument.

Findings

The following section presents the findings of this study. Findings are presented according to the four main dimensions of Do Coyle's 4C model: Content, Cognition, Communication and Culture.

I. Criteria related to Content dimension

According to the review of literature 6 criteria were selected to assess the content dimension. The following table shows the defuzzified values and their ranking according to the agreement of experts.

Table No 4: Experts Agreement for content in the textbooks

No	Item-	*DF Value	Ranking
	Connecting Mathematics content in the text book to:		
1.1	Student's Daily Family life/Students Experience (SDFL)	0.8263	1
1.2	Students' Past Learning(SPL)	0.8020	6
1.3	Regional and National Level Problems /issues(RNLP)	0.8055	4
1.4	Global problems mankind face	0.8055	4
1.5	Other Mathematical Concepts/	0.8131	2
1.6	Other Subjects (OMC).	0.8125	3

*DF Value- Defuzzification Value

According to the above table, the majority of experts agreed on all the items with the highest level of agreement for item 1.1 which asked experts comments on connecting

the mathematics content in the textbook to the students' daily family life. All these five criteria are above the cutoff point 0.8 and therefore, they were included in the instrument to analyze the mathematics text book. This criterion has been emphasized in the literature in CLIL as well as in the mathematics and language education. Experts in Sri Lankan context too regardless of the medium of instruction have agreed on this criteria and it was taken as a criteria to be included in the instrument.

II. Criteria related to Cognition dimension

The following table shows the defuzzified values and their ranking of criteria according to the agreement of experts. The table number 4 shows the defuzzified values obtained.

Table No 5: Experts Agreement for cognition in the textbooks

No	Item	*DF Value	Ranking
	Connecting Mathematics content in the text book to:		
2.1	Activities that develop students' Lower Order Thinking Skills-LOTS-(Remembering, Understanding and Applying)	0.8402	4
2.2	Activities that develop students' Higher Order Thinking Skills-HOTS-(Analysis/synthesis/creation)	0.8472	1
2.3	Simple to complex progression of the lesson	0.8368	5
2.4	Multi model learning aides	0.8423	3
2.5	Problems/Activities to arouse creative thinking skills	0.8472	1

*DF Value- Defuzzification Value

According to the Table 3, the majority of experts agreed on items, 2.1, 2.2, 2.3, 2.4 and 2.5 with item 2.2 and 2.5 having the highest level of agreement.

III. Criteria related to Communication dimension

According to the review of literature 6 criteria were selected to assess the communication dimension. The following table shows the defuzzified values and their ranking according to the agreement of experts.

Table No 6: Experts Agreement for communication in the textbooks

No	Item	*DF Value	Ranking
3.1	Introducing mathematical specific words /definitions/ grammatical structures	0.8035	4
3.2	Activities designed to make students communicate using social registers	0.7718	6
3.3	Activities designed make students communicate using Cognitive Academic Language registers	0.8125	3
3.4	Activities to get the pushed language output.	0.8035	4
3.5	Making use of rich inputs- authentic materials	0.8368	2
3.6	Using word problems/activities/assignments etc. to arouse students creativity	0.8472	1
3.7	Activities involving social interaction (Teacher - students/Students-Students/ Group works/ pair works/)	0.7083	7

*DF Value- Defuzzification Value

According to the Table 4, the majority of experts agreed on items, 3.1, 3.3, 3.4,3.5, and 3.6 with item 3.5 having the highest level of agreement. However, the criteria, 3.2 & 3.7 have scored below the cut of point (0.8) and therefore, all the items exceeding the cutoff point 0.8 were included in the instrument.

IV. Criteria related to Culture dimension

According to the review of literature 6 criteria were selected to assess the communication dimension. The following table shows the defuzzified values and their ranking according to the agreement of experts.

Table No 7: Experts Agreement for culture in the textbooks

No	Item	*DF Value	Ranking
4.1	Activities/examples related to appreciate one's own culture	0.8125	4
4.2	Activities/examples related to appreciate other cultures	0.8125	
4.3	Activities/examples making use of cultural artifacts	0.7684	
4.4	Activities to maintaining conducive classroom culture so that students experiment with target language/mathematical concepts freely	0.7753	2
4.5	Activities/examples /problem solving situations which involve group works/Pair works fostering a learning culture	0.8333	3

*DF Value- Defuzzification Value

Referring to Table 3, the majority of experts agreed with item 4.1,4.2,& 4.5 with the highest score of 0.8333 for item 4.5 which says "Activities/examples /problem solving situations which involve group works/Pair works fostering a learning culture" . Items 4.3 and 4.4 were not selected for the instrument as the value is below the cutoff point.

Implications of the study

As discussed above in Sri Lankan school system centralized curriculum is implemented for both monolingual and bilingual education. However, there has been a gradual increase of enrolment of students and schools practicing BE in the country which calls for special learning materials such as textbooks appropriate for CLIL contexts. According to the education policy there cannot be special series of text books only for BE students which will create unnecessary social problems. Therefore, it is essential that authorities should provide for the needs of BE students while thinking of the vast majority of monolingual students. Fortunately, Do Coyle's model provide opportunity to plan BE programmes in a very flexible manner. The criteria developed through literature is important not only for BE students but also for monolingual students. For example, vast majority of respondents agreed that the mathematics content in text nook should connect to students' daily life. Developing text books adhering this criteria will not only benefit BE students but also monolingual students. Therefore, this instrument can be safely employed to assess the quality of text books appropriate for CLIL environments to promote BE in Sri Lanka.

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