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Specific and General Knowledge in Geometric Proof Development

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Abstract

School mathematics curricula at all levels place a high degree of importance to spatial cognition and the development of more formal geometric understandings. While the assessment of students' knowledge and depth of their understanding of geometry can be undertaken by a range of strategies, the observation of their actions that involve the construction of proofs with prior geometric knowledge provides the researcher with a powerful context. In the research reported here we examine two issues that relate to geometric understanding. Firstly, we address the continuing issue about why students experience difficulty with proof-type problems in geometry. Secondly, our investigation led us onto a larger issue that has featured prominently in educational research about the relative role of specific vs general knowledge in problem solving. The results indicate that a) proof-type geometry problems are inherently complex and demand higher levels of cognitive processing and b) the interplay of problem-relevant geometric content knowledge, general metacognitive knowledge and reasoning.

Key words

Specific and general knowledge, Geometry proof, Problem solving, Secondary mathematics, Spatial thinking, Mathematics cognition

Introduction

The discourse of mathematics is emerging to be a key concern in current reforms and debates about mathematics teaching and learning. The shift in focus onto the mathematics communication and talk is based on the assumption that learning activities need to scaffold deeper conceptual understanding of mathematics, and that we need to move away from the transmission model of mathematics instruction. The approach has generally been well received by the mathematics community in Australia and elsewhere. However, for students to engage in activities that demand talk that has more mathematics content rather than general conversation that might contribute to the social well-being of their peers, we need to focus on both the knowledge and processes that can be played out during the discourse. Mathematically rich discussion could focus on learning a concept and using that concept for problem solving.

In the key strand of school geometry, reasoning, conjecturing and proving constitute pedagogically valuable learning activities. While, there is consensus that we need to give priority to these processes, these activities are less well researched in mathematics education and, specifically, their role in the solution of proof-type geometry problems is not clear (ICMI****). The activation of all the three processes must draw on a body of previous geometric and other knowledge that students have acquired. Thus, the elucidation of potential links among students' prior content knowledge of geometry and processes that help marshal this knowledge during the construction of geometry proofs is an important areas of research.

The above line of argument raises an important issue about the relative role of domain-specific knowledge, domain-general processes and mathematical reasoning during mathematics cognition and talk. The issue had received considerable attention in the research on learning and instruction (Chinnappan and Lawson, 1996; Lawson, 1989; Sweller, 1989). Sweller (1989) argues that domain-specific knowledge plays a prominent role in mathematics understanding and problem solving in comparison to general processes while the work of Chinnappan and Lawson suggested that both these strand of knowledge interact and complement each other. Thus, it seems that domain specific vs general issue is very much alive in discussions about teaching mathematics and other subjects. For the mathematics education community, the issue is of increasing significance

particularly against the backdrop of the current emphasis on encouraging students to express their mathematical understanding and problem-solving actions.

Construction and communication of proofs

The construction of proofs constitutes an important problem-solving activity in mathematics. Among the various strands of the mathematics curriculum, this activity had been deemed to play a central role on students' understanding of geometric concepts. In the present study, we examine the specific-general issue in the context of proof development and communication. While there is some support for the seem to be relevant to proof-type geometry problem solving, the relative influence of these three key knowledge-related factors has yet to be established, giving rise to the research question:

As proof-type geometry problems are domain-specific, it can be anticipated problem-solving process in this domain may be content knowledge driven. Content knowledge that is related to Euclidean geometry is a coherent body of mathematical knowledge. Understandings about the characteristics of objects such as point, angle, triangle, and shapes as well as knowledge about axiomatic reasoning are important components of this content knowledge. The non-algorithmic nature of the proof-type geometry problem-solving process demands the use of non-algorithmic problem-solving strategies. These strategies seem to have links with domain-general processes.

As a component of mathematics, mathematical reasoning has been argued to influence proof-type geometry problem-solving process. These refer to the broad range of reasoning skills that students activate in the context of solving a range of classroom mathematics problems. It would seem that these mathematical reasoning skills would contribute to the solution outcome of proof-type problems.

Background

The above situation raises two important issues: first, students are reluctant to select proof-type problems; second, when they do decide to tackle these problems, their performance is relatively low. The above observations have been persistent during the past twenty years. The relevance of this problem has frequently been acknowledged, but it has received little attention from researchers.

Students perform differently in construction type versus proof-type geometry problems because although the underlying rules are the same for both types, the approach to solving construction problems rests on a set of procedures such as constructing triangles, bisectors, perpendiculars, circles and parallel lines. The critical task in a construction problem seems to be the identification of the set procedure relevant to the problem. On the other hand, there are no set procedures for solving proof-type problems, and students need to find strategies throughout the process (Koedinger and Anderson, 1993). Students at SSL seem to be familiar with algorithmic problem solving, but not with non-algorithmic problem solving that requires a logical inferential approach.

Nature of geometry problem solving

It is acknowledged that proof-type geometry problem solving is difficult not only to learn, but also to teach (NCTM, 2000; TRS, 2001). This implies that the difficulty is located in the subject and the purpose of instruction would be to reduce subject complexity. These instructions should be tailored to suit the complexities associated with proof-type geometry problem solving.

According to an analysis of categorisations (Jonassen, 2000; Robertson, 2001), proof-type geometry problems are *well-structured, domain-specific,* and *non-algorithmic*. These three features can be considered as key determinants of what students need to bring to solving proof-type geometry problems as well as what pedagogical strategies teachers should develop in order to support student learning. This argument suggests domain-specific knowledge (henceforth *content knowledge*) and skills for solving non-algorithmic problems could be vital prerequisites for student success in solving proof-type geometry problems.

Role of content knowledge in proof-type geometry problem solving

Content knowledge that is related to proof-type geometry problem solving comprises geometric shapes and their relationships, definitions and axioms, representation of information such as conventions and practices, symbols and diagrams. Students should acquire those components of geometry knowledge in order to solve proof-type problems. Charalambos, (1997) ,reports that 78% of students lack the necessary basic content knowledge for the solution of proof-type geometry problems.

The development of content knowledge is intertwined with that of related reasoning processes. Research shows that the development of geometric reasoning is different from that of other subjects. It does not follow Piagetian development phases. The van Hiele theory (Fuys, Geddes & Tischler, 1988; Lawrie, 1998; Senk, 1989) describes that the development of geometric reasoning takes place in five discrete levels namely: van Hiele Level 0, van Hiele Level 1, van Hiele Level 2, van Hiele Level 3, and van Hiele Level 4.

Different van Hiele levels have different characteristics and requirements in terms of language, reasoning and thinking (Fuys, Geddes & Tischler, 1988). The development of geometric thinking is hierarchical and takes place sequentially from vHL 0 to 4 successively. Without adequate maturity at level *n,* the student cannot make progress to level *(n+1)*. Research on van Hiele theory suggests that acquiring geometry content knowledge can be difficult as the geometric thought process develops in discontinuous phases (Clements & Battista, 1992; Mistretta, 2000). For instance, to develop the concept of angle (content knowledge at vHL 2), students should reason out two sides and a common vertex in a closed geometric figure (maturity of reasoning at vHL1). This highlights the importance of reasoning skills in acquiring content knowledge. It is also important that geometric reasoning develops through inductive reasoning. Table 1 summarises the relationship between the geometric reasoning and inductive reasoning related to the content knowledge about a triangle.

Table 1 : Differences between geometric reasoning across van Hiele levels about 'triangle'

vHL Levels	Geometric reasoning	Inductive reasoning Process	Nature
vHL 0	Thinks as a Physical object	Generalising visual perception of physical laminas and faces of solids into a shape	A physical shape: inside is necessary
vHL 1	Thinks as an object having three sides and three vertices	Generalising physical lamina, faces and triangular networks into a shape	A physical shape: inside is not necessary
vHL 2	Thinks as a geometric shape having three angles, three sides, and three vertices	Generalising physical sides into lines: vertices into points	A geometric shape: physical measurements for angles and sides are necessary
vHL 3	Thinks as an ideal geometric shape	No generalisation: according Euclidean deductive system	Triangle is perceived as a quality

Information in Table 1 raises two issues: the influence of inductive reasoning on the development of geometric reasoning across van Hiele levels, and the importance of experiences in vHL 2 to understand the concept of triangle (ideal geometric triangle) as defined in the Euclidean system. Both themes demonstrate the importance of inductive reasoning, which is domain-general.

The reasoning level appropriate for learning proof-type geometry problem solving is van Hiele Level 3 (Senk, 1985; 1989; Shaughnessy and Burger, 1985). Students at this level are expected to possess geometry content knowledge including: concepts and properties of geometric shapes; diagrammatic representation of geometric information and interpretation; identifying required shapes or parts in a complex diagram; geometric relationships; selection of appropriate relations for a given situation and providing reasons.

A student who is at a lower van Hiele level (vHL 0, vHL 1, and vHL 2) is not cognitively ready to participate in proof-type geometry problem solving activities.

Senk (1989) reports that not only do about 93% of students not possess appropriate prerequisite knowledge but also that they are located among three lower levels: 27% at vHL0, 51% at vHL1 and 15% at vHL2. Conventional instructions in a classroom setting are not appropriate for the majority of the class unless students are provided with opportunities to make progress to vHL 3. More complex reasoning is based on advanced content knowledge and vice versa.

Traditional instructional efforts also tend to be less effective due to the gap that exists between instruction and learning. Having students at different van Hiele levels creates a paradox for the mathematics teacher within the frame of conventional instructional settings. Shaughnessy and Burger (1985) describe this situation:

> Teachers and students often confront levels in a geometry class. That is, it is very likely that the teacher and students are reasoning about the same concept but at different levels. While the teacher is writing a careful definition of a rectangle on the chalkboard (Level 2), [some] students may be thinking about all the properties that the teacher has left out (Level 1)
> (Shaughnessy and Burger, 1985, p. 425).

This quotation indicates that the gap that exists between instructional process and the learning process is a major difficulty in learning about proof-related problems. Given that proof-type geometry problems are at found at vHL 3, and students are located at vHL 3, 2, 1 or 0, it is obvious there will be a range of gaps between instructional process and learning process.

Geometric reasoning is not the only critical issue related to content knowledge. Mathematical formal proof is a process that deals predominantly with abstract concepts that are usually not visible. In proof-type geometry problems, students work with diagrams that are visible, as well as concepts embedded in the diagrams (Fischbein, 1993). This dual nature of geometric figures creates two types of problems:

(i) Generalisation

The first difficulty is related to generalisation. Proof must reflect a general situation, whereas a diagram is usually perceived as a specific object that can be associated with that situation. Hence, most students cannot develop a generalised relationship in geometric proof (Charalambos, 1997).

(ii) Fixedness

The second difficulty is associated with fixedness to prototypical configurations. The prototypical configuration is a result of the visual property of geometric diagrams. In classroom practice, the teacher frequently draws, and draws on, typical geometric diagrams with specific orientations to explain geometric relationships. For instance, an isosceles triangle is typically drawn with a horizontal side (most frequently the base). As a result, the perpendicular from vertex to the base is vertical. Consequently, students associate a relationship with such a prototypical configuration, and apply the relationship only when they see that configuration. As these prototypical configurations are seldom found in typical problem situations, students are less capable of retrieving the relevant relationship (Charalambos, 1997). Constructing generalisations and perceiving relevant parts from a complex diagram through concrete visual figures are also difficulties faced by students.

In summary, acquiring and applying geometry content knowledge is a complex process as it is influenced by various factors. Some of these factors are domain-specific such as geometric reasoning while the others are domain-general such as inductive reasoning and visual perception.

The VH's levels do provide insight into the quality of thinking that learners need to develop. However, the model provides limited insight into the nature of content knowledge that would drive the levels-based thinking. Equally, the levels analysis does not inform us about the complexity of cognition that underlies thinking within and between the levels. There is thus a need to 'unpack' the knowledge and cognitive processes.

Non-algorithmic nature of proof-type geometry problem solving

Geometry problem-solving process is complex in nature. The complexity of this process is related to the non-algorithmic nature of this class of problems. There are no formulae or other predetermined procedures to use as algorithms in the proof-type geometry problem-solving process. It requires students to repeat a chain of logical inferences. In case of failure, they need to try another inferential path.

In the process of developing a computer-based geometry proof tutor, Koedinger and Anderson (1993) calculated the number of possible inferences that has to be fed in to the computer program, and noted the following.

> Of the 27 definitions, postulates and theorems that are introduced prior to such a problem in a traditional curriculum, 7 can be applied at the beginning of this problem. Some of these rules can be applied in more than one way yielding 45 possible inferences that can be made from this problem's givens. Using the results of these inferences, essentially as new givens, we did the same thing over again and found that 563 inferences can be made at this second layer. At the third layer the options really explode, as there are more than 100,000 possible inferences. The number of options continues to increase at further layers - at minimum it takes 6 such layers of inferences to reach the problem goal (Koedinger and Anderson, 1993).

As the quotation describes, a typical proof-type geometry problem can exceed 100,000 possible inferences. From such a large number, selecting appropriate inferences is critical. Most of the other inferences could also be applied to produce a result that is not mathematically wrong, but does not produce the expected result and, therefore, is not appropriate. Extensive practice in problem solving is required to minimise inappropriate inferences.

The non-algorithmic nature of problem solving contributes to the novelty aspect of the problem. As a student as well as a secondary mathematics teacher, the *investigator* of the present study has experienced that students seek teacher explanation for almost all problems. Although the teacher provides the necessary information orally, all expressions cannot be recorded and students lose vital information.

Their workbooks also provide incomplete information. Anderson (1995) asserts that the most important information related to the solution process such as the reason for making a decision is lost in class textbooks. Resources such as teachers, class textbooks and workbooks may not provide the required scaffolding for the majority of students. In addition heuristics such as working backward and using auxiliary objects can sometimes be helpful for the students.

Proof-type geometry problem solving is different from other mathematical problem-solving processes. The acquisition of content knowledge may not be sufficient for the success of proof-type geometry problem solving.

General problem-solving processes in proof-type geometry problem solving

Another feature of the non-algorithmic nature of proof-type geometry problem solving is the difficulty of finding a starting point or a method for approaching the problem (Healey and Hoyles, 1998; Riess, Kleime, and Heinze, 2001). Working backward seems to be helpful as a general problem-solving skill in proof-type geometry problem-solving process (Anderson, 1985). Cognitive processes such as planning have a role in searching for strategies and heuristics (Schoenfeld, 1985). As a control process, metacognition orchestrates the solution process. In addition to metacognitive processes, in order to deploy available content knowledge students need to activate appropriate reasoning processes.

Reasoning in proof development

Reasoning skills play two key roles during the solution of proof-type problems. Firstly, reasoning facilitates the construction of important links. During the course of proof development, the solver is required to show the connections between the different steps through chains of reasoning. A proof is incomplete without reasoning. The National Council of Teachers of Mathematics considers reasoning and proof is intertwined.

Systematic reasoning is a defining feature of mathematics. Exploring, justifying, and using mathematical conjectures are common to all content areas and, with different levels of rigor, all grade levels. Through the use of reasoning, students learn that mathematics makes sense. Reasoning and proof must be a consistent part of students' mathematical experiences in pre-kindergarten through grade 12 (NCTM, 2000-2004, Online).

Secondly, reasoning is important for the development and enrichment of mathematical content knowledge. This in turn facilitates the reasoning process and pattern generation. On the other hand, deductive proof draws on deductive reasoning skills. Both inductive and deductive reasoning are thus important in proof-type geometry problem solving.

Method

Three key variable emerged from the review of literature conducted for the present study: *Geometry Content Knowledge* (GCK), *General Problem-Solving processes* (GPS), and *Mathematical Reasoning Skills* (MRS) that can influence *Proof-Type Geometry problem-solving skills* (PTG).

A number of methods could have been adopted to investigate the hypothesis. The literature related to research methods however suggests that a multiple linear regression (MLR) analysis is the best method to investigate the simultaneous effects of several independent variables on one dependent variable.

When researchers are interested in understanding the relationship between more than two variables, they often use a technique called multiple regression analysis which measures the relationship between one interval level dependent variable and several independent variables (Polit and Hungler, 1995, p. 358).

> Linear Multiple Regression (MLR) is not just a data analysis technique but a research design strategy as well (Norwood, 2000; Punch, 1998). The main advantage of the MLR is its straightforwardness in addressing the research question.
>
> … MLR is useful, because it addresses directly questions of key substantive significance.
>
> … First it is flexible, in being able to accommodate different conceptual arrangements among the independent variables including their joint effects on a dependent variable. … Second, it is not difficult to understand, conceptually or operationally.
>
> (Punch, 1998, p. 83).

MLR can be used to identify, compare and estimate the contribution of the independent variables that affect the dependent variable. This study was designed to identify the influence of a set of three predictive variables.

This study aims to compare the relative strengths of three independent variables in influencing the dependent variable: *Proof-Type Geometry problem-solving skills* (PTG). The independent variables are: *Mathematical Reasoning Skills* (MRS), *General Problem-Solving processes* (GPS) and *Geometry Content Knowledge* (GCK). The hypothesised linear relationship among the independent variables and the dependent variable can be expressed as:

$PTG = b_0 + b_? (MRS) + b_2 (GPS) + b_3 (GCK)$

Design

Tests were developed in order to collect data on each of the three variables PTG, GPS, and GCK. Students' Grade 10 final scores for School Based Assessment (SBA) were collected to represent MRS scores. Figure 1 provides an overview of the tests and associated scores for the variables.

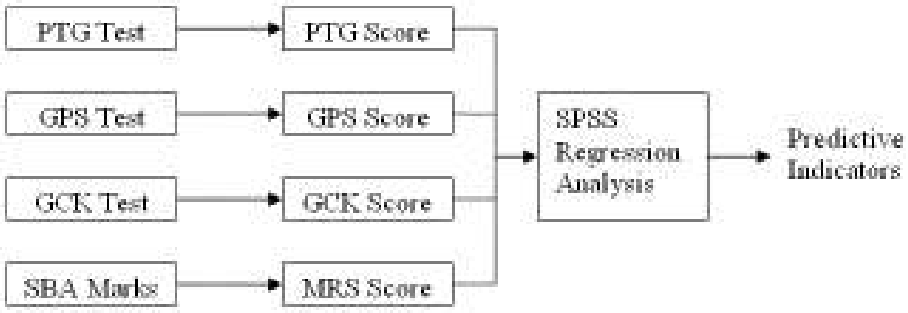


Figure 1 – The design of the study

Participants

Participants in this study were Grade 11 (Age 16 – 17 years) students in Sri Lanka. All senior secondary students in Sri Lanka are required to complete a common course of mathematics. 166 students from four schools were involved in all tests in the present study. They were from a boys' school, a girls' school and two mixed

schools. The schools were located in two major urban areas (Colombo and Kandy) and rural areas of Sri Lanka. All schools had parallel classes - that is they were not streamed. At each school a class was chosen at random.

Materials

This section provides a detailed account of materials, the purpose and the procedures that were adopted during the administration of the tests. As discussed earlier, three tests were developed in order to generate scores for three independent variables:

A written test for PTG
A written test for GPS
A written test for GCK

Tests were prepared by a panel of experienced mathematics educators and experienced teachers. The items for the test were selected from a pool of resources such as textbooks, examination papers and research papers. Some items were modified to fit the purpose of the study. The items were reviewed by two colleagues and edited by another colleague. Each test was piloted with a group of 15 students. The piloting provided a better indicator of the duration for each test and potential areas of difficulties for students. The duration for each of the tests was as follows:

PTG	80 minutes
GPS	80 minutes
GCK	60 minutes

Proof Type Geometry Problem Solving (PTG) Test

Five geometry problems of different difficulty levels were selected and modified for this test. Mathematics textbooks and previous examination papers were the first source of these problems that were subsequently modified with guidance from mathematics teachers. All problems were well-structured proof-type problems. One of them was not a typical proof, but a proof followed by a find -type task.

General Problem Solving Skills (GPS)Test

The test contained five non-familiar items. The written test was constructed so that students could present evidence related to all four afore-mentioned general

processes of problem solving: (a) *analysis* (b) *representation* (c) *planning* and (d) *use of knowledge retrieval*. As was discussed in Chapter 2, these four general processes are involved in all kinds of problem solving. This section presents solutions for the selected problems and the anticipated use of the general processes.

Scoring rubric used to quantify the scores related to PTG and GPS.

The scoring rubric was developed by drawing on the matrix coding strategy of Chinnappan (1992) and the one-dimensional linear model of Senk (1985). The criteria for scoring were developed from a proof-type problem-solving perspective. The scoring rubric includes features of a two-dimensional matrix. The general processes: *analysis*, *representation*, *planning* and *use of knowledge retrieval* were used as coding criteria. This design is shown in Table 2.

Table 2 : The scoring rubric for Proof-Type Geometry problem-solving (PTG) and General Problem Solving skills (GPS)

Level	Criterion	Rating *			
		3	2	1	0
analysis					
representation					
planning					
use of Knowledge retrieval					

Key: 0 – not attempted 1 – attempt incorrect 2 – attempt contains faults
3 – attempt correct: excluded one fault

Geometry Content Knowledge (GCK) test

Proof-type geometry problem solving requires the activation of *Geometry Content Knowledge*. The topics for the content area are clearly and comprehensively documented in curriculum resource materials. The *Geometry Content Knowledge* (GCK) test was designed to measure various rules and declarative knowledge components that are associated with content knowledge. This knowledge tested here was the content requirements for the solution of five proof-type geometry problems that were the focus of the present study.

Scoring rubric of the Geometry Content Knowledge test (GCK)

The following schema was used in the scoring of items in the *Geometry Content Knowledge* test:

1 - correct response

0 - incorrect response

Procedure

The following steps were followed during data collection.

- A 2-hour session was conducted to practise answering the GPS test. The problems used in the practice session were not similar to the test items in the GPS test, because the aim was to practise written presentation of general problem solving.
- In order to avoid possible practice effects of the training session on performance in GPS, the practice session was followed by the PTG test instead of GPS.
- In order to avoid possible practice effects of the PTG on GCK, PTG was followed by the GPS test instead of GCK.
- In order to avoid possible practice effects of the GCK on PTG, GCK was administered last.

Data analysis

The multiple linear regression (MLR) procedure commenced with screening data for the purpose of verification of suitability (Francis, 2001; Hair, Anderson, Tatham & Black, 1995; Tabachnick and Fidel, 2001). The data analysis was computed with the SPSS program.

Pearson correlation coefficient (r)

The Pearson correlation coefficient indicates the degree of the linear relationship between two numeric variables. Pearson correlation coefficient is usually a decimal figure between -1 and 1. Higher values of correlation coefficients, regardless of their sign, indicate more strong relationships, whereas values closer to 0 from either side indicate weaker relationships. When the two variables are not related, their correlation coefficient is zero.

As MLR analysis deals with several variables, correlation coefficients are presented as a matrix. This matrix allows a comparison of correlation coefficients of different variables with each other. It also provides information as to which independent variables have significant correlation coefficients. The correlation matrix is shown as Table 3.

Table 3 : Pearson correlation coefficient matrix

Correlation Coefficients			
	GCK	GPS	GPS
PTG	0.820*	0.703*	0.536*
GCK		0.667*	0.529*
GPS			0.410*

* Correlation is significant at the $\alpha = 0.01$ level (2-tailed).

The first row of Table 3 represents the Pearson correlation coefficients between the dependent variable PTG and each of the other independent variables. It reveals that the dependent variable is positively correlated with each of the independent variables with correlation coefficients 0.82, 0.70 and 0.54. These correlation coefficients are significant at $\alpha = 0.01$ level.

The next two rows of Table 3 show the correlation coefficients among independent variables. As it appears there, they are correlated with each other with

correlation coefficients 0.67, 0.53 and 0.41. All of these are significant at a = 0.01 level.

According to these correlations, GCK is the independent variable most strongly related to proof-type geometry problem-solving performance. The other variables: GPS, (*General Problem-Solving processes*) and MRS (*Mathematical Reasoning Skills*) are also significantly correlated to PTG. This suggests that while *Geometry Content Knowledge* (GCK) is the major predictor of proof-type geometry problem-solving performance, the other variables GPS and MRS also are powerful predictors.

Partial correlation coefficients and part correlation coefficients

The Pearson correlation coefficient is a statistical indicator that describes the relationship between two variables. A correlation coefficient between two variables is not affected by the variations of other variables. Because of this, the Pearson correlation coefficient is not sufficient to compare the individual relative influences of each independent variable on the dependent variable.

There are correlation coefficients among independent variables too. These correlation coefficients suggest the existence of other relationships. It is an indicator of the influence of one independent variable on the other. Such influences also eventually affect the variability of the dependent variable. Because of these interrelationships among independent variables, the magnitude of the Pearson correlation coefficient is not sufficient to compare and contrast the individual influence of each independent variable (Hair et al., 1995). In this regard, two specific correlation coefficients: the *partial correlation coefficient* and the *part correlation coefficient* (some authors title part correlation as semi partial correlation) are important.

The partial correlation coefficient refers to the strength of the relationship between the dependent variable and a single predictor, when the effects of other independent variables are held constant. The use of this coefficient is to identify the independence with the greatest incremental predictive power beyond the predictor variables already in the model (Hair et al., 1995). It can be viewed as the influence of the independent variable assuming that other variables do not change their influences.

Second, the part correlation coefficient refers to the strength of the relationship between the dependent variable and a single independent variable when the effect of

the other independent variables in the regression models is removed. This is used to describe the unit predictive effect on a single dependent variable among a set of independent variables (Hair et al., 1995). This can be viewed as the influence of the independent variable assuming that the other variables do not have influence.

Table 4 shows the Pearson correlation coefficient, partial correlation coefficient and part correlation coefficient of each variable with PTG.

Table 4 : Partial and part correlation coefficients with PTG

	Pearson Coefficient (Zero)	Partial coefficient	Part coefficient
GCK	0.820	0.606	0.398
GPS	0.703	0.357	0.200
MRS	0.536	0.192	0.102

Table 4 shows the order of the influence demonstrated by each independent variable GCK, GPS and MRS at three levels (zero, partial and part). It is similar to the order that is suggested by the *correlation coefficient matrix*. When different coefficients are compared, the relative differences among three variables in the Pearson correlation coefficients column are different to the relative differences among three variables in the column of partial correlation coefficients. Both partial correlation coefficients and the part correlation coefficients magnify the relative strength of the *Geometry Content Knowledge*.

The differences in the figures between the first and the second columns imply how great is the influence of GCK on PTG compared to the other two variables. For instance, while the figure of GCK decreases from 0.820 to 0.606 (by 26%), GPS decreases from 0.703 to 0.357 (by 49%) and MRS decreases from 0.536 to 0.192 (by 64%). This indicates that, when the process holds the influence of other variables at a constant level, the difference is comparatively small, indicating the importance GCK. On the other hand, as it appears in the third column of Table 4 at part correlation coefficient level, the magnitude of the correlation coefficient drops, from 0.82 to 0.39, by 49%. This suggests that the influence of the other two variables is also significant in the success of GPT.

Analysis with standard regression method

To examine how the predictors combine to influence the dependent variable, standard regression analysis was executed on the SPSS program. In this method, all selected variables are entered into the model at once.

The Multiple Regression coefficient (R) is an important statistic in the regression analysis. It is the square root of the coefficient of determination or the correlation squared (R^2), which is the total proportion of variation of the dependent variable explained by dependent variables. The results of the analysis are shown in Table 4.6.

Table 5 : The regression figures

Variables Entered	Variables Removed	R	R^2	Adjusted R^2	Std. Error of the Estimate
MRS	-	.852	.726	.721	5.34
GPS					
GCK					

a All requested variables entered.
b Dependent Variable: PTG.
c Predictors: (Constant), MRS, GPS, GCK.

R^2 indicates the collective variation of all three independent variables on the dependent variable. According to this, 72.6% (almost 73%) of PTG is explained by these three variables: MRS, GPS, and GCK. The adjusted R^2 is an estimated value to use as the population estimator, as small samples tends to overfit. The difference between R^2 and adjusted R^2 is not large. This is also a good indicator of the strength of the prediction. Standard error is an estimate of the standard deviation that represents the variation of the actual value of dependent variables around the regression line. In other words, it is a measure of the absolute size of the prediction error. If the standard error is too large, R will not be significant.

The significance of R is determined by the F value, which is generated in the analysis of variance (ANOVA). The ANOVA, thus, is useful to test the null hypothesis:

H_0: There is no significant linear relationship in the population between the dependent variable and the independent variables.

The ANOVA is shown in Table 6

Table 6 : The ANOVA

	Sum of Squares	df	Mean Square	F	Sig
Regression	12283.391	3	4094.464	143.440	.000
Residual	4624.254	162	28.545		
Total	16907.645	165			

a Predictors: (Constant), MRS, GPS, GCK
b Dependent Variable: PTG

Since R^2 is significant according to the ANOVA ($F_{3, 162}$=143.440, p =. 000), the prediction is also significant. This is a statistical requirement for explaining the variation of the dependent variable in terms of the independent variables.

Coefficients related to the regression analysis

R^2 in Table 5 indicates that all three variables can describe 72.6% of the variation of the score for PTG. Since this value represents a collective effect, it cannot be used to explain the variation in terms of the individual contribution of each independent variable. Regression coefficients for each of the independent variables are required in that regard. The information related to regression coefficients is shown in Table 7.

Table 7 : Coefficients related to the regression analysis

	Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig
(Constant)	-6.399	2.337		-2.738	.007
GCK	.939	.097	.567	9.684	.000
GPS	.314	.065	.269	4.865	.000
MRS	.122	.049	.121	2.492	.014

a Dependent Variable: PTG

The coefficients that can be used to build up the regression model are shown in the unstandardised coefficients (B) column. The figures in the significance column show that all coefficients are significant at a = 0.05 level. If the standard error is large, the SPSS program indicates the respective B as not significant. *Beta (b) coefficients* are the coefficients of the independent variables in the linear regression equation that represent the standard scores. It is important when scores are presented in standard scores are in the same scale with mean = 0 and standard deviation = 1 and scores of different subjects come into a same scale.

Discussion and Conclusion

The study draws the following conclusions:

1. *Geometry Content Knowledge* (GCK), *General Problem-Solving processes* (GPS) and *Mathematical Reasoning Skills* (MRS) are predictive indicators of the success of students' proof-type geometry problem solving skills.
2. *Geometry Content Knowledge* (GCK) is the major determinant of the success of proof-type geometry problem solving.
3. Both *General Problem-Solving processes* (GPS) and *Mathematical Reasoning Skills* (MRS) can promote the contribution of *Geometry Content Knowledge* in the success of proof-type geometry problem solving.

4. Emphasis on mathematical reasoning in the instructional process for proof-type geometry problem solving yields less but significant improvement.

The greater contribution of content knowledge to success in proof-type geometry problem solving among students is an important result of the analysis. The linear multiple regression analysis showed not only that *Geometry Content Knowledge* is the major determinant of the success of proof-type geometry problem solving. The analysis also indicates that about 67% of that success is attributable to *Geometry Content Knowledge*.

The correlation coefficient between content knowledge and proof-type geometry problem solving was found in this study to be 0.82. In a comparison study carried out in Australia, Chinnappan (1992) obtained virtually the same correlation coefficient of 0.83. Both studies point to the fact that success in proof-type geometry problem solving has a significant positive relationship with *Geometry Content Knowledge*. This suggests that improving *Geometry Content Knowledge* will result in the success in students' geometry problem solving performance in general.

This result is consistent with that reported by Senk (1985). In that study, which involved the participation of 2567 students from the United States, Senk obtained a value of 0.67 for Pearson correlation coefficient between proof-type geometry problem solving and *Geometry Content Knowledge*. This further demonstrates the importance of *Geometry Content Knowledge* in successful proof-type geometry problem solving. Senk (1985) also suggested the need to prepare students with *Geometry Content Knowledge* that is based on van Hiele theory.

Figure 1 illustrates a typical successful solution attempt by a student who participated in the present study. The answer shown in Figure 1 provides further support to the claim made by Reiss, Klieme and Heinz (2001) that claims methodological knowledge to be a prerequisite for proof-type geometry problem solving. The student has demonstrated all forms of methodological knowledge: knowledge about proof scheme (Harel and Sowder, 1998), proof structure and correct logical chain. In other words, the answer contains the correct mathematical proof procedure. The answer also demonstrates that the student has knowledge about geometric concepts, relationships and diagrams. Now it is important to see how these features could exist in the answer.

The answer shown in Figure 1 demonstrates that the solving process requires content knowledge and mathematical reasoning skills. For instance, the student has combined two known relationships: AP = CQ (given) and AB = DC (opposite sides of the parallelogram) to deduce a new relationship: BP = DQ. This demonstrates formal deductive reasoning. The deduction was made on the basis of mathematical reasoning in order to decide that subtraction is appropriate. Then the student has established a logical chain: if AB = DC and AP = CQ then AB – AP = DC – CQ leading to BP = DQ. To do this, the student needs to have content knowledge about the properties of parallelograms and axioms. In addition, the student has represented information on the diagram showing knowledge related to the geometric diagram.

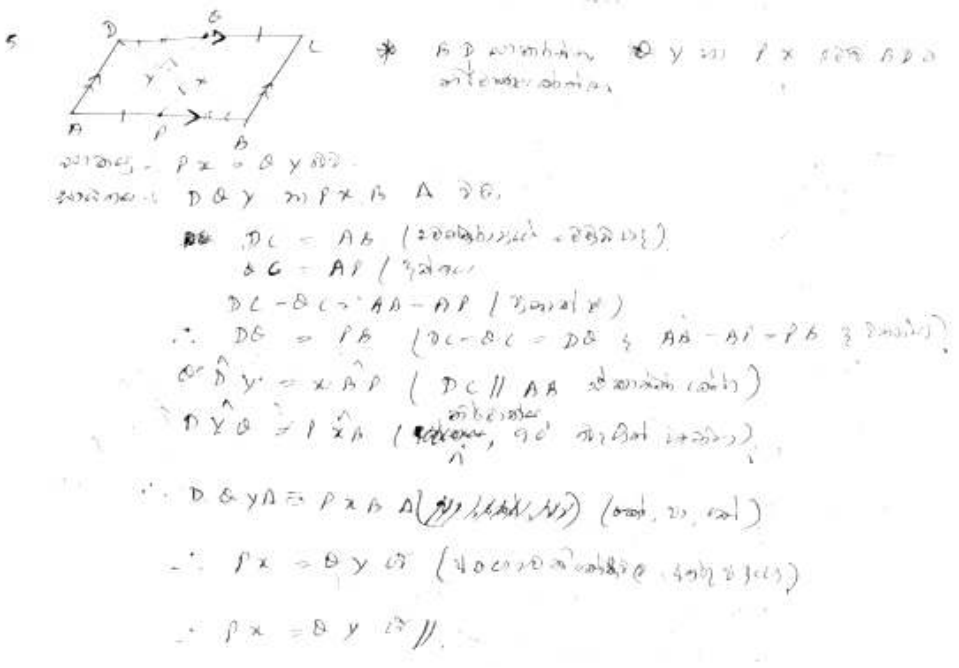
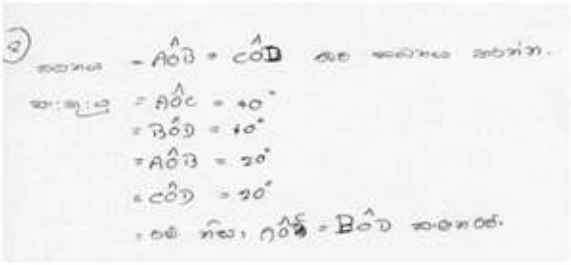


Figure 1 : A successful solution for Question No. 5

Proof-type geometry problems have their own solving standards and conventions. The content knowledge related to geometry problem solving includes methodological knowledge that contains knowledge about geometric concepts, knowledge about geometric relationships and knowledge about geometric diagrams. Knowledge related to this methodology has been acknowledged by Reiss et al. (2001) as a part of content

knowledge associated with proof-type geometry problem solving. Without adequate applications of formal deductive reasoning, the student cannot demonstrate evidence in the construction of a proof. For instance, the answer in Figure 2 demonstrates a lack of methodological knowledge by one of the students.



Lack of methodological knowledge

No diagram
No generalisation
No logical chain of reasoning

Figure 2 : An answer demonstrating lack of methodological knowledge

The answer in Figure 2 shows three difficulties resulting from lack of content knowledge that is required for proof-type geometry problem solving. First, any proof-type problem in geometry could not be solved without a diagram. Second, the student does not know that the proof represents a generalized certainty, and the difference between mathematical proof and verification. Third, the student does not know the conventions of presentation.

General processes are: *analysis*, *representation*, *planning* and *use of knowledge retrieval* in generating new information.

This section provides evidence to demonstrate how successful students have used these processes during the solving process or how students have faced difficulties if they did not possess each of these skills. The section also discusses why each of these skills is important in the problem-solving process through evidence drawn from students' solution attempts. The following examples of student efforts in proof-type problem solving highlight the importance of the above processes of general problem solving.

During proof-type geometry problem-solving process, the student has to convert text-based information into diagrammatic form. For this conversion, the student has to understand the problem. Figure 1 provides evidence that the student has correctly recognised the problem information such as parallelogram, its name (ABCD), locations of P and Q, perpendicular distance (to BD). Without skills in *analysis process*, the

student cannot understand the problem. This emphasises that *analysis process* is essential in making a start and further progress.

Secondly, the student has represented the problem information as a diagram. The *representation* process seems to be content knowledge-dependent. The student has converted geometric information in the problem situation from one form to the other. Skills in diagrammatic representation are not confined to converting text information into diagrammatic form; they are also required to generate goal-directed new information. This particular student has marked newly found equal segments and alternate angles.

In the *planning* process, the student has identified all structural steps that were not related to any particular algorithm. In order to prove the triangles PBX and DQY to be congruent, the student has planned to prove DQ and PB to be equal as a sub-goal. One of the effective ways to identify and achieve this sub goal is to work backward. This process shows the influence of planning in proof-type geometry problem-solving processes.

The solving process related to the answer presented in Figure 1 exemplifies the *use of knowledge retrieval*. Retrieving appropriate knowledge, and accurate use of those retrievals are influenced by metacognitive skills. In the answer shown in Figure 1, the student has proven the ability to access and retrieve required theorems and required geometric concepts, and to use them in generating new information in a goal-directed manner.

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Principal's Leadership Style and some other Factors Affecting Work Motivation of Teachers in a Secondary School - A Case Study

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Abstract

Teachers' motivation and quality of education are linked together. Unless teachers themselves are motivated and committed, it will not be possible to improve the standard of school education. Therefore, the overall significance of work motivation of teachers has to be taken into account and hence the case study method was employed to probe into factors that affect work motivation of teachers in a secondary school of Baroda city. There were three main objectives of the present study where an attempt was made to study; how the principal's leadership style affect the work motivation of teachers; teachers' role perceptions ,and the quality of classroom learning teaching process. In achieving the objectives, three main data collecting instruments were used; Leadership Behavior Description Questionnaires (LBDQ) by Halpin and Croft (1963), Interview schedules, and classroom observation schedule. The data so collected were mainly analyzed using qualitative techniques and some of the emerging variables were partly quantified as means and percentages. The research findings indicate that principal's leadership style, student teacher interactions and several other school and out of school related factors have an impact on teachers' work motivation.

Key Words: Work Motivation, Secondary schools, Leadership Behaviour Description Questionnaires (LBDQ)

Introduction

The National policy on education 1986 has pointed out the need for redefining the role of teachers and their vital importance in Indian society. As the country has placed boundless trust in the educational system, the people have a right to expect concrete results from the secondary schools. In the advent of 86th Amendment to the constitution of India to grant the Right to Education to all children of 6 to 14 years old and the Right to Education (RTI) Act, 2009 a fresh need and demand for systemic reforms has come in. The present problems in education are seen in continuous dropout rate among the students, low levels of learning and shortage of teachers and teacher's absenteeism, lack of facilities, lack of teachers commitment, improper planning, deploying teachers for non-teaching jobs and mixing of politics and education have given scope for politicization of teacher unions, court litigations etc. Thus, one of the main national priorities today is the deteriorating standards and quality of education

The role and importance of teachers in the present society, the work motivation and the factors affecting that particular aspect, their job performance and the incentives the government provides them to stimulate their efficiency and better working conditions within which they are asked to perform. Desai, (1981) studied organizational climate and teacher morale and found that proper leadership style of the principal was a leading factor in setting the tone of school climate and also it inspires teacher motivation in the work place. Researchers have also focused their attention on the relationship between motivation and the organizational culture of schools. The work of Maehr (1990) in this area is very important that centers round the theme "Psychological Environment" of school.

The government and the community should endeavor to create conditions which will help motivate and inspire the teachers on constructive and creative lines. Teachers should have the freedom to innovate to devise appropriate methods of communications and activities relevant to the needs and capability of and the concerns of the community". (NPE, 1986 part IX) What is required is that the school system should trust teachers and assign them roles in preparing work plans. They should be enabled to join the apex bodies like State Council of Educational Research and Training. Moreover, examination system should be reformed in such away that it is a part of teaching learning process. Decentralization should be the principle of School

administration. Ifinedo (2003) demonstrated that a motivated worker is easy to identify by his or her ability, dedication, enthusiasm, focus, Zeal and general performance and contribution to organizational objectives and goals.

Whatever be the national objectives of our educational enterprise, whatever be the recommendations of various National Commissions or committees of education, one thing is very clear that what finally matters is what goes on in individual classrooms, the quality and type of interactions and relationships that happen there, the learning the questioning and answering that take place there and the atmosphere and the climate of the classrooms and most importantly how the teachers motivate and handle children, and how they shape the destinies of the nation and the future tomorrows.

The rational model of human motivation

It is an established principle that all human behaviors are guided by human motives and needs (Maslow, 1954). In the sphere of school organizational functioning, it is necessary to understand how teachers perceive their goals and try to bring efficiency to the performance of teachers. Modern studies in behavioral psychology point out that man is conceived as a rational being and is aware of his goals and duties and steers his behavior in those ways which he feels would help him achieve his goals (Pintrich and Maehr, 2003). This rational model can be influenced by the use of goals, one's active participation in all that goes in schools. Most studies in the field of industrial and organizational psychology have employed the rational model of motivation. For example, Lawler, (1973) points out that the teachers' reactions are both predictable and important in understanding behaviours in the context of work and organization based on the following assumptions

- People have many conscious, often complex and competing goals.
- Most behaviors are consciously goal oriented.
- People have reactions to the outcomes they obtain as a result of their behavior. (Lawler 1973 p12.).

Not surprisingly, many different factors play a role in determining job satisfaction of teachers in the secondary schools. The most important of these, however seems to involve general working conditions, aspects of the work itself and other benefits with respect to general working conditions. It is assumed that satisfaction tends to increase

as such conditions improve. For e.g. teachers who perform their job in pleasant and comfortable settings (Climate) tends to express greater satisfaction than those who do not enjoy such conditions.

Work motivation of teachers

The encyclopaedia of management has defined motivation as "the degree of readiness of an organism to pursue some designated goal and implies the determination of nature and locus of the forces including the degree of readiness. Motivation refers to the way in which urges, drives, desires, aspiration, strivings or need, direct control or explain the behavior of the human beings. Therefore, in this study "the work motivation" is defined as the complex forces, drives, needs, tension states or other mechanisms that start and maintain work related behavior towards the achievement of designated goals. The aspect of work itself and several other factors seem to be important and significant in the context of work motivation of teachers. It is found that most teachers prefer jobs which give them a degree of autonomy, a sense of freedom to perform activities in the order they wish, freedom to be creative and innovative, and freedom to use new methodologies and strategies for better teaching learning outcomes. It is also found that job satisfaction of teachers is often higher when autonomy is present than when it is entirely missing. It is seen that many teachers prefer jobs which have variety, to jobs which otherwise is totally routine. Satisfaction is usually higher when jobs involve a degree of personal improvement and the degree of responsibility with which a teacher performs his job. Teachers express greater satisfaction when can make at least same decisions for them than when the teachers must respond strictly to the orders of the principals.

School climate

School can be said to have its our own vibrations and soul and different schools express tones of feeling that are both important and distinguishable from each other. These come from the interpersonal relationships in the school and they compose the school climate. The term "school climate" is meant to capture the overriding social emotional and academic tone of the school. (Freiberg 1998).

Bloom, (1956) classified the educational objectives as imparting cognitive, affective and psychomotor skills in students and for this the teachers are to be well qualified with human technical, conceptual and methodological competence. Also motivation on the part of teachers inspires the student's to acquire these skills in a meaningful way for preparation of their future life. Clearly, school climate is multi-dimensional and influences many individuals, including students, parents, school personnel, and the community. School climate can significantly impact educational environments, as Freiberg (1998) notes,

"School climate can be a positive influence on the health of the learning environment or a significant barrier to learning" (p. 22).

Regarding the roles of teachers and administrators, Taylor and Tashakkori (1995) found that a positive school climate is associated with increased job satisfaction for school personnel.

Classroom climate is important in teacher motivation. If a teacher experiences the classroom as a safe, healthy, happy place with supportive resources and facilities for teaching for optimal learning, he/she tends to participate effectively and efficiently in the process of management, administration, and the overall improvement of the school. The teacher commands and emits the image of one who improves knowledge and the physical conditions of the classroom through orderliness, discipline and control. The teacher also, makes diagnosis of student's feelings and attitudes inferred by their behavior and response in the classroom environment. Hence, Lash and Kirkpatrick (1990) concluded that in the absence of school programmes the major responsibility of working with children in the school rests with the teacher. Likewise, Maehr and Midgley (1991) affirm that what takes place in the classroom, even though the classroom itself is not an island, is critical.

Motivation theory according to Maslow and Herzberg

According to Maslow (1943), People attempt to satisfy their physiological need first. As long as they are unsatisfied, they dominate behavior. As they become

reasonably satisfied, they however lose their motivational "Power" and the next level of needs occupy their place. The process continues up to the need nearly so, as Maslow (1943) points out that motivating someone need to understand that person currently is on what hierarchy and focus on satisfying these needs at or above the level. Maslow's needs approach was considerably modified by Herzberg (1954) and his associates. Their research purports to find a Two Factor Theory of Motivation. In one group of needs are such things as school policy and administration, supervision, working conditions, interpersonal relations, salary, status, job security and personal life. These factors were found by Herzberg and his associates to be only dissatisfiers and de-motivators. Their existence does not motivate in the sense of yielding satisfaction, and lack of these factors would, however result in dissatisfaction. Herzberg called them Maintenance, Hygiene, or Job Context factors. In the second group, Herzberg listed certain satisfiers and therefore, motivators all related to job content including achievement recognition, challenging work, advancement, autonomy, and growth in the job and the existence of those factors will yield feelings of satisfaction. The first group of factors (The de-motivators) will not motivate people in an organization, yet they must be present or the dissatisfaction will arise.

The second group or the job content factors are the real motivators, because they have the potential of yielding a sense of job enrichment and work motivation, Herzberg theory points out that principals must give considerable attention to upgrading job content for the work motivation of teachers. Herzberg made significant contribution toward improving the principal's basic understanding of human behavior. He draws the attention of principals to the importance of job content factors and work motivation which had been neglected previously. One of the important contributions of Herzberg's work is tremendous impact it had in stimulating "thought research" on the topic of motivation at work. Job enrichment is the direct outgrowth of Herzberg two factor theory of motivation and this is based on assumption that in order to motivate teachers, the job itself must provide opportunities for achievement recognition, responsibility, advancement and growth. These findings have given attention to the organizational roles of teacher which provide the possibility of interaction of the job with the teacher's or organizational or personal goals.

A brief review of Literature

The literature cited here focused on outcomes mainly because the researcher wanted to understand what areas in the field have been explored in the area and what is yet to be explored.

Many studies done on work motivation of teachers have revealed that various factors are related to job satisfaction. For example, Principals' leadership quality measured as a combination of consideration and trust from the organizational climate, Halpin (1964). In this study, teachers' satisfaction was found to be positively related to

- Elements of climate - reciprocal trust among senior school teachers with the principal is associated with satisfaction measured by fulfillment of Maslow's need categories.
- Teacher participation in decision making is also related to work motivation of teachers. High levels of participation and delegation of certain decisions by the principal are also factors for work motivation of teachers. (Halping, 1964)

In a more extensive report on teachers work motivation, Resenholtz (1989) describes the effect of several social variables on teacher commitment, such as task autonomy, psychic rewards, teachers learning opportunities, and teacher certainty. She demonstrates that task autonomy is the most powerful explanatory variable of teacher commitment. Accordingly, teacher commitment is enhanced when principals trust the teachers with discretionary decisions and give up their need for control. Moreover, the variable, psychic rewards also contribute to explaining why some teachers are more committed than the others. It appears that the more positive feedback is given to teachers, the more committed they become. Finally, the variable learning opportunities explains some of the variance on teacher's work motivation the more opportunities to learn are provided to teachers, more motivated they become. In addition, following studies reveal major variables related to the work motivation of teachers.

Desai (1981) studied organizational climate and teacher morale and found that proper leadership style of the principal was a leading factor in setting the tone of school climate and also it inspires teacher motivation in their work place. Bumia (1986) studied work values and life in teachers at in service stage and found that there is positive significant relationship with work values of creativity, management;

achievement, prestige, economic reforms and a deep sense of purpose in life. All these factors influence the work motivation of teachers.

De-sales (1989) studied the effectiveness of school climate on teacher performance and student learning. She found that the nature and quality of interactions that took place between teachers and students contributed considerably for building up school climate and better learning outcomes.

Patel (1983) studied the attitude of secondary teachers towards the teaching profession and found that the attitude towards the teaching profession depends upon the leadership style of the principal.

Education in India today

The growth of the Indian economy in the recent past and the compulsion to sustain it is also forcing the Indian government to accelerate the process of developing all the branches of the Indian education system. The schooling system is not homogenous in India. There are mainly two different types of schools (Government and Private schools) and these two types of schools cater to a widely different clientele and they possess different management systems. For example, government schools are managed by the central or state governments or by local bodies. The Government of India, state governments, local self-government institutions (panchayats) in rural areas and municipal bodies in urban areas manage government schools. Overall, the relative share of various types of management in schools is 46% (central and state), 38% local bodies and 16 % private (aided and unaided). These shares vary from one state to the other. On the other hand, private individuals or institutions manage private schools. These can be aided or unaided. Private individuals or trusts establish private aided schools. Private unaided schools are owned and funded privately with no state support. For purposes of recognition, they have to ensure adequate pupil-teacher ratio, conform to certain qualifications regarding recruitment of principal and teachers and assure their financial viability. However, all management decisions are taken by the school, including recruitment procedures and teacher salaries. They frame their own admission rules and fee structure for students

Different norms and rules govern teachers in the various kinds of government schools. Regular teachers are full-time, permanent employees of the government. These teachers are governed by strict entry and qualification norms (1 to 12 years of General education and minimum two years of diploma or degree in education). The

government teachers are covered by a range of welfare benefits and get a pension after retirement. They can be promoted from a teacher to a head teacher and even a supervisor/administrator/teacher trainer. Para teachers or contract teachers are appointed on a contract basis by the local body (panchayat or municipal body). Eligibility requirements differ from one state to the other and they are not entitled to receive any welfare or pension benefits or eligible for promotion.

Education system n Baroda

Baroda is a cosmopolitan city in the State of Gujarat. The educational system in Baroda is diverse. The schools have three stages; The Primary, the Secondary and the Senior Secondary or Higher Secondary. The secondary and higher secondary schools have different types of management systems. Some schools are governed by Gujarat Government Regulations and few are governed by Central Board of Secondary Education (CBSE). Schools under Gujarat State Educational Boards (GSEB) also are completely governed by the Government and they are named Government Schools. Other schools are privately managed and sometimes these schools are aided and sometimes or not aided by the government. There are English medium and Gujarati medium schools in all three types. Baroda education plays a vital role in uplifting the social and economic condition of the city. It is being highly improved by the ministry of education of the state of Gujarat. Serious measures are being taken to enhance the quality of the educational system. School curriculum also is being gradually improvised and steps are being taken to focus more on the overall development of the student. More and more number of colleges and schools are being established in order to provide education to the maximum number of individuals. Schools and colleges are also being established in the rural regions of Baroda, in order to uplift the social condition of the rural section of the Baroda. There are some of the eminent institutions of Baroda which have raised quality of education.

Rationale for the present study

It is a fact that secondary education in India continues to be the weakest link in the overall educational system. It is a serious concern that the students who are graduated from the school system are in competent and have no clear goals in their lives as to what to study further and what to do next. There are aimlessness and a clear evidence of drift in them. As the students enter the college, what is observed is

a state of hopelessness and frustration and inability to cope up with the challenges of life. They are less enthusiastic and unproductive. This may be one of the reasons of India's backwardness in the unproductive human resources who cannot contribute to national growth and development. In this context, it is important to find out what went wrong while these students were in secondary schools; were they treated well, or motivated well enough to have clear cut goals in life? What was the role of teachers in shaping the life and destinies of these future citizens? The way teachers mould them and develop them play an important part in making them fit for life's needs and challenges. In this context, part of the solution may be to understand whether the teachers are motivated enough in their work place to teach students and use remedial measures to rectify the situation.

It is also observed that there is deterioration in the quality and standard of education in secondary schools while some schools, mostly private schools perform well, majority of the schools have lack satisfactory performance. It is utmost important to find out the causes behind this kind of performance variability and this would enable the educators to take remedial measures.

It is an established factor that only committed and motivated teachers can bring out qualitative performance from students. Therefore, the present study wants to find out factors those effect the work motivation which are positively related to teachers job performance and students learning outcomes and creating a congenial school climate where interactions and relationship help in creating atmosphere for growth for teachers as well as for the students.

The present study

The present study is an attempt by the investigator to study some of the factors that facilitates the teacher's work motivation. These factors help in improving their role perception and job efficiency which in turn promote better classroom management and the teachers adopt better teaching strategies for better learning outcomes. All this can happen, it is assumed, in an atmosphere of congenial relationships between the principal and teachers between the teachers and their colleagues and between the teachers and students.

Objectives of the study

The following are the objectives of the study:-

1. To study the leadership style and role of the principal in promoting work motivation of teacher's in a secondary school in Baroda city
2. To study how teachers perceive their roles.
3. To study the instructional processes going on in individual classrooms and result of teacher's motivation for better performance.

Methodology

Rationale for selecting the school

The present investigation is a case study of a secondary school in Baroda, and it attempts to study the factors that affect the work motivation of teachers. The case study probes deeply and analyses interactions between the factors that explain the present status or that influence change and growth. The school selected by the investigator for the study is a Secondary School, Baroda. The rationale for using this particular school in the study is due to the fact that it has been able to establish good record in this vicinity, especially during the past few years, under the present management. This school was established in the year 1976, today after a span of thirty five years, the School has been able to demonstrate an excellent performance. The school possesses a record with a good strength of students and teachers, with all necessary infrastructural facilities for providing effective teaching learning experience to enable the students to excel in academic domain and various other extracurricular activities. This has enabled them to secure positions in sports and games at State and National levels and making the School as one of the best educational institution in Baroda.

Sample of the study

The sample for the study was selected in order to represent entire school personnel, viz, the principal, the teachers and the students. A summary of the process of selection of subjects for the study is as follows

a. The, sample includes the school principal.

b. The sample of teachers is selected on the basis of stratified random sampling technique. As the school has primary secondary and higher secondary sections, the stratified random sampling procedure was adopted where one-third (1/3) of the teacher population were selected from each of these three sections. The sample comprised 20 teachers in all 05 from primary, 07 from secondary section and 08 from higher secondary.

c. The sample of the students constituted the 10% students from each class from Std. VIII to XII selected on the basis of the random sampling technique. Each class has 03 divisions and the total number of students selected was 75.

Instruments used for the study

Three main research instruments were used in the present study.

Instrument No.1

Leadership Behavior Description Questionnaires (LBDQ) by Halpin and Croft (1963).Although the questionnaire was constructed and standardized by Halphin and Croft in 1963, which can still be used in determining the leadership styles of the principal in a particular school. This questionnaire consists of 31 Likert type items which have been organized in to four dimensions related to principal's behaviour such as; Aloofness, Production emphasis, Thrust and consideration. Each of these dimensions is defined as follows.

(1) **Aloofness-**Refers to behaviour by the principal which is characterized as formal and impersonal. His behaviour is universalistic rather than particularistic.

(2) **Production Emphasis**-Refers to the behaviour by the principal which is characterized by close supervision of the staff. His communication tends to go in only one direction and he is not sensitive to feed back from the staff

(3) **Thrust-** Refers to behaviour by the principal which is characterized by his evident effort in trying to "move the organization". Thrust behaviour is marked not be close. Supervision by the principals' attempt to motivate the teachers through the example which he personally sets.

(4) **Consideration-** Refers to the behaviour by the principal which is characterized by an inclination to treat the teachers 'humanly' to try to do little something extra for them in human terms.

In these four dimensions, two of them (Aloofness and Production emphasis) are negative. For example, a principal with the quality of more "Aloofness" keeps away from teachers and a principal having the quality of "production emphasis" emphasizes just work, forgetting mutual trust and human qualities. On the other hand, a principal having more of the other two dimensions act in such away assuring human relationships, good communication, mutual trust and warm relationship with teachers. The interaction between negative and positive dimensions creates variation in an array of leadership styles of the population of principals.

Scoring:-

This questionnaire consists of 31 items and the respondent has to indicate his/her response to each item in a scale where each number indicates different degree of the quality which the principal possesses according to their estimate as:

(1) Rarely Occurs

(2) Sometimes Occurs

(3) Often Occurs

(4) Very Frequently Occurs.

Therefore the maximum score on LBDQ is 124 (31 x 4) as she recorded their responses.

Instrument No. 2

The investigator prepared open ended questionnaires for the interview schedule to find out how motivation affects teacher student relationships.

Instrument No. 3

The investigator observed a number of classrooms using classroom observation schedule prepared by the investigator to study the instructional processes that go on

in the individual classrooms as a result of work motivation of teachers. Thus, the investigator used this technique to observe the following points

a. Teachers leadership in the class as a facilitator or controller.

b. Classroom interaction of students and teachers and interaction of students with themselves.

c. Use of cooperative methods

Data collection procedure

For the administration of the research instruments and data collection, the investigator visited the above mentioned school a number of times and the following table shows how the required data were gathered.

Table No 1 : The research objectives, source of data and research instruments

Research Objectives	Source of Data	Research instruments used to collect required data
1	Principal	Separate open ended questionnaire for the interview schedule
	Teachers	LBDQ to study leadership hehaviour of Principal
2	Teachers	Separate open ended questionnaire for the interview schedule
3	Teacher/student interactions classroom processes	Classroom observation technique to study the instructional processes that went on in individual classrooms

Data analysis

In the present study, the data collected has been analyzed both quantitatively and qualitatively objective wise.

The technique employed is described below.

Objective No.1

This objective deals with the leadership style of the principal that affect work motivation of teacher in secondary schools. The data collected from the open ended questionnaire for interview schedule was analyzed qualitatively. The data collected through LBDQ was analyzed quantitatively. The procedure for the identification of the principal behaviour was carried out as follows.

- The first step was to find out the raw scores of four dimensions of the principal's behaviour for the subjects in the sample of teachers. It was added up to get the total score of entire sample for each 04 dimensions.
- Then, mean value each dimension was obtained by dividing the total raw score by the number teachers in the sample. The value so obtained, depends on the number of items on each dimension. Mean value for each dimension was again divided by the number of items in each dimension of LBDQ. Then, the mean value so obtained were independent of the number items of each dimension, and therefore, it was used for comparing principal' leadership style. Thus, from the dimension which got the highest score a particular style of principal behavior emerged.

Objective No.2

This objective deals with the perceptions of teachers regarding their role as teachers. In analyzing he data gathered through open ended questionnaire was carried out as follows.

- First, the data were received to each questions were read carefully paying attention to identify recurring themes
- The pattern of responses was identified under each question and was counted under different themes.
- Percentages of these different themes were calculated

Objective No. 03

This objective deals with the instructional processes that went on in individual classroom as a result of work motivation of teachers. The data collected through classroom observation technique mainly dealt with teachers leadership in the class

(as a facilitator or controller) classroom interaction of students and teacher interactions of students with themselves. The investigator analyzed the data percentage wise.

Leadership style of the Principal and Teachers' work motivation.

The First objective is to study the leadership style and role of the principal in promoting work motivation. In order to achieve this objective, research instrument (LBDQ) developed by Halphin Croft (1963) and data received through teachers interviews were employed.First the data analysis with regard to LBDQ will be presented and then the qualitative analysis .

The LBDQ instrument has four sub scales namely, Aloofness, Production Emphasis, Thrust and Consideration each measuring different dimensions of the principal's leadership style. Teachers were asked to answer in the scale where 1 – indicating lowest value and the 4- indicating the highest value in each of the items of four sub scales of the instrument. In each of the sub scale total score and the mean values were calculated using data analysis soft ware. The following Table no. 2 shows the results.

Table NO.2:- The Principal's behaviour scores on each dimension.

SCORE	ALOOFNESS	PRODUCTION EMPHASIS	THRUST	CONSIDERATION
Total Score	225	203	695	415
Mean Score	1.25	10.15	34.75	20.75
Final Score	1.04	1.45	147	3.45

The table shows that the mean values obtained for teachers' perception on dimensions related to "Consideration" and "Thrust" are fairly higher than that of other two qualities of the principal. In analyzing the qualitative data, received from the principal, and teachers through the interview the following major findings were made.

Qualitative data analysis from the interview with the principal suggests that his perspective about work motivation of teachers is one of the difficult tasks. However, the principal is determined to achieve his targets. It also implies that he is more a leader possessing the qualities of "Thrust" and "Consideration" –two positive dimensions of LBDQ, This fact is evident from the following utterances made by the principal at the interview.

"It is very difficult to enforce work motivation of my teachers. I myself have to set an example for my teachers. Most of the time, I try to share ideas with my teachers. I try to give them opportunities for innovations. I find that the trade unionism among teachers is the worst thing happened to this noble profession"

These responses implies that the principal possess the characteristics of democratic leadership style based on "Thrust" and "Consideration" which in turn increase the work motivation of teachers. Especially the utterances such a;*" I myself have to set an example for my teachers"; "I try to share ideas with my teachers"* and "*I try to give them opportunities to innovations"* echoes his perspective on teachers.

This finding is further strengthened by the findings made in the above quantitative analysis of the LBDQ. The mean values obtained for the dimensions "consideration" (20.75) and "Thrust" (34. 75) are fairly higher than that of other two dimensions. Teachers' interviews were also conducted to achieve this objective. During the interview, teachers were questioned on their perceptions about the leadership style of the principal .Ninety percent {90%} of the teachers of the sample are on the perception that the leadership style of the principal is delegating powers to the teachers affect their motivation in schools. Only a very low percentage of teachers in the sample (10%) teachers' comment were on other variables which affect their motivation. These variables include better salaries, better staff relations and strict discipline. 90% of teachers feel that they need to be given autonomy and it has been given by the Principal.

It was also revealed that human relations approach by the principal is a major factor in increasing the teacher's work motivation and job efficiency, in service training through seminars and workshops on modern methodologies and approaches equip the teachers to deal with classroom situation and to improve better learning outcomes.

Pearson (1987) studied the leadership qualities of principals in different schools in Uthrapradesh in india by making use of the LBDQ. The findings made here is similar to the findings made in this work. Therefore, on this ground it is safer to conclude that the increased motivation of the teachers in this particular school could be at least partly due to the principals, democratic leadership style based more on "Thrust" and "Consideration".

Desai (1981) studied organizational climate and teacher morale and found that proper leadership style of the principal was a leading factor in setting the tone of school climate and also it inspires teacher motivation in their work place. Therefore, the success of this school could partly be due to the principal's leadership quality based on "Thrust" and "consideration"

On this ground, it is safer to conclude that principal's leadership style is based on "Consideration" and "Thrust" are determining factors of the work motivation of teachers in this school.

Teachers Perception of the "role of teacher"

The second objective of the study is to study how teachers perceive their roles. Teachers' interview data were used in addressing this objective. In the analysis of data related to the second objective mainly qualitative techniques were used. First, the qualitative data were coded and categories were built. Next step was to quantify the variables emerged. The variables so emerged were calculated into frequencies and percentage that comes under each category. Following are the major findings related to the second objective of the present study

90% of the teachers' perception on the leadership style of the principal is delegating powers to the teachers affect teachers' motivation in the school. 10% teachers feel that better salaries, better staff relations and strict discipline by the principal affect the motivation of the teachers. 92% of the teachers feel social recognition is an important factor for work motivation. 90% of teachers feel that they need to be given autonomy. 87% of the teachers feel that teachers affect classrooms qualitatively**.** Only 10% of the teachers feel that academic qualification is the only factors that affect work motivation. 60% of teachers feel that principal's behaviour

and his respect for teachers and recognition of the various talents through rewards and incentives play on important part in ensuring work motivation. The investigation revealed that only 70% of the teacher's find dis-satisfaction in the teaching profession. The prominent reasons the teachers pointed out to this effect are listed below.

(a) Poor recognition of teacher's role in the society as compared to other profession like Engineers, Doctors, Architect etc.

(b) Lack of respect to the teachers by the students.

(c) Commercialization of educational institutions.

(d) Lack of proper working conditions.

(e) Arbitrary administrative style of principal.

(f) Lack of in service training.

(g) Lack of job enrichment programmes.

(h) Lack of knowledge in new approaches and strategies which can create better learning outcomes.

(i) Overcrowded classrooms.

(j) Teaching is a tedious job and unless one gets enough response from the students it leads to dissatisfaction.

The quality of teachers' instructional process in the classroom

The third objective of the study was to study the instructional processes that go on in individual classrooms and result of teacher's motivation for better performance. To achieve this objective data received from the classroom observations were used. To gather data classroom observation schedule was employed. Investigation based on classroom observation technique focused on 03 aspects.

1. The leadership of the teachers in classroom as a facilitator or controller.
2. Interaction of the students low and high.
3. The teaching strategies of the teachers to bring about better learning outcomes.

90% of the classrooms were observed to be using the facilitative role against controlling role where the teachers encouraged the students to take part actively in the learning teaching process rather than the teachers giving all .They encouraged students contribute to the subject matter from their own experience and their previous learning

92% of classroom situation, interaction was scored as highest. It was also observed that student was taking part in the discussions regarding the subject matter and interacted with the teachers and among students purposefully and meaningfully. This kind of interaction created a conducive classroom climate for internalizing the subject matter and come out with desirable outcomes.

93% of teachers used facilitative strategies based on cooperative learning

The present study revealed that human relations approach by the principal is a major factor in increasing the teachers work motivation and job efficiency, in service training through seminars and workshops on modern methodologies and approaches equip the teachers to deal with classroom situation and to improve better learning outcomes. The principal's leadership style based on the dimension of "thrust" and "consideration" creates a conducive climate for the teachers to function with motivation and commitment, commitment and work motivation of teachers are visibly seen through the pains they take to make the classroom interaction meaningful and purposeful one. It was also observed that recognition of teachers and their contribution to bring about quality in students are to be complimented through incentive and rewards and these factors are also satisfying aspects for the teachers.

Findings of the study

The following list summarizes the major findings of the present study

a. The study revealed that human relations approach by the principal is a major factor in increasing the teachers work motivation and job efficiency.

b. The study showed that to a certain extent the teachers' motivation and performances depends on the attitude and respond of the students.

c. The study found that better working conditions, incentives and facilities in the school contribute to teachers work efficiency.

d. The study pointed out that in service training through seminars and work shops in modern methodologies and approaches equip the teachers to deal with classroom situation and to improve better teaching learning outcomes.

e. The study showed that the teachers' role and profession are not recognized by the society at par with other profession and then is a need to perceive transaction roles as the most significant one.

f. The study revealed that certain authority and responsibility are included in the teachers profession is found to be more creative and innovative and better motivated.

g. The study brought for the aspect of interpersonal relationship in increasing or reducing work motivation of teachers.

h. The study showed that the principal style based on the dimension of "thrust" and "consideration" creates a conducive climate for the teachers to function with motivation and commitment.

i. The study focused that the participatory decision "making and democratic styles of the leadership bring staff cohesion and improve staff morale.

j. The study also found that the students learn from teachers whom they like and this is expressed in the caring concern, personal interest of the teachers in the affairs of the students.

l. The study revealed that the commitment and work motivation of teachers are visibly seen through the pains they take to make the classroom interaction meaningful and purposeful one.

m. The study showed that recognition of teachers worth and their contribution to bring about quality in students are to be complimented through incentive and rewards and these factors are also satisfying aspects for the teachers.

n. Finally, the study revealed that empowerment of teacher through personal and academic skills and with administrative responsibility increase the teachers work motivation and involvement in all the aspects and functions of the school.

Discussion and suggestion

The purpose of the study was to find out the factors that promote work motivation in this particular school. One of the disturbing trends in any organization is as how to motivate the people for better work efficiency. The investigation showed that in this particular school the leadership behavior is based more on "Thrust" and "Consideration" rather than "Aloofness" and "production Emphasis". Investigation revealed that teachers act as facilitators more learning takes place because facilitative

strategy as opposed to the custodial one. The teachers need to develop the students in all activities that they are involved in, interactions and better relationship between teachers and students paved the way for better internalized learning. It is an established fact that students learn from teachers whom they like most, so the personality skills of principal in communicating right attitudes and values in recognizing the worth of each individual child are better requisites for better teaching learning outcomes. Quality education can be a reality through the cooperation and involvement of teachers in all the aspects of school life on a continuous basis. A person oriented approach and inspiring leadership along with better recognition of teacher's role and contribution can create factors that affect work motivation of teacher. The present study suggest that following areas taken up for future study

1. A study could be taken to establish a relationship between student's response to teachers and teacher's role efficiency.
2. A qualitative study can be undertaken on the perception of teachers of their roles and the work motivation.
3. Another area study can be undertaken to see how far working condition affect teacher's job efficiency and job performance in secondary schools.

To conclude, the findings of the present, study are pointing to the realities of the educational scenario of India today. Instead of lamenting on the deteriorating standards of education in secondary schools today it's high time to focus attention by empowering teachers with facilities rewards and recognition job enrichment programmes and better human relations skills.

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New Guidelines for Secondary School Curriculum in Sri Lanka

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ABSTRACT

The main purpose of this study is to develop new guidelines for the secondary school curriculum in Sri Lanka. The decision on developing the new guidelines for secondary school curriculum was to fulfil the real needs of the students and the nation. To achieve this purpose, 20 curriculum experts were interviewed to help develop a questionnaire for Delphi techniques which were employed in this study to achieve consensus among the experts regarding the proposed guidelines. The research findings indicate that the recommended new guidelines to the planned curriculum had been accepted by the majority in the sample; in both rounds of the Delphi technique more than ninety percent of the statements have achieved the experts' consensus on new guidelines for planning the secondary school curriculum. The goals of the present and the future secondary school curriculum were consistent with needs and capabilities of students; the content in the current curriculum was moderate and there is a need to improve the new structure in order to meet the students' needs and national goals; future development in the common curriculum should also provide knowledge in solving students' current social problems.

Findings of this study also recommend that the new guidelines under this study for all secondary school students in Sri Lanka are in the right path to develop their knowledge, skills attitude and capabilities to face future challenges. The guidelines suggested for the new curriculum will give students a sound system of values, and skills needed for employment and occupational activities, and the ability to solve problems of daily life. The various skills scheduled for incorporation in the new guidelines will enrich their development as full-fledged citizen who can be the leaders of the new generation.

Key words : Secondary Curriculum, Ddelphi technique, Curriculum guidelines

Introduction

In Sri Lanka, curriculum is a written document which includes strategies to achieve the desired educational goals of the country. Accordingly, curriculum consists of on going experiences of children under the guidance of the schools. It represents a special environment for children in achieving self–realisation through active participation within the school. But curriculum is also a field of study made up of research, theory and principle.

It is a well-known fact that a curriculum is not implemented according to intent in many countries and this is true even in Sri Lanka. We live in a constantly changing world. In fact, change is one of the most striking characteristics of the universe we live in today. Therefore, the challenge that we have to face is to learn to survive in a changing environment. Thus, in the educational field, modifications are needed to keep up with political, socio-economic, cultural and technological developments. Changes or substitutions are constantly taking place in classrooms, teachers' rooms, at district, provincial, and national levels. Education is the stepping stone preparing students to face the impending global development. Curriculum is that which we design to meet these challenges; one that is adjustable, depending on the changing conditions in the world. Thus, curriculum is not static; instead it should be a dynamic field in which changes could occur and could be developed and implemented without taxing the educational system

Curricular changes elicit other changes; Fullan and Pomfret (1977) identified changes in material, structure, role behaviour, knowledge, understanding and value, as some of the obvious changes involved in education and its implementation. These changes bring about a host of problems and challenges that have to be handled effectively. Failure to do so would render a curriculum change ineffective and cause much wastage. A developing country like Sri Lanka can ill-afford this wastage.

In Sri Lanka, for instance, the structure in the field of occupation undergoes many rapid changes. The essential occupational skills vary with each individual. The country needs an educational system which can create a special workforce trained for the current and future needs with abilities to analyse and reason out and apply knowledge in line with practical problems, such as problem solving technique, knowledge of contemporary social and economic development, leadership, potential ability to work with others as a team, work ethics, knowledge in promoting productivity, creating good discipline and communication skills. Employers should consider that these attributes make graduates easily trainable and facilitate their entry into an efficient and productive workforce (The General Education Reform, 1997)

Secondary education in particular plays a critical role in preparing a large number of young entrants for the labour market. These requirements need to be reflected adequately in the Secondary School curriculum when making evaluation. In Sri Lanka, for a change in curriculum the National Institute of Education is responsible for developing curriculum. This was legislated by the act of parliament of the Democratic Socialist Republic of Sri Lanka National Institute of Education Act 28 of 1985 section 3.

Sri Lanka has a population of nearly 20.4 million, which is increasing at the rate of 1.2% per annum. The country has had an "education for all" policy for more than five decades. As a consequence it has secured a national gain in literacy growth estimated at about 90.3% percent. Since this proves that education is considered as an important basic development factor of our country, the contribution rendered by any institution solely engaged in developing material and manpower to achieve the goal of producing well equipped persons to fulfil the occupational needs of the country cannot be achieved other than the National Institute of Education (NIE).

Statement of the Problem

Miles (1994) believes that educators frequently forget that curriculum change involves not only the change in the institution but also the change in people as well. A change in people demands not only a change in skills and knowledge but also in beliefs, values and attitudes.

"The secondary school curriculum will be revised to improve the quality and effectiveness in teaching in all schools and to incorporate the new component on knowledge, attitudes, skills, capabilities, and values which are necessary for holistic development" (The General Education Reform -1997-section 2). National Education Commission Report (2004), states that the secondary schools curriculum should be strengthened with all knowledge, attitudes, skills and abilities.

The above statements show that the curriculum development at the national level was unable to meet all the needs of the country, especially the local needs of the students who hold different cultural beliefs. It shows that curriculum guidelines are not strong in providing knowledge, attitudes, skills and capabilities in secondary school curriculum. Until now there are no proper guidelines in developing curriculum based on the students needs. So the secondary school curriculum should be revised and the quality improved with new guidelines. Therefore; changes are needed to develop the curriculum in secondary schools based on the new guidelines. Hence, developing the guidelines to meet needs of the secondary school curriculum is the main concern of this study.

Rationale of the Study

Students of secondary schools should be provided with all abilities and skills which are helpful to solve current problems. Therefore, guidelines will provide a much clearer structure on what should be the content, goals and structure in designing a curriculum to fulfil this aim. Guidelines will also provide the framework on how the secondary school curriculum should be designed with all skills, knowledge, attitudes, and capabilities. Furthermore, there is significant importance in developing multi skills for future employment in the country.

The Sri Lankan secondary schools curriculum at present needs proper guidelines followed by the National Institute of Education in developing curriculum materials of

secondary schools. Therefore the researcher found that developing guidelines for the secondary school curriculum is of utmost importance and it has become the major concern for this study. Since the present curriculum gives only subject matter knowledge, it largely neglects to provide all necessary skills that the student needs to live in the globalized and rapidly changing world. Hence, the findings as concluded by the researcher for developing guidelines for the secondary school curriculum hold out much promise for curriculum development activities of the National Institute of Education.

Research Questions

To meet all the requirements of this study, the following questions have to be looked into properly and clearly. Helpful insights would be gained thereby.

1. How can the discrepancies between present and future secondary school curriculum be minimized?
2. What guidelines should be developed for the new curriculum in secondary schools?

Methodology

There are two methods used in this study

1. Interview (Qualitative method)

The first step in the interview is for 20 curriculum experts. They were required to answer Research Question 1. The interview was held every fortnight. The main objective of the interview was to identify their opinion on minimal discrepancies between the present and future needs of the secondary school curriculum.

2. Delphi technique:(Quantitative method)

1. The second step was a series of questionnaires, which were distributed by hand to the same selected 20 curriculum experts.
2. The main purpose of applying the Delphi technique was to achieve the most reliable answer from a chosen group of curriculum developers who met the required criteria regarding the guidelines for developing the secondary school curriculum. These questionnaires had two parts and were distributed in two rounds.

Delphi Technique

The Delphi technique which others also called the Delphi study or the Delphi method, has been widely used in curriculum research. For instance, Reeves and Jauch (1978), has conducted research on developing curriculum for higher education. In this study, using the Delphi technique they extracted the experts' views on higher education: curriculum contents. They concluded that the Delphi method is of "potential benefit in curriculum design process" (p. 166).

Bell(1992),used this method in his study on developing curriculum guidelines for communication technology area of teacher preparation programmes in technology education. He initially conducted interviews with three groups of professionals consisting of teacher preparation professionals, communication technology professionals, and technology education supervisors. From these interviews he gathered list of guidelines which were later distributed to the panel of experts via email and by post asking from their agreements. The experts had agreed that 19 of the items should become curriculum guidelines.

The Delphi study on curriculum development was also conducted by Walley and webb (1997), They applied this technique in developing a core curriculum in clinical pharmacology and therapeutics. Howze and Darlymple (2004), applied the Delphi method in their study on determining course contents for library instruction. They stated that this method is " a very versatile method in conceptualizing and assessing a problem to be solved and or a decision to be made because movement towards group consensus can be measured " (p.182). A list of 134 items containing learning objectives was distributed to a group of experts. They concluded that the Delphi technique is effective in generating practical learning objectives which then can be developed into course contents. Another study using the Delphi method was conducted by Stitt-Gohds and Crews(2004).They conducted the research on technical education. Regarding the application of Delphi technique. They summed up that'' the Delphi method provide different opportunities to researchers than survey research, and its most significant strength lies in the ability to garner opinion and seek consensus among a diverse group of participants''(P.64).

The Delphi technique is a method of structuring a group communication process so that the process is effective in allowing a group of individuals as a whole to deal

with a complex problem (Linstone & Turoff, 1975).It operates on the basis that some individuals' opinions are more reliable than the opinion of a single individual. Developing a curriculum for any institution requires deep analysis and smart objectives selections as all this would be implemented in the future. Certainly, this technique is applicable to be used in educational research, particularly, in the areas of curriculum development

Delphi Technique is the method used in this study to bring about a consensus among the curriculum experts towards planning new curriculum for the secondary schools. This involved two rounds to arrive at a consensus. Two sets of questionnaires were distributed in two rounds.

The first round:

Sets of questionnaires were distributed among selected curriculum experts. During the first round they were given open ended questions to test their in-depth knowledge of the curriculum. This questionnaire was designed based on the literature review. The scale is a five point Likert-type scale. In this round each curriculum developer was expected to add any item considered important or delete any items which were considered unimportant. The experts were expected to indicate in their reply to the confirmation letter, together with the attached questionnaires, whether they were willing to participate in this study. An additional information guide was given to each respondent to help in responding to each item.

The second round:

The second round of questionnaires was based on the summary of curriculum experts' responses from the first round. The questionnaires are designed based on a five point scale based on the Likert scale from 5 to 1. The responses of the experts are determined by the descriptive statistical instrument such as mean, mode and inter quartile range.

Sample

The sample of 20 curriculum experts who have expertise in curriculum development working in different subject areas at the National Institute of Education, were included in the sample. The sample chosen to participate in this study were assigned using purposive sampling. These persons were purposefully chosen because

of their rich understanding of the current situation of the research side (Creswell, 2005). Thus in selecting the respondents the researcher used purposeful sampling procedure. This sampling procedure allows the researcher to choose the participants with rich information. Moreover, purposive sampling procedure applied in the present study was defined based on certain criteria which are considered fulfilling the purpose of this study. The sample selection done by the researcher was based on the various subject curriculum experts by using purposive method from the seven departments at the National Institute of Education as given in Table 1.

Table 1 : Distribution of Curriculum Experts by Major Subject Discipline

Department	Sample
Mathematics	4
Science	2
IT	2
Social studies	4
Religion	2
Tamil	4
Business Studies	2
Total	20

Instrumentation

In this study, various instruments are used in data collection. There are questionnaires including rating scales and interview schedule. The rating scale used in the questionnaire was adapted from a 5 point Likert scale. The instruments used in this step were divided into two categories as follows.

1. Interview schedule for curriculum experts
2. Questionnaire for curriculum experts

Data Analysis

Data collected in this study were analyzed according to various methods that can be divided into two stages.

Stage One is to answer the research question (1). Data obtained at this stage were analyzed using appropriate descriptive statistics including percentage. Statistical analysis was done using a statistical computer package.

Stage Two answers research question (2) on data analysis. This was accomplished by using the Delphi Technique for the purpose of achieving the most reliable consensus of a group of selected experts. To achieve a consensus the SPSS program was selected to determine the consistency of the experts' opinion on the development of the curriculum. Statistics used in this phase are median, mode, inter quartile range, mean and standard deviation.

Analysis of Interview

The responses for research question No. 1 "How can the gap between the present and the future secondary school curriculum be minimized?" are discussed and analyzed in this section. Here an attempt is being made to analyze the opinions of the curriculum experts on reducing the gap between the needs of the present and the future secondary school curriculum.

The opinions of the curriculum experts were obtained using an interview schedule. The responses revealed the perceptions of the experts with regard to minimizing the gap between the present and the future curricula for the secondary schools. Responses were related to the goals, content and the structure of the present curriculum compared to the needs of the future curriculum. The respondents mostly disagreed with suitability of the goals, content and structure of the present curriculum for the future needs of the secondary schools.

The responses in relation to the goals of the present curriculum indicate that most of the respondents are of opinion that the goals are not consistent with student needs and local needs. Also, most of the respondents agree that the goals of the present curriculum are inconsistent with the student capabilities. Further, it should be noted that the respondents unanimously agreed that the goals of the present curriculum are not consistent with the future needs. This indicates that the respondents feel that the goals of the present curriculum need to be revised.

Responses for the consistency of the content of the present curriculum too showed that most of the respondents are of opinion that the content of the present curriculum is not consistent with the students' needs and local needs. The respondents further indicated that the content of the present curriculum is also not designed to cater students' needs. Moreover, the respondents are of the opinion that the structure of the curriculum is not consistent with the goals, student needs and vision.

They suggested that the curriculum developers should address this problem in order to change the goals of the curriculum to cater the needs of the students, their capabilities and their future needs. It was further suggested that the change should minimize the gap in the goals of present and future curricula such that it will be consistent with student needs such as their wants, desires and their culture. It should also emphasize the local needs of the country and focus more on developing student capabilities. The respondents stressed that the future needs should be taken into consideration when spelling out the curriculum goals so that the gap may be reduced. Thus, it could be surmized that the curriculum developers should employ futuristic approaches in the process of curriculum development in order to reduce the gap. It was further pointed out that there is no provision in the present curriculum to provide an awareness of job opportunities to the students. It is the responsibility of the teachers to provide guidance to the learners for employment. The curriculum should be more competency-oriented; as such the syllabi for the various subject areas should contain the required competencies for the future needs of the students. Therefore, the content of the curriculum should enhance the provision of needs of the students and the local needs in order to reduce the gap between the present and the future curricula. The curriculum structure should thus balance the aspects of goals, needs of students and their vision.

The interviewees attest that it is apparent the present curriculum does not fulfil the goal, content and the structure whereby a gap occurs in the curriculum. At present, the learning environment forces the students to prepare for answering the examination paper. This depresses the students spiritually and mentally. This situation does not help the students to realize their real needs. This is the gap which is seen. In this regard the interviewees were of the opinion that the curriculum developers should focus their attention on developing a curriculum that will provide the necessary knowledge, attitude and skills to the learner in contrast to the present examination oriented curriculum.

Further, they stated that if this gap is not reduced the students will become more stressed and feel mentally burdened while engaging in learning. They further

pointed out that due to the present rapid advancement and development of technology and other fields, what is taught in the class at present is more meaningless to the needs of the future. The curriculum developers should take this point into consideration when planning the future curriculum. They further emphasized that the real needs of the learners should be studied through enquiries with the teachers prior to developing the curriculum as at present the real needs of the students have not been taken into consideration in the curriculum. It is important to ensure that the students should not face any mental stress in the process of learning.

Education is provided for both students from urban and rural areas. In developing a curriculum this is another factor that should be considered. The interviewees suggested that the syllabus for each subject and each unit should be designed, in future, in a local or a global context. In Sri Lanka, in general, rural children are quiet ignorant of the urban set up. Hence, a rural child will find it difficult to understand the theme of a lesson based on an urban set up. Similarly an urban child will find it difficult to understand lessons based on a rural set up. Thus, the interviewees suggest that lessons should be based on the children's needs and the needs of the country and lesson delivery should be more practical so that the children could grasp and comprehend the content.

They further stated that it is very important for the learner to learn with an understanding of the nature of the subject matter, because only then can the learner achieve the goals of the curriculum. Good ethics should be taught and inculcated in order to achieve the goals of the country, especially the goal of bringing about social cohesion among the diverse communities of Sri Lanka.

In concluding the above discussion, it could be surmized that the overall suggestion made by the respondents in regard to the goals, content and structure of the present curriculum is that it should be modified to suit the needs and capabilities of the learners in order to bridge the existing gap.

The respondents fully agreed that the goals of the future curriculum should be consistent with student needs. Most of the respondents were also of opinion that the future curriculum should be consistent with the local needs and learner capabilities. Respondents also unanimously agreed that goals of the future curriculum should be consistent with the needs of the future; unless this is achieved, there will be a wide gap between the actual curriculum and the intended one. It was also suggested that more researches and studies should be carried out to identify the needs and capabilities of the learner in order to avoid any gap. Also new knowledge will have to be adapted in accordance with global changes in the field of technology.

The day to day need of the future will be complex due to the rapid advancement of modern technology. It is important that the future curriculum, therefore, should provide the relevant knowledge, attitudes and skills necessary to cope with the new needs created by such developments in technology. The future curriculum should address the issue of developing suitable future citizens who could contribute to the development of the country with their new knowledge.

Interviewees pointed out that the learning and teaching process also should change. At present the learner is dependant only on the teacher to acquire knowledge. Learners should become independent of the teacher and should be guided to seek knowledge on their own from various sources. Thus the curriculum should guide the teachers to apply new methods in order to make learners acquire knowledge from various sources.

In summarizing the above discussion, it could be stated that majority of the respondents agree that the structure of the future curriculum should be consistent with the goals, needs of students and vision for the future. Therefore the curriculum goals should be identified and spelt out to suit the future needs of the learner as well as society in order to reduce the gap between the present and future needs of the learners in the secondary grade classes. Basically the subject oriented curriculum catering to the vocational needs will help the learner in the future because it enables the learner to achieve the vocational needs and moulds the learner to fit into the future world.

The majority of the respondents stated that the students in GCE O/L will not be able to further their studies in the academic field and the vocational field and also they will not be able to find employment at present. Similarly, in relation to the capabilities learners should possess in GCE A/L in the present curriculum the responses show that the majority were of opinion that school leavers will not be able to further their studies in the academic field and the vocational field and also that they will not be able to find employment.

In relation to the capabilities learners should possess after completing their O/L and A/L, the responses show that the majority were of opinion that continuing the studies at tertiary level and various other fields does not happen at present; only half of the respondents partially agreed that school leavers will be able to go for work. The majority of responses stated that the present curriculum does not provide the learners with the ability of acquiring occupations after leaving school. This too shows that there is a gap between the present curriculum and the students' needs.

They further pointed out the that curriculum developers should address the following facts to reduce the gap in the Sri Lankan secondary curriculum thereby providing more capabilities to the students to continue their studies in the academic fields, vocational fields and prepare them for employment in all sectors in the country. But there is fierce competition for employment. Therefore, the new GCE O/L curriculum should provide opportunity to further education in the academic fields as well as vocational fields. The curriculum should challenge the learner to face the future world as it becomes a global village. The students should face the global needs, such as the industrial field, information technology, computer literacy, and so on. So the future curriculum should be designed to cater the students' need to continue their studies. However, the child is ready and matured enough to do a job after completing O/Levels and A/Levels. Therefore, at this level, the students should be able to possess a job in the relevant field. The learners thus should get knowledge regarding how to acquire jobs. So the future curriculum can be designed to fulfil the students' needs to further their studies in the academic and vocational fields and tertiary level. Through this they can find employment and can be taken through the curriculum to their goals.

With regard to the curriculum contents, respondents further stress that the content should synchronize with vocational needs and should develop the learner's capabilities. Content is generally developed in terms of technology advancement. Technology should link with learner capability because when technology is incorporated into the curriculum the country will advance towards global needs. If not, the learner will be isolated from society as well as global developments. The contents of the present curriculum do not focus on vocational needs or learner capabilities. Therefore it is essential to introduce more practical work in the future, which in turn will motivate the learners toward learning.

Analysis of Delphi technique.

The purpose of this section is to answer the Research Question No. 2. "What guidelines should be planned for a new curriculum for secondary schools?" will be achieved by applying Delphi technique. In this section descriptive statistics of median, mode and inter quartile range are used simultaneously to obtain the results.

The questionnaire is administered to a panel of curriculum experts during this round. Collected data are then interpreted in order to identify the consensus of the experts on the guidelines for constructing the future curriculum. A computer package is used to determine the consistency of the opinions of the experts. Difference between

the median and mode is analyzed to determine the consistency of the opinions of the experts and difference between the third and first quartiles to determine the extent of achievement of the curriculum according to the opinions of the experts between rounds.

Analysis of data included the following topics:

1. Descriptions of the experts
2. Round one
3. Round two

Descriptions of the curriculum experts

Several criteria were used as basic requirements for selecting the panel of curriculum experts. To ensure the delivery of subjective opinion the following are considered as criteria for selecting the panel of curriculum experts:

1. Age of curriculum experts
2. Educational background
3. Experience in curriculum development

In selecting the panel of experts, the purposive method is utilized since the criteria for selecting the experts are according to their expertise rather than at random. In accordance with the determined criteria, 20 curriculum developers from the National Institute of Education representing different departments are invited to participate in this study (100 percent accepted the invitation). Details are elaborated in Table 7, 8, 9, 10, and 11.

Round One

In this round the panel of curriculum experts was requested to assess the open ended questionnaire. Each curriculum expert is expected to add or delete any items as consistent, important or unimportant.

The results of the questionnaire assessment are summarized in the form of rating scale. The scale is a five point scale based on the Likert scale. The details of each scale are indicated in the questionnaire.

Analysis of Consensus by using the median, mode and inter-quartile range

Table 2 shows the results of analysis in the form of median, mode and inter quartile range for the responses.

Table 2 : Analysis of Expert Consensus with Regard to Curriculum Goals, Content and Structure

Curriculum goals, content and structure	Median	Mode	*D*	Inter-quartile range
1.0 Goals				
1.1 Goals are consistent with student's needs	4	4	0	1
1.2 Goals are consistent with local needs	3	4	-1	1
1.3 Goals are consistent with student's capabilities	3	3	0	1
1.4 Goals are consistent with present needs	3	4	-1	1
1.5 Goals are consistent with future needs	3	3	0	0
2.0 Content				
2.1 Consistent with student's needs	3	3	0	0
2.2 Consistent with local needs	3	3	0	1
2.3 Consistent with present needs	3	3	0	1
2.4 Consistent with future needs	3	3	0	0
3.0 Structure				
3.1 Consistent with the goal	3	3	0	1
3.2 Consistent with the student needs	3	3	0	1
3.3 Consistent with the vision and mission	3	3	0	1

Table 2 shows that the median and mode of item 1.1 is 4, and for items 1.3 and 1.5 is 3. The difference between median and mode of items 1.1, 1.3 and 1.5 is 0 and the inter quartile range is 1 for items 1.1, 1.2, 1.3, 1.4, 2.2, 2.3, 3.1, 3.2 and 3.3. The inter quartile range for items 1.5, 2.1 and 2.4 is zero. This shows that there is consistency of the opinions of experts for the items 1.1, 1.3 and 1.5. Also it shows that the panel

of experts highly agree with the items 1.1 to 1.4, items 2.2, 2.3, 3.1, 3.2 and 3.3 and moderately agree with the rest of the items.

Table 3 shows the analysis of consensus of the experts with regard to the capabilities that learners should possess in GCE O/L.

Table 3 : Analysis of Expert Consensus with Regard to Capabilities Learners Should Possess in GCE O/L

Capabilities that the learners should possess		Median	Mode	*D*	Inter-quartile range
4.0	Capabilities that the learners should possess in O/L				
4.1	Able to further their studies in academic field	4	4	0	1
4.2	Able to further their studies in vocational field	3	3	0	1
4.3	Able to go for work	3	3	0	1
5.0	Capabilities that the learners should possess in A/L				
5.1	Able to further their study in academic field	4	4	0	1
5.2	Able to further their study in vocational field	3	3	0	2
5.3	Able to work	3	3	0	1
6.0	Capabilities that learners should possess after completing their O/L and A/L				
6.1	Able to go for work	3	3	0	2
6.2	Able to further their studies at tertiary level	3	3	0	1
6.3	Able to further their studies various fields	5	5	0	1

Table 3 shows that median and mode of the items 4.1 and 5.1 is 4. The difference between median and mode of the above items is 0. The inter quartile range is 1 for all items except for items 5.2 and 6.1 for which the inter quartile range is 2. This shows that there is very high consistency of opinion of experts for item 6.3 and that all the other items too have consistency of opinion of experts. Further it is evident from Table 4 that the experts have very highly agreed with item 6.3. Table 4 shows that

expert panellists very highly agreed with item 6.3, highly agree with items 4.1 and 5.1 and moderately agree with other items.

Conclusion

The findings have been very enlightening and helpful to us in formulating guidelines for the secondary school curriculum in Sri Lanka. The majority of the curriculum experts have clearly shown that the goals of the present secondary school curriculum are consistent with the capabilities and needs of students, and should be included in the future planning of the curriculum. However, under the present secondary school curriculum, the expert panel found that the current curriculum is moderated and needed improvement under the new structure to meet the students' needs and national needs.

The findings of the curriculum goal, content and structure show that there is consistency in the opinions of experts for items 1.1, 1.3 and 1.5 that are gaols should be consistent with students' needs, present needs, and local needs. It also reveals that consistency of goals with students' needs highly agree, while the others moderately agree. The contents with the present and local needs highly agree and the contents with the future and student needs are consistent. Under the structure of curriculum, all items 3.1, 3.2, and 3.3 that are consistent with the goal, student needs, and vision and mission moderately agree.

The finding related to capabilities students should possess in GCE (O/L) and GCE (A/L) curriculum indicate that there is very high consistency in opinion of experts under item 6.3 that *students are able to further their study in various fields* and the remaining items should also have the same consistency of opinion from the experts. Also the expert panelists highly agree with items under 4.1 and 5.1that *students are able to further their study in academic field in GCE (O/L) and GCE (A/L)* and partially agree with the remaining items.

Proposed Guidelines for the Secondary School Curriculum

Goals, Content and Structure of the new curriculum can be planned according to the following guidelines.

1.0	**Goals of Curriculum**
1.1	Goals should be Consistent with student needs
1.2	Goals should be Consistent with present needs
1.3	Goals should be Consistent with local needs
1.4	Goals should be Consistent with students Capabilities
1.5	Goals should be Consistent with future needs

2.0	**Content of Curriculum**
2.1	Content should be consistent with student needs
2.2	Content should be consistent with future needs
2.3	Content should be Consistent with local needs

3.0	**Structure of Curriculum**
3.1	Structure should be consistent with the goal
3.2	Structure should be consistent with the student needs
3.3	Structure should be consistent with the vision and mission

4.0	**Capabilities learners should possess after completing O/L**
4.1	Able to further their study in academic field
4.2	Able to further their study in vocational field
4.3	Able to go for work

5.0	**Capabilities learners should possess after completing A/L**
5.1	5.1 Able to further their study in academic field
5.2	5.2 Able to work
5.3	5.3 Able to further their study in vocational field

6.0	**Capabilities learners should possess after completing both their O/L and A/L**
6.1	Able to further their study in various fields
6.2	Able to further their study at tertiary level
6.3	Able to go for work

The majority of the curriculum experts have clearly shown that the goals of the present secondary school were consistent with the capabilities and needs of students, and should be included in the future planning of the curriculum. However, under the present secondary school curriculum, the expert panel found that the current content was moderate and needed improvement under the new structure to meet the students' needs and national needs.

The findings on the curriculum goal, content and structure show that there was consistency in the opinions of experts for items 1.1 to 1.5 but they highly agree with 1.1 that is the goal should be consistent with students' needs. Under numbers 2.1 and 2.4, the content of curriculum is consistent with the needs of the students and the future and also under items 3.1, 3.2, and 3.3, the structure of curriculum is consistent with the goal, the needs of students and vision and mission. The findings related to the capabilities student should possess in GCE (O/L) and GCE (A/L) curriculum indicated that there is very high consistency in opinion of experts under item 4.1, 5.1, and 6.3 that are able to further study in academic field in the O-Level and A-Level, and able to further studies in various fields in A-Level.

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Model for Integrating ICT in Instructional Process in Secondary Education: Sri Lankan Perspective

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Abstract

Any model employed to integrate Information and Communication Technology (ICT) in the secondary school curriculum should address functional requirements and non-functional requirements of the implementation. Functional requirements deal with services provided and non-functional requirements deal with conditions to be satisfied to ensure the efficiency and effectiveness of the services.Guided by this philosophy the objectives of this research study were to discover the context sensitive issues of the scope of ICT integration in the school system, ascertain software and hardware tools that are effective in the process and design a suitable model to implement the integration.A qualitative approach supported by quantitative data was adopted in this study and data was collected via case studies, interviews and questionnaires. The sample consisted of principals, teachers, students and educational authorities of curriculum and administration.The functional requirements were established in terms of instructional strategies, multimedia design, use of the mother tongue and evaluation methods, to ensure the cognitive development of students, motivation of students for learning and facilitation of teachers' work. The non-functional requirements, both at school and at national level, were identified in terms of

infrastructure, institutional issues, instructional leadership, professional development, technical support, maintenance of assets, alignment of the curriculum with technology, decentralization of development of learning material and attitudinal change in teachers. The model proposed encapsulates both functional and non-functional requirements.

Key words : Information and Communication Technology, Secondary School Curriculum

Introduction

Background of the study and the research problem

Computer education started in Sri Lanka way back in 1983 (UNESCO Bangkok, 2009). At that time a small sample of schools with G.C.E. science stream was provided computers and operating systems, wordprocessing, spreadsheets, database management and programming were taught on DOS platform to G.C.E. (A/L) science students. As studies found out that this program did not provide a sufficient impact on ICT education, in 1994 a new concept emerged. Instead of providing computers to individual schools a computer center called Computer Resources Center per educational zone (cluster of schools) was established (UNESCO Bangkok, 2009). Although these centers were established on school premises, a separate curriculum outside the main stream was implemented and a separate national examination was conducted. The students were those who were awaiting results of G.C.E. (O/L) and G.C.E. (A/L) and a nominal fee was levied on students to cover operational cost and maintenance of centers. Aims of this course were to give a basic knowledge in ICT for day to day work, to give practical skills in basic computer applications, to give students a competitive edge in job market and to form a strong basis for higher education in ICT (National Institute of Education, 2000).

Due to the changes in political, social and educational spheres in the country, vision of ICT in education changed. As a result, a massive quantitative increase in the implementation of ICT resources began to take place from 2002. Free internet facility was provided to schools and the service provider was Schoolnet (www.schoolnet.lk) that was maintained by the MOE. The services were hosting of school websites, e-mail facility to students and teachers, provision of learning material and implementation of LMS (SchoolNet). These projects were funded by the ADB and World Bank. The

basic objectives of this project were to promote ICT as a school subject and use of ICT in the instructional process of other subjects. Although the dispatch of ICT hardware was carried out speedily but the acquisition of relevant software and professional development did not keep pace with this. Due to these reasons, in majority of cases, the supplied ICT resources remained underutilized.

The investment made by the Ministry of Education of Sri Lanka in the acquisition of ICT resources for the school sector and the professional development of teachers is huge but whether this investment has paid dividends in terms of improving the quality of the instructional process is a question that is yet to be answered. The methodology to employ to ensure an effective use of ICT in the classroom is very context sensitive. Therefore, the research problem is formed by two aspects in this case: the study of the contextual issues and the proposition of a methodology to improve students' performance and at the same time facilitate task of the teachers.

Research questions raised in the study are as follows.

Regarding physical assets and infrastructure

1. What is the current status of ICT hardware resources including hardware for Internet in schools?
2. Do students receive a fair and adequate share of ICT resources?
3. What is the status of educational software provided?

Regarding institutional issues

4. Do schools have their own ICT plans?
5. Do schools get adequate support from the authorities to solve problems in the use of ICT?
6. What kind of arrangements do schools have to maintain the ICT resources?

Regarding professional development

7. Are teachers adequately trained?
8. Are teachers provided with a sufficient amount of resources to keep up with ICT plans?

9. Do teachers receive sufficient technical support to maintain ICT facilities?
10. Have teachers with additional skills and attitudes been catered to?
11. Does paucity of knowledge of English pose a barrier to teachers in the use of ICT?
12. Do teachers have a positive attitude towards the use of ICT in learning/ teaching process?

Regarding students' characteristics

13. Do students have minimum skills to use a computer?
14. Do students have a positive attitude towards the use of ICT in learning/ teaching process?
15. Does English present a barrier to students in the use of ICT?

Regarding the effectiveness of the methods used to integrate ICT in the school sector

16. Are there specific methods to use various ICT tools like wordprocessing, spreadsheets, database management to enhance the instructional process?
17. Is current practice with regards such use effective?
18. Do teachers have their own field tested methods?
19. Have teachers been provided with such methods in their training programs?

Research Objectives

a. To carry out a critical study to identify the extent to which ICT resources have been provided to secondary schools in the island.

b. To evaluate the current status of the ICT resources provided.

c. To assess the attitude of teachers and students to the use of ICT in the classroom.

d. To evaluate the impact of ICT on the instructional process as well as the performance of students.

e. To identify the factors affecting the successful implementation of ICT plans in schools.

f. To make recommendations for the improvement of the quality of ICT use in education in terms of environmental factors affecting integration of ICT in the instructional process and propose a model for its integration.

Conceptual Framework

Functional and non-functional issues

Khan (1998, p 1) states "If knowledge is the engine of development and technology is the fuel, then without the fuel the engine cannot run."

Design of a model to ensure the effective use of ICT in instructional process is a complicated issue and the design alone is not adequate to reap the full benefit of the monetary cost and the social cost involved. The effective use has two aspects: one is the implementation and the other is the maintenance thereof.

Any model proposed as a solution to a complex problem should ensure that it meets functional requirements and non functional requirements of the system that needs the solution. The functional requirements describe the services expected from the solution. Non functional requirements are not directly concerned with the functionalities of solution but are related to aspects like reliability, availability, and sustainability of the solution (Sommerville, 2001).

Information and Communication Technology (ICT) is defined as a diverse set of technological tools such as computers, the Internet, radio, television, telephones, and audio-visual equipment and resources used to create, disseminate, store, and manage information. This includes media for collection, storage, processing, transmission, and presentation of information (voice, text, images). Out of these resources computers and the Internet are the most outstanding. Over the past decade ICT has had a tremendous impact on all fields of work in the world and as such education is no exception (Tinio, 2002; World Bank, 2002). During the last 30 years, the role of ICT in education has expanded its wings to cover many subject areas particularly science. ICT can be used in teaching and learning to help students understand difficult concepts (Angela and Silvestra, 2002). Advancements in computer

based multimedia technology paved the way to a new era in Computer Assisted Learning (CAL) from the late 1980's to the early 1990's and there was abundance of CAL software and hardware. The term e-learning was coined in this era (Leinonen, 2008). Based on the assumption that computers and the Internet have the potential to promote individualized instruction, e-learning may either be used as complementary or supplementary in the instructional process (Bajunid, 2001).

Models used to integrate ICT in the instructional process should be context sensitive, take care of non-functional requirements and be future-proof in the face of rapidly changing technology. For a sustainable implementation of such ICT integration plans, the models used should have a sound instructional strategy and a built-in evaluation criteria that are unequivocally interpretable and easily implementable (Mun and Seng, 2001, Camacho et. al.,2005). Leadership, professional development, time, and evaluation play supportive roles in this regard. (Carrigg et. al., 2000 as cited in Wang and Woo, 2007). A complete top-down approach could be too rigid and a sole bottom-up approach is presumed to be less practical. But starting from teachers' current situation could be a sensible approach (Kooi, 2001; Haddad, 2009; Alessi & Trollip, 2001).

The external and internal motivation of teachers is essential for the successful integration of ICT in education. According to ARCS motivational model (Keller, 1983) attention, relevance, confidence, and satisfaction are forces of motivation for an individual to be engaged in a novel learning situation. The proper administrative support is essential in this case (Educational Communications and Technology Agency, 2003). In general, teachers cooperate to carry out ICT plans but they need adequate training and access to ICT resources whenever necessary. ICT innovations are challenging in nature to many teachers as they are required to create new learning environments to students. (Belawati, 2005; Cabanatan, 2001; Kooi, 2001; Farrell & Wachholz, 2003; Harris and Kington , 2001; Haydn, T.,undated).

In order to maintain motivation in teachers, access to quality resources, their readiness to use ICT and sustainable professional development with new structures, and meaningful assessment models must be ensured (Roberts et.al. as cited in Kooi, 2001). Use of ICT in the instructional process is not likely to reduce teachers' workload; it rather offers more choices for pedagogical practice (British Educational Communications and Technology Agency as cited in UNESCO, 2005).

ICT cannot be integrated with the instructional process without making adjustments in the current practices of curriculum and pedagogy to accommodate expected innovations facilitated by technology. (Reddi & Sinha, 2005; Camacho, 2005). On the other hand, teachers should be convinced that use of ICT is related to the curriculum they are responsible for (Byrom, 1998 as cited in SEIR*TEC, undated). Moreover, teachers will be likely to use ICT creatively in the instructional process if the objectives of their courses are consistent with the culture of thinking (Ping, 2001). In developing countries the lack of localized software, books, and websites also hinders the use of ICT in education (Farrell & Wachholz, 2003).

The integration of ICT in education is not a mere acquisition of ICT resources but is rather a process of upgrading skills and knowledge of teachers. Due to the inherrent inertia in the school system the integration of ICT in education demands procedures for change mangement with the exercise of utmost patience. It is important to note that ICT cannot repair a bad education system. It is the responsibility of the school system to develop ICT materials (Case study one V3.0: Malasian Smart School Project, 2002). However, it is debatable whether teachers are supposed to develop instructional software (Fung and Pung, 2001). To ensure the successful implementation and sustainability of an ICT plan in the school system, characteristics of the ultimate stakeholders must be taken into serious consideration. Opportunities must be available for the use of materials for both learning modes: teacher-centered and student-centered. In the case of students, their learning styles and multiple intelligences should be addressed (Case study one V3.0: Malasian Smart School Project, 2002). In order to gear the teachers to the use of ICT in education the professional development programs for teachers should comprehensively address the features described above (Smart School Conceptual Blueprint, 1997).

As viewed in Singapore and Hon Kong, for successful integration of ICT in education, a radical change in the curriculum is necessary such as forcing of ICT on certain portion of it (Mun and Seng, 2001; Waitayangkoon, undated; Lankshear,2000 as cited in Kooi,2001). However, some educationists cast doubt on the success of this type of approach as it may result in adaptation the learning environment to the technology rather than the other way around thereby harming the learning process (Law et.al. cited in Fung and Pun, 2001; Rowe cited in Kooi, 2001).

Models of effective use of ICT in instructional process

Effective use of the ICT in instructional process has two basic stages: one is the design of effective models to integrate ICT and the other is implementation of such models in the classroom. It is the duty of the instructional technologists to concentrate on both these aspects when proposing ICT enhanced instruction. Use of ICT in the classroom should be to support learning environments that are more learner-centered, knowledge-centered, assessment-centered, and community-centered (MIICE, 2002).

The role of ICT in instruction is to improve the learning environment of students and at the same time facilitate the teacher's effort (Jackson, 2005). Computer based lessons are generally called learning with interactive multimedia (IMM). IMM is defined as "A computerized database that allows users to access information in multiple forms including text, graphics, video and audio" (Reeves, 1992, p 47). As the use of multimedia has proven track records of enhancing learning by constructing strong cognitive schemas (Mayer, 2002) ICT tools can be used to code lesson content with multimedia. Further a high level of interactivity in terms of self-access, self-pacing, and self-direction from the learner's point of view can be build into these material (Bajunid, 2001, Dhanarajan, 2002). However, it is not advisable to digitize every learning material as it is a resource intensive process (Mayer and Warren, 2000 as cited in UNESCO, 2005).

According to Smith & Throne (2007), driven by the high level of interactivity that is provided by computer hardware and software, ICT lends itself to design instruction based on students' IQ, interest, readiness etc. The use of interactive multimedia and Internet can create multiple of learning environments that is difficult without the use of ICT, addressing different learning styles. (Shelley et. al, 2001 as cited in UNESCO, 2005).

Wang & Woo (2007) have proposed a model with systems approach to integrate ICT in instructional process. According to this model identification of the problem, determination of the learning objectives, ascertainment of technology based on the problem and the objectives with justification should be carried out as initial steps. Then the design and implementation strategies should be determined followed by students' assessment plans. Once these steps are carried out results of the assessments

are used to reflect on and revise the whole process. Models used to integrate ICT should encapsulate elements of creativity within realistic limits, reflective practice to evaluate impact on learning, responsibility in the proper use of ICT, and reciprocity - the practice of collaboration among teachers or administrators for mutual benefit (Kooi, 2001).

Another aspect of the use of ICT in education is the provision of students with ICT tools to facilitate interacting with the subject matter. The more the subject matter the students process, higher will be the cognitive skills they could develop. Creation of computer based presentations, use of wordprocessing software to create wallpapers or periodicals, development of websites, contribution to bulletin boards, creation of blogs, sensible chatting with fellow students to share knowledge, use of database management software to create and share databases with respect to various subject matter are substantial examples of the use of ICT in enhancing interactions (UNESCO Bangkok, 2004). Teachers can set assignments for students to explore various aspects of lessons they are supposed to learn using Internet.

A multimedia projector is very useful in ICT integrated learning environments (McKenzie, 1998 as cited in UNESCO, 2005). This helps teachers to demonstrate procedures, give common instructions, display and explain multimedia coded information and display exemplary work of students to the whole class with relevant emphasis (British Educational Communications and Technology Agency, undated). In a study conducted in Hong Kong, it has been revealed that use of ICT in the instructional process by teachers who worked in ICT enhanced classes with ceiling-mounted video projectors considerably higher than that of teachers who taught in ICT enhanced classes but without projectors (Kong et. al., 2000 as cited in Fung and Pun, 2001).

The use of Geographical Information Systems is a great way to learn geography. With this, students can study more maps than they could with manual methods in a given time (Qualifications and Curriculum Authority, undated). For example Google Earth is a freeware tool that can be integrated with a geography lesson.

For schools who cannot afford to own ICT labs with 10-20 computers, International Society for Technology in Education (2004) has recommended the following strategies: Cooperative group station (students use computer in rotation), demonstration station (teacher does demonstration on computer), independent research

station (students can access a computer when necessary), learning center (position computer as a part of a well defined activity), small group instruction (teacher works with a small group on the computer while the rest of the class is engaged in a different activity). To ensure maximum participation by the students in ICT enhanced learning they should be provided with maximum thinking space, maximum collaborative opportunities and minimum typing (Bond as cited in UNESCO Bangkok, 2005).

ICT in Education Policy of Sri Lanka

The vision behind the policy of the Ministry of Education (MOE) with respect to ICT in Education is to offer a "Digital Bridge through Education" and the mission in this regard is "Preparing a knowledge-based society through developing knowledge and skills in Information and Communication Technology" (Ministry of Education Sri Lanka, 2005).

As at 2009, out of over 9700 schools, including primary, in the Sri Lankan educational system, 3415 schools were provided with computer laboratories summing up to 56941 computers. The computer to student ratio was approximately 1:100 (Hudah, 2009). Teachers trained on ICT were over 96,000. The number of schools enjoyed Internet connection was about 1700. It was envisaged that schools with computer laboratories would reach 6000 mark during 2010/2011 (Hudah, 2009). Currently, all 'SchoolNet' programs use broadband facilities provided by Sri Lanka Telecom (SLT), through fixed lines and code division multiple access (CDMA) networks which provide Internet speeds of 64 kbps especially in rural areas. By the end of 2010 it is proposed to expand ICT facilities to reach 80 percent of school children in Sri Lanka. (Lanka Business On Line, 2008). The following table : 1 shows the targets to be achieved for the next 10 years, according to National Education Commission, Sri Lanka, 2009.

Table 1 : Targets for next 10 years

No	Level	Aspect of Learning	Target	
			In 5 years	In 10 Years
1	Primary (Years 1-5)	Availability of Digital Contents	60% of total contents	60% of total contents
		Non-interactive Audio Visual component	50% of total instruction	10% of total instruction
		Interactive Learning	10% of the total instruction	50% of total instructions
		Learning anywhere	20% of course material	60% of course material
		Learning anytime	60% of course material	60% of course material
		Connectivity to education Network and the internet	30% schools	100% of schools
		Data-driven decision making	30% of instances	100% of instances
2	Secondary (Years 6-13)	Availability of Digital Contents*	80% of total contents	80% of total contents
		Non-interactive Audio Visual component	60% of total instruction	20% of total instruction
		Interactive Learning	20% of the total instruction	60% of total instructions
		Learning anywhere	20% of course material	60% of course material
		Learning anytime	80% of course material	80% of course material
		Connectivity to education Network and the internet	50% schools	100% of schools
		Data-driven decision making	50% of instances	100% of instances

Source: National Education Commission, Sri Lanka, 2009

One of the major tasks of the Department of Information Technology of the National Institute of Education is development of educational software for secondary education. This is implemented in two projects as development of software for Grades 6-9 and Grades 10-13. The subjects identified for this software are science, English, history and geography for grades 6-9 and physics, chemistry, biology, mathematics,

and English for grades 12 & 13. Although teachers of the school system are professionally developed in the process, lack of physical and human resources have hindered the progress of this endevour (Annual Plan of National Institute of Education, 2006, 2007, 2008, 2009)

Research conducted in the field of ICT education in Sri Lanka.

Table 1 predicts the transformation of the school system in the use of ICT in education through the next 10 years (National Education Commission of Sri Lanka, 2009). This envisages a progress in the use of ICT in education in terms of increase in interactive learning, learning independent of time or location, Internet connectivity in schools, data driven decision making and reduction in non-interactive multimedia. However, for the success of these efforts the Multiple Streams Model of Kingdon, as cited by Richardson (2008), should be strictly adhered to. In this model it is stressed that streams of problems, policies and politics should unite to ensure success of national level reforms.

There is a dearth of research conducted in the field of ICT in education of Sri Lanka. The main reason for this is that although ICT was introduced to the school system of Sri Lanka way back in 1983, the coverage of school system has been very low for a long time. A research conducted by Damayanthi (2003) has revealed that during the period 1980-2000 computers have been used in the school system only to impart computer literacy to students. The contribution of these computers to the professional development of teachers was rather negligible. Professional programs to enhance competency of the teachers in the use of computers were essential as their competencies in the instructional process were very low.

An island-wide census conducted in 2006 has revealed that 95.2% National schools and 90.1% Navodya schools had computer laboratories with private schools contributing 84.1%. Only 17% of other government schools had computer laboratories. Availability of Internet facilities in National schools was 50% while the same in other government schools was mere 3%. While 63% male teachers were considered computer literate the figure with respect to female teachers was 58%. It was further revealed that provision of computers only would not improve the computer literacy of teachers while the absence of good knowledge of English would not prove an obstacle

in gaining computer literacy. In contrast, computer literacy positively affected the knowledge of English in teachers (Satarasinghe, 2006).

Methodology

Sample

Seven case studies were conducted in seven schools where good practices of ICT use in instruction were observed. "A case study is both a process of inquiry about the case and the product of that inquiry" (Stake, 2000:436). The 'case' in this instance is the possibilities of productive implementation of computers in schools and product is the outcomes that could be observed so far. The case study approach for this research is in the form of what Merriam (1998) terms an interpretive case study where it provides space to develop data into theoretical categories which in turn help expand researcher's original understanding of the context. Cohen et.al (2000) point out that the interpretive researcher focuses on the participant's point of view rather than his/her own analysis of the situation.

The case studies and interviews were required in this study due to the facts that the integration of ICT in instructional process of the secondary schools is still in its early stages of development and not much research is conducted in this context that is rich in vital qualitative data. Therefore the researcher's personal involvement was essential. In order to collect complementary quantitative data, survey technique was also used. Further analysis of qualitative data will lead to form theories those can be quantitatively tested in subsequent research.

A stratified random sample of 100 schools was selected from seven provinces in order to take a set of participants from each school. This set consisted of the principal of the school, teacher in charge of the computer lab, two teachers each who taught mathematics, science, English and either history or geography in grades 6-11 and two students each from grades 6-11. Eventually this set comprised 23 participants.

In addition to these, ICT coordinators of six provinces, eleven In-Service Advisors of the Western province and one curriculum development officer each from ICT, Mathematics, English, Science and Social Studies department of the National Institute of Education were also included in the sample. Eventually the sample

comprised 100 principals, 100 teachers in charge of ICT laboratories, 800 subject teachers, 1200 students, six provincial ICT coordinators, 11 in-service advisors of ICT and five curriculum development officers of the NIE.

Participant from only 51 schools responded to the questionnaires. The final tally was 51 principals, 51 teachers in charge of ICT laboratories, 403 subject teachers and 305 students.

Instruments

Four different questionnaires, aimed at conducting opinion survey, were administered on each group of principals, ICT laboratory in-charge teachers, subject teachers and students. All items in the questionnaires were measured on a five-point, close-ended Likert scale. The last section of a questionnaire except for students was open-ended questions for participants to add their comments. Interview guides were prepared to interview provincial IT coordinators, ISAs and officers of the NIE. The interview guide for the provincial IT coordinators and the ISAs covered their academic qualifications, nature of their involvement, the current practice of ICT use in school system and their attempts to streamline such use. ICT skills, attitude of using ICT in instruction and views on methodologies of ICT integration in curriculum were the aspects covered in the guide used to interview curriculum officers of NIE. The questionnaire administered to the principals (19 items) dealt with professional development, extent of use of ICT in their respective schools, ICT resources, curriculum alignment and students' attitude. The questionnaire for the ICT laboratory in-charge teachers (15 items) dealt with aspects of their training, lab maintenance, and teachers and students use of laboratories. The questionnaire for subject teachers (33 items) dealt with their training, development of software, availability of time slots in labs and opinion on type of software useful in ICT integration. The questionnaire for students (12 items) was about their ability to handle computers, use and interest of software and kind of ICT involvement in their learning.

Procedure to collect data

The questionnaires were revised after reviewed by a panel of experts to identify any insufficiencies. Later, questionnaires were pilot-tested in two schools to remove

any ambiguity of questions and to add or remove unsuitable questions. Based on the pilot test the questionnaires were further revised.

Seven schools from three provinces were visited by the researcher to conduct case studies. The aspects covered in these studies were administrative leadership, teacher involvement, success so far, innovative practices, training needs, and technical issues.

Ten per cent of the questionnaires were mailed to the subjects as the researcher could not find data collectors to reach them and the balance was sent through research assistants. Triangulation of data was carried out based on comments made by participants, results of case studies and responses of the teacher in charge of the ICT laboratory and the principals' responses. Multiple data collection methods covering qualitative and quantitative techniques were used as each method had it own contribution to the process. In order to obtain first hand qualitative data on how creatively and innovatively teachers practice ICT in instruction, setbacks they face, involvement and view of the educational authorities in the process, case studies were required. To expand the coverage of the research site and thereby improve the reliability of the findings within the allowed time-frame of the research, quantitative techniques were used.

Analysis of data and conclusions

As each question of the questionnaires was one dimensional, the One-Dimensional Chi-Square statistical test was used to analyze the responses from the scaled portion of the survey instrument. This statistical test measured the significance of difference. A 0.05 level of significance was used to test the results of the study. All the differences of opinions in all questions were statistically significant. The lowest Chi squared calculated in principals, lab in-charge teachers, subject teachers and students were 10.96, 14.16, 71.31 and 14.51 respectively as against the tabulated Chi squared of 9.488 at 0.05 significant level and of degrees of freedom equal to four.

Interpretations pertaining to the data analysis of case studies.

Although principals and teachers were happy about the training programs they have participated in, lack of focus on their role in the integration of ICT in instructional

process could have been the stumbling block in the effective use of ICT in instruction. Further they insisted that professional development programs should be on a continuous, rather than a one-off, basis so that their IT knowledge is upgraded over time. In all cases the release of a teacher for the ICT laboratory on full time basis was highly stressed. Out of the seven schools only one expressed that repair and maintenance was not an issue. It was highly appreciated if there was a comprehensive monitoring system on integration of ICT in the instructional process.

Use of ICT in mathematics must be carefully handled so as not to deskill students. The use of the multimedia projector with lessons supported with electronic presentation was an effective mode of use of ICT in instruction. The use of students' mother tongue was a must in all ICT applications in learning. A computer based question bank could be very useful for revision work of students. The low availability of time periods in the ICT laboratories has been a major setback in the use of ICT. The quality of the ICT based material developed by teachers was not up to standard due to the lack of knowledge of multimedia principles and principles of instructional design. Multimedia used for learning should be fitted with suitable interactivity for its maximum benefit to be harnessed. Computer based encyclopedias were a good ICT tool but its effectiveness was at a minimum as the medium was English. It was agreed that teachers could download relevant websites, review content thereof, restructure downloaded websites, and support with the mother tongue of students to use the Internet off-line. This would probably compensate the slow Internet connection they are provided with. Although project based learning with ICT was a method appreciated by teachers its time-consuming in nature and the lack of ICT laboratory periods posed a drawback. As a solution to the lack of practice of students and teachers in the use of standard keyboards in their mother tongue, fonts that use phonetic key strokes may be introduced for the development of ICT based materials and to interact with educational software. This could facilitate on line submission of assignments.

Involvement of private sector in the integration process was observed in two of the cases. In these cases the ICT integration model coupled with hardware and software donated did not seem to be effective on a continuing basis. Although wireless connectivity provided networked learning in these contexts, teachers had to waste

time setting up the learning environment. On the other hand, the size of the screen of the computers provided was not large enough for the learning purposes. Lack of educational software also hindered the utility of the system. Another school had an ICT enhanced learning system which facilitated simultaneous operation of a number of "computer mouses" for students' interactivity with computer based lessons. The benefit of this system could not be obtained due to the lack of lessons and the limited training the teachers had received. Implementation of this type of introductions should have been done in consultation with the National Institute of Education as this is the apex body for curriculum and instruction in Sri Lanka.

The development of ICT based learning material should preferably be centralized as teachers hardly have time to spare on these tasks. Peer coaching has been highlighted by many teachers as a way to improve the use of ICT in instruction. Involvement of the educational authorities at least at zonal level is much needed to help schools to raise necessary funds to meet maintenance cost of ICT laboratories. For this purpose the authorities could conduct discussion forums with principals of their respective zones to share good practices. The use of ICT in grades 10-11 appeared to be lagging behind due to three main reasons. The first was that these classes were examination oriented, second was the subject matter to be covered was heavy and the third was the lack of suitable educational software.

Analysis of responses to the questionnaires administered to principals.

SA- Strongly Agree A- Agree

Table 2: Responses to questionnaire administered to principals

Qno	Question	SA%	A%
1	I have received comprehensive training on how to handle ICT hardware	17.39	63.04
2	I have received comprehensive training on how to handle ICT software	10.87	36.96
3	I have received comprehensive training on the principal's role in ICT integration in learning/teaching process	13.04	30.43
4	I theoretically believe that ICT integration can enhance students' cognitive development	32.61	56.52
5	I theoretically believe that ICT integration can enhance students' motivation to learn	34.77	54.35
6	I have evidence from my school to be convinced that ICT is successfully integrated in the learning process.	17.39	52.17
7	I see lack of time on the part of teachers as an obstacle to the integration of ICT	21.74	30.43
8	I believe that a capable teacher should be fully released to carry out the functions of ICT integration	36.96	28.26
9	I am convinced that my teachers who attended ICT training have received adequate amount of training in ICT integration.	10.87	45.65
10	In my school there is a master plan for ICT integration	4.35	54.35
11	I believe that peer coaching will help teachers get more skills in ICT integration	43.48	54.35
12	I believe that teaching of certain parts of a given syllabus using ICT should be made compulsory to encourage the use of ICT in learning.	21.74	52.17
13	I believe it is more successful to integrate ICT at grades 6-9 rather than at grades 10-11	32.61	39.13
14	My school has adequate funds to maintain the ICT laboratory	8.69	8.69
15	I think a multimedia projector is a must in ICT integration	41.30	50.00
16	The educational authorities have a systematic program to monitor whether the ICT integration process in the learning/teaching process is successfully carried out.	6.52	26.09
17	I believe that the use of ICT in learning must be determined at the design stage of curriculum	23.91	56.52
18	I believe the development of ICT enhanced teaching materials should be developed centrally by the NIE or at provincial level and not passed down to individual schools.	17.39	45.65
19	There is a streamlined program in this country to encourage the use of ICT in the learning/teaching process.	8.69	19.56

Vast majority of principals have admitted that they had received comprehensive training on how to handle ICT hardware and software (Question 1 & 2). In contrast, principals did not admit that they had received comprehensive training on the role of principal in ICT in learning (Question 3) Principals were very much of the opinion that ICT could enhance learning and motivate students in learning (Questions 4 & 5).

They were confident that teachers in their respective schools had received sufficient training on ICT in instruction (Question 9) and were using ICT in instruction successfully (Question 6). They, though not strongly, supported the view that lack of time for teachers was an obstacle to use ICT in instruction (Question 7). Full time release of a teacher for ICT integration process is most welcome by majority of principals (Question 8). Principals, though not strongly, stated that they had a master plan to use ICT in instruction (Question 10) and further believed that peer-coaching could improve this arrangement (Question 11). Making certain subject matter to be taught with ICT compulsory was a move welcomed by a vast majority of principals to improve integration of ICT (Question 12). They preferred to use ICT in instruction in grade 6-9 classes over grades 10-11, students of the latter had to sit a national examination (Question 13). Raising of funds for the maintenance of ICT laboratories had been a major issue in vast majority of schools (Question 14). Multimedia projector had been a favorite equipment to be used in ICT integration process according to the principals (Question 15). Vast majority of principals did not agree that either there is a sound monitoring system (Question 16) or streamlined program to encourage the ICT integration process in the country (Question 19). Principals were of the opinion that the integration of ICT in instruction should be determined at the development of curriculum (Question 17), which is a centralized issue, and development of ICT enhanced lesson material should also be carried out by central bodies (Question 18).

Analysis of responses to questionnaires administered to teachers in charge of the ICT laboratories.

SA- Strongly Agree A- Agree

Table 3: Responses to the questionnaire administered to the teachers in charge of ICT labs

Qno		SA	A
1	I have received adequate training in handling computer hardware and software	20.41	57.14.
2	I have received adequate training in using ICT in the teaching/learning process	18.37	63.26
3	The Internet access in the ICT laboratory is fast enough	2.04	24.49
4	Repairs and maintenance of computers is a problem	30.61	28.57
5	I have developed an adequate number of ICT material in training sessions.	0.00	44.90
6	I have tried out these developed lessons at school	8.16	59.18
7	The use of the ICT laboratory by teachers to teach subjects other than ICT is at a satisfactory level	4.08	32.65
8	The use of the ICT laboratory by teachers who teach in grades 6-9 for teaching is higher than that of teachers who teach in grades 10-11.	6.12	28.57
9	Students use ICT laboratory for their projects satisfactorily.	55.10.	16.33
10	Powerpoint is a popular method used by teachers to teach non ICT subjects	32.65	57.14
11	Encarta like encyclopedias are a popular method used by teachers to teach non ICT subjects	6.12	63.26
12	Use of the Internet in learning is a popular method in my school.	12.24	46.94
13	The currently available educational software in the ICT laboratory is used successfully to teach non ICT subjects.	2.04	32.65
14	ICT enhanced learning/teaching is more successful than that without the use of ICT.	20.41	59.18
15	A teacher should be completely released for the ICT laboratory to ensure successful integration of ICT in the learning/teaching process	69.39	16.32

Vast majority of these teachers held the view that they had received an adequate training on handling of ICT hardware and software (Question 1) and use of ICT in instruction (Question 2). They admitted the Internet speed is not satisfactory (Question 3). Although not strongly, teachers admitted that repair and maintenance were a problem (Question 4). Although majority of these teachers had not produced ICT adequate number of based learning material in their training sessions (Question 5),

majority of such material had been tried out in their respective schools (Question 6). The use of ICT laboratory by teachers who taught subjects other than ICT was not satisfactory (Question 7) and on the other hand it was not agreed that teachers of grades 6-9 used ICT laboratory more than those of grades 10-11(Question 8). In contrast the use of ICT laboratory by students for their projects had been viewed as satisfactory (Question 9). Vast majority of teachers believed that ICT enhanced learning environment could be more successful than that without ICT component (Question 14). The most welcomed idea was the proposal to release a teacher on full-time basis to the ICT laboratory to ensure the successful integration of ICT in instruction (Question 15)

Analysis of responses to questionnaires administered to teachers in charge of the ICT laboratories.

Table 4: Preference of non-ICT teachers to use ICT tools as observed by teachers in charge of the ICT labs. (Questions 10,11,12 & 13)

ICT tool	Strongly agree%	Agree%	Total
Electronic presentations	32.65	57.14	89.79
Encarta	6.12	63.26	69.38
Internet	12.24	46.94	59.18
Educational software	2.04	32.65	34.69

Table 5: Responses to questionnaire administered to non ICT subject teachers (Science, Mathematics, English, Geography, and History)

Q no		SA	A
1	I have received adequate training on handling computer hardware and software.	10.36	54.24
2	I have received adequate training in the use of the ICT in the teaching/learning process.	5.44	43.52
3	I have developed an adequate number of ICT material in training sessions.	3.11	31.86
4	I have tried out these developed lessons at school.	1.81	27.46
5	I believe ICT enhanced lessons are more effective than lessons without ICT.	12.69	40.94
6	I get an adequate number of periods in the ICT laboratory to teach using ICT.	2.85	23.57
7	The technical assistance I get in the laboratory is adequate.	3.63	21.76
8	I believe certain lessons should be studied by students using educational software on their own.	6.73	42.75
9	Certain lessons should be taught with ICT but it should be teacher-centered in the ICT laboratory	16.06	58.03
10	It is effective to use ICT integrated lessons with the multimedia projector	33.94	46.63
11	Internet connection in the laboratory is fast enough	5.96	24.09
12	If fast enough it is possible for students to learn certain lessons on the Internet	10.62	46.89
13	It is more efficient for students to use relevant teacher downloaded web pages.	23.83	49.74
14	I get adequate laboratory periods to use ICT resources for my professional development and prepare myself for lessons	5.44	27.98
15	I believe Internet can be used to conduct project based learning	11.40	67.10
16	I believe that if lesson content and relevant multimedia are put on web sites students will benefit	38.86	47.15
17	It is productive to give assignments to students to find answers from the computer based material like Encarta in ICT laboratory	23.32	51.81
18	It is productive to use educational software that provides more activities as extension of lessons.	14.25	56.73
19	It is productive to use a computerized question bank in the computer laboratory for students to access and answer	25.13	57.77
20	To get the maximum benefit of ICT in education the use of ICT to teach certain subject contents must be made compulsory.	15.54	49.22
21	Creation of learning objects (programs which you can modify by inserting your own text and multimedia) facilitates the teachers' contribution.	16.84	59.07
22	The use of ICT enhances learning.	13.99	58.55
23	The use of ICT enhances motivation in learning.	21.50	59.58
24	Integration of ICT strategy and development of material should be handled provincially or at a higher level	21.50	50.26
25	The use of ICT in teaching process is a challenge for me.	4.67	31.61
26	The use of ICT in my teaching process wastes my teaching time	11.92	30.05

Although there was a high percentage of teachers admitted that the training they had received on handling of ICT hardware and software had been adequate (Question 1), this figure slightly dropped in the context of training on ICT in instruction (Question 2). Majority of teachers had not developed sufficient number of ICT enhanced learning material in their training sessions (Question 3) and even less percentage had used them in their lessons (Question 4). Due to the lack of availability of laboratory periods (Question 6) and poor technical assistance in the laboratory (Question 7) teachers did not seem to favour strongly the view that ICT enhanced lessons could be more effective than those without ICT (Question 5). Further they stated that they did not get sufficient number of laboratory periods for their professional development and preparation of material (Question 32). Majority of teachers were not in favour of the student centered ICT enhanced lessons (Question 8), but more in favour if these were teacher centered (Question 9). In this case also introduction of multimedia projector is most welcome (Question 10). Majority of teachers were not happy about the speed of Internet (Question 11) but they believed Internet could be useful as a learning source (Question 11) and the control should lie with the teachers (Question 13). They believed Internet could be useful in project-based learning (Question 15) and it would be beneficial to students if relevant multimedia coded subject matter was uploaded to websites (Question 16). The use of electronic encyclopedias (Question 17), activity rich educational software in the form of extension of lessons learned (Question 18) and computerized question banks (Question 19) were welcomed by these teachers as integration of ICT in instruction. Another form of material attractive to the teachers as facilitation of ICT integration was use of learning objects (Question 21). These teachers highly admitted that use of ICT in instruction enhances learning (Question 22) and motivates students to learn (Question 23) but to reap the maximum benefit of it certain subject content should be taught using ICT (Question 20). Neither the use of ICT in instruction was considered to be a challenge for majority of these teachers (Question 25) nor they thought it as a waste of their teaching time (Question 26) but the opinion that teachers do not have sufficient time to develop ICT integration plans was well supported (Question 27). They well confirmed the view that plans for ICT integration and development of ICT enhanced material should be a central concern (Question 24) but the majority welcomed peer-coaching as a way to help them with ICT integration (Question 28).

Although teachers did not strongly support the view that the use of ICT in instruction in grades 6-9 is effective (Question 29) they strongly rejected that it is not effective in grades 10-11 (Question 30). Use of electronic presentation had been supported by the majority as effective in teaching (Question 31). Teachers were of the opinion that sufficient number of educational software was not available for their lessons (Question 32). In the use of ICT in instruction, allocation computers on individual basis was not strongly supported (Question 33).

Analysis of responses to questionnaires administered to students.

Table 6: Responses to questionnaires administered to students

Qno		SA	A
1	I have skills to operate a computer	61.34	35.32
2	I have skills to play a computer game.	52.04	39.78
3	I have skills to use educational computer programs.	28.62	45.72
4	I like to use Encarta to collect content to enhance my learning.	36.43	34.57
5	I know how to use Internet to search for information.	24.16	34.94
6	I like to learn from Internet based projects	31.23	46.09
7	I learn better when teachers use Powerpoint to teach than when they do not use them.	32.34	45.72
8	I learn better if a multimedia projector is also used when Powerpoint is used to teach.	32.71	39.78
9	I like to learn when computers are used in teaching.	60.22	33.83
10	I think certain lessons should not be taught using ICT	16.36	40.89
11	I like if one computer per students is available to be used when ICT is used in learning.	68.03	23.42
12	I think if one computer is shared by 2-3 students in the use of ICT in learning, it will produce better results.	16.00	17.47

Vast majority of students surveyed had skills to operate a computer (Question 1), and play a computer game (Question 2) but it appeared that they were less confident about using educational software (Question 3) probably due to low exposure to such software. Electronic encyclopedias had been popular among them to improve learning (Question 4). Further majority of students had the skills to use Internet for searching information (Question 5) and liked to learn from Internet based projects (Question 6). The combined effect of responses to Questions 7 & 8 was that students strongly believed that use of electronic presentation in instruction would improve learning and the effect would be enhanced if a multimedia projector was used with electronic presentations. Vast majority of students welcomed the use of computers in instruction

(Question 9). Majority of them in disagreement with the view that ICT should not be used in the instructional process of certain subject matter (Question 10). Vast majority of students stressed that computers should be allocated to students on one-to-one basis when ICT is used in instruction (Question 11 &12).

Table 7: Average numbers and percentages of parameters with respect to ICT laboratories as collected from questionnaires.

Item	Value
Computers provided per school	19.3
Computers in working order per school	16.3
Periods (40 mnt) **available** for teaching with ICT per week	11.8
Periods (40 mnt) **required** for teaching with ICT per week *	72
Periods (40 mnt) ICT lab in-charge teacher teaches per week	22.4
% Schools where lab is open in the absence of in-charge	88.3
% Schools with register to reserve labs	63.6
% School with multimedia projector	34.1

* This is on the assumption that from grade 6-11 there are a minimum of three parallel classes and four subjects are supposed to teach with ICT, but in most cases the number of parallel classes are four or above.

(6 grades X 3 parallel classes each X 4 subjects=72)

Interpretation of the data collected in interviews with the zonal ICT coordinators

The zonal ICT coordinators, in most cases, did not play a full time role in assignments. Moreover, they did not have formal educational qualifications in ICT. Therefore not much light was shed on the duty of ICT coordinators as far as the integration of ICT was concerned. Their involvement in conducting competitions on ICT enhanced learning material development seems to have a positive effect on the use of ICT in instruction by the teachers but no attempt at the dissemination of such material in the school system was revealed.

Only in one province did the researcher have discussions with In-service Advisors (ISAs). All of ISAs, except one individual, had formal ICT qualifications. In order to facilitate and encourage the use of ICT in instruction these ISAs have to be geared to work with ISAs of other subjects.

Interpretation of the data collected at interviews with the academic officers of the National Institute of Education.

The use of ICT has to be done based on a rationale which provides guidance for the selection of lessons that demand ICT, device appropriate ICT enhanced learning material and evaluate the impact of use of ICT. In order to expedite the development of ICT enhanced learning material, customization of existing material may be recommended but at the same time the authenticity of such material has to be established with subject matter experts. It was very evident that the lack of human and physical resources had severely affected the progress of the Information Technology Department of the NIE in the attempt of the development of educational software. This has resulted in the underutilization of the potential of academic officers of this department.

Conditions prevailing that are favourable to the integration of ICT in the instructional process in the school system as summarized from analysis of data.

Principals, teachers and students strongly believed that the use of ICT would enhance students' learning and boost their motivation to learning. The current status of the computers in the ICT laboratories is satisfactory. A vast majority of teachers in charge of the laboratories had arrangements to keep the laboratories open in their absence. Further, they maintained a reservation system for the allocation of laboratory periods to teachers. They were all eagerly looking forward to improvements by the educational authorities to enhance the quality of the use of ICT in learning. Principals were confident that teachers were capable of handling this integration. Teachers have made constructive suggestions such as provision of multimedia projectors, speeding up of the Internet connection, centralized scheme to develop ICT based learning material, and upgraded professional development programs to improve the

current situation. Further, they sincerely welcomed peer coaching as a part of professional development programs.

Conditions prevailing that are not favourable to the integration of ICT in the instructional process in the school system as summarized from analysis of data.

The main problem was the lack of time available in the ICT laboratory for learning with ICT. The professional development programs received by the principals and teachers were not aligned with the true integration of ICT in the instructional process. The availability of an adequate number of educational software in the students' mother tongue was a barrier to the use of ICT. The speed of the Internet in most cases were not adequate. The absence of powerful centralized involvement in the design and development of ICT enriched learning material retards progress. Most schools complained that they did not have adequate funds to meet the maintenance cost of ICT laboratories. Various private sector organizations have attempted to contribute to the use of ICT in the instructional process in the school system but they did not seem to act in consultation with the curriculum authorities (NIE) of the country. This could result in waste of useful time in the school timetable and disorientation of teachers with respect to the correct use of ICT in the curriculum. Above all, it was observed that the absence of a theory based, comprehensive and flexible methodology to integrate ICT in the instructional process would hinder the attempts to harness the full potential of the available ICT resources in the schools sector.

How to rectify the deficiencies prevailing in the school system to ensure successful implementation of ICT integration plans in the instructional process.

Certain deficiencies such as lack of ICT laboratory hours cannot be rectified forthwith as this demands construction of additional ICT laboratories. Slow Internet link is another problem and this has to be discussed with the authorities concerned with the provision of this facility. On the other hand it is a matter of concern how long the Internet supply will be provided free of charge. Lack of suitable educational software is another problem and either the MOE will have to raise funds to outsource

the provision of such software and/or strengthen the government sector like NIE to produce an adequate number of software. Professional development of teachers and principals needs to be reviewed and streamlined. More training sessions need to be carried out studying their needs carefully.

Recommendations

The recommendations made in order to ensure the effective use of ICT in the instructional process are based on the empirical data collected in case studies, responses to questionnaires, matters revealed at interviews and facts extracted from literature review. The recommendations are forwarded as a model that is composed of two components: functional and non-functional specifications. The functional component consists of two parts. The first is a model to plan, create, implement and maintain ICT solutions to learning problems. The second is a methodologies on how to utilize commonly available generic software tools to integrate ICT in the instructional process. The problems discovered that hinder the successful integration of ICT are expected to be rectified in order to ensure a supportive structure for the sustainability of the ICT integration process in the non-functional component of the model.

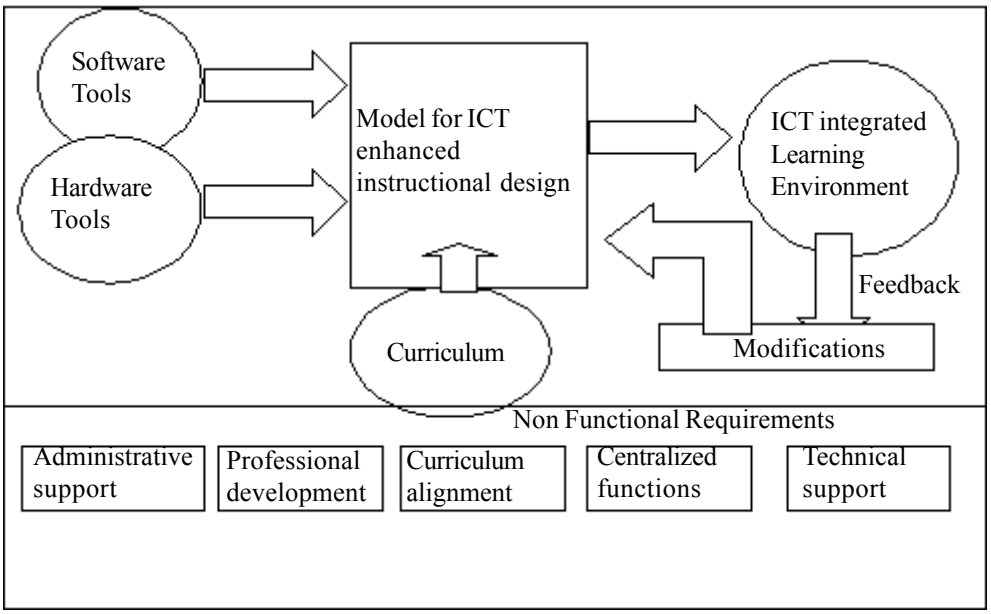

Figure 1: Model for integration of ICT in instructional process

Functional Requirements

The functional requirements should indicate how to enhance students' cognitive development and improve motivation to learn by implementation of effective and efficient interactivity with subject matter that is coded in multimedia based on the principles of multimedia learning. The view was shared by curriculum developers as well as teachers were very careful planning and deep comprehension is required to ensure such an effective method. ICT resources, tools, content and pedagogy are to be seamlessly integrated into one coherent entity to confirm a successful ICT integration in instruction. Further principals also joined to ratify the view that the integration of ICT in instruction should and will not commence at the classroom level It should be initiated at the time of curriculum design: including content identification, design of instructional methods and formative and summative evaluations. At least well defined links should be extended to the parties who subsequently undertake to complete the process by completing ICT integration plans at classroom level. This is evident from the teachers' agreement to the use of learning objects. Learning objects are small electronic units of educational information that are flexible, reusable, customizable, interoperable, retrievable, facilitate competency-based learning, and increase the value of content (University of Wisconscin-Extension: Glossary) In general, many educationists have proposed various models to integrate ICT in instruction. Most of them are at high levels of abstraction and very few are found to be dealt with at the instructional level. The following is such a model for the integration of ICT in instruction. Although no teacher who participated in the case studies had completely conceptualized the integration of ICT in the instructional process as a well defined structure, some of them had really followed certain aspects of good practices.

Based on this empirical data and guided by research data found in literature review, the following model is recommended for ICT enhanced instructional design.

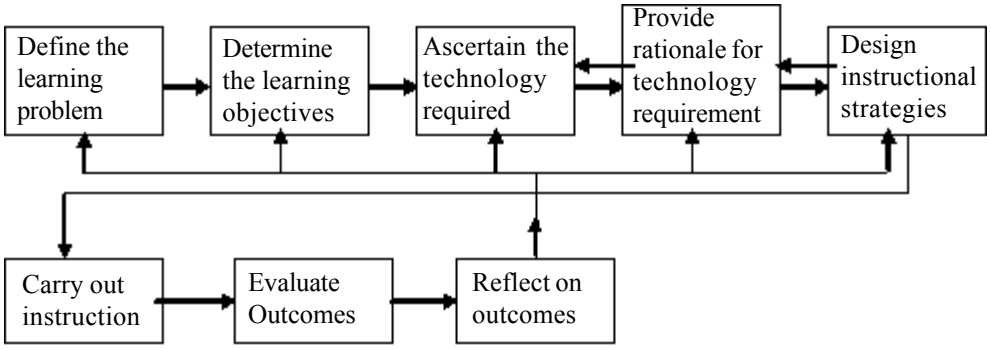

Figure 2 : Model for ICT enhanced instructional design (Adaptation of systematic model for ICT integration by Wang & Woo (2007))

This systematic model starts with a problem statement, which describes the major problems or issues to be addressed in a topic. Teachers may state specific learning objectives for a particular learning event but have to be based on those specified in the curriculum. Teachers should justify the selection and the use of technology. Once teachers establish the required technology and rationale, they design strategies to implement ICT supported activities. The entire task has to be analysed into several sub tasks and how the ICT is to be integrated has to be separately identified. It is very important that the integration of ICT should not lead to deskilling of students.

The following is a guideline for this purpose.

1. Students' and teachers' activity in each subtask.
2. What particular ICT resources and tools are to be used and how.
3. Ensure technical support right through.
4. Saving and backing up of information collected.
5. Time frame to be adhered to.
6. Teacher's role as facilitator.
7. The output of each subtask is meaningfully constructed to be used in the following tasks.

Evaluation is of two forms: formative and summative. Formative evaluation is implemented while students are engaged in the activities. The observations made by the teacher are base for this evaluation. Teachers should provide necessary feedback and "feedforward" to students, set them on the learning objectives and the effective use ICT resources and tools in particular, the time management. Summative evaluation is done on the final product and on the process followed by the students. The final product should reflect the use of ICT resources: either directly or indirectly. Any plan that looks good will not give guarantee of success until its impact is evaluated. If a plan is to be repeated over and over again reflection on the outcome and the conduct is essential. The arrows leading back to the steps followed indicate this concept. The results of reflection point to the probable modifications of the process. For this purpose teachers themselves should have a portfolio or at least mental notes of what they have observed during the process and students portfolios or verbal feedback. To go ahead with this model several popular and available at school level software tools are proposed here.

Use of computer-based presentations in the instructional process

Although it was initially not meant to use as a learning tool, computer-based presentations are gaining popularity in instructional process. It is very important that special care and attention have to be paid in the use of computer-based presentations in the classroom since, if inappropriately developed, such presentations can cause more harm than any good. Computer-based presentations could be used in two basic modes: one-to-many and one-to-one. In other words the former is teacher-centered and the latter is student-centered. The one-to-many mode in instruction is conducted with one computer coupled to a multimedia projector or using any software application for audio and video conferencing on a local area network such as "NetMeeting" on Windows OS. Following guidelines are worth adhering to develop effective electronic presentation in learning. It is important to note that slides are guides. Layout design, right use of color and multimedia and duration of a slide are other important considerations. The development of effective computer-based presentation is a skill-demanding endevour and a resource-intensive process. Therefore, this work has to be facilitated by organizing teachers' workshops at least at school level to ensure a concerted effort in making presentations. The spending on resources is an investment

as most work can be shared and are reusable. Periodically, presentations once prepared have to be updated in similar workshops making use of the reflections of teachers.

The use of computer-based encyclopedias in the instructional process.

It has been observed that the use of computer-based encyclopedias is a popular mode of aiding learning. Schools have been provided with two such commercial products. The limitation in this attempt is that text and narrations are not in the students' mother tongue. For the effective use of encyclopedias the search on them should be purposive and focused to a well set target based on the subject matter. Teachers can use the model in Fig.1 to design and develop such learning experience. The simplest form of an activity is to give students a question paper to answer, searching information from the encyclopedia. Computer based encyclopedias can be integrated as a part of project based learning also. Whatever the activity it should have a special reference to the curriculum. Activity and output should not be made by the students by copying and pasting information from the encyclopedia and teachers should take special care to avoid this and design activities to ensure students' deep processing to come up with the final product. The final output may be computer based like wordprocessed document, oral presentation using computer based slides or handwritten wallpaper.

Use of Internet in the instructional process

In this study use of Internet was not found to be used effectively in the instructional process. Based on the facilities available and the revealing of the literature review several modes may be proposed. The mediation of the teachers in this regard is very important as the authenticity is an issue in the Internet based information. On the other hand the volume of information resulting searches, suitability of information, language issue and speed of Internet access in the schools demands remodeling of the use of Internet in the instructional process. Again the model in Fig.1 can be used for this purpose. Teachers will have to plan all the Internet based activities beforehand and all the very relevant websites have to be downloaded and stored. Later, new websites have to be made using the downloaded web pages to suit the assignments. The new websites can either be saved on the server of the LAN of the ICT laboratory

or on individual computers. If there is the opportunity, these web pages can be translated into the students' mother tongue. The websites may be edited to remove irrelevant information and restructured to suit the assignments. On a later stage students are given assignments to work out, using the downloaded websites. . This strategy ensures that students access correct and relevant information, avoids speed problem of Internet as students work off line of Internet and prevent students accessing unsuitable material . Schoolnet is the Ministry of Education sponsored web site to promote web-based learning. This website has published learning resources. Teachers or students also can contribute to this collection. Schoolnet hosts about 544 school websites and a small number of them have included a page for information drawn from their locality that is of educational value. Students should be encouraged to contribute more and more of such information so that students could share them across the country. For example students of the North Central province could include photographs of ancient ruins in their websites. Inclusion of photographs and details of fauna and flora would enable science students learn lessons in bio-diversity. This type of endevour may not be spontaneous and needs motivation to maintain. Therefore, teachers should initiate these activities. Another useful application of Internet is to create a group mail and upload assignments so that when a teacher is absent the students can download the assignments, work them out and either e-mail to the teachers or manually submit on a later date. This kind of a practice was found out in one of the case studies.

Use of spreadsheet software in the instructional process.

Spreadsheet software offers database management, statistical and mathematical calculations and business graphics, among other things. The above functions have productive use in learning as well. The direct use of computational facilities may harm students' manual skills. Therefore, students should be encouraged to do manual calculations and then verify results on spreadsheets. Spreadsheet software is useful in the statistical data analysis part of students' projects. It is imperative that students should use the computing available in spreadsheet software with understanding. For example, in project based learning of the study of the weather during a period of about six months, quite a volume of data may be collected. This data can be stored on

a spreadsheet and updated regularly. This project may demand plotting of graphs, creation of various charts, sorting and searching of information. Teachers should discuss with students to identify and advice possible spreadsheet applications beforehand. Further, teachers should ensure that students are able to do all analyses and plotting of graphs manually, prior to the use of spreadsheet software. Students who learn accounting could simulate a ledger system on spreadsheets software. Here again, spreadsheet application is only be used to verify the manual maintenance of accounts. Extraction of trial balances, profit and loss accounts, balance sheet etc. can be automated using spreadsheet software. Book-keeping and accounting of a fictitious business undertaking may be set as a project for accounting students. This project should be an on going one extending up to at least six months.

Use of database management software in the instructional process.

Databases and the management thereof are very important concepts in any context that uses a large volume of data. Understanding these concepts and learning how to manage data are useful in any stage of one's life. Although learning database management is somewhat demanding, very interesting educational applications can be created. Therefore, the teacher will have to create the application for students to interact with. Database management software can include textual information and multimedia. To create an encyclopedia, teachers can use database management software. As many teachers wished this software can be used to create and maintain a database of questions for revision purposes. The most popular and easy to implement variety is multiple choice questions.

Non functional requirements at the school level

In the Sri Lankan school system as revealed by the study the major problem is the limitation of the availability of ICT laboratory time slots for the use of ICT in the instructional process of non-ICT subjects. The main reason is that the same laboratory has to be shared between the students of ICT subject and the others. Hence a separate ICT laboratory is preferable for effective use. In order to have consistent technical and pedagogical support the service of a fully released teacher was well established. Principals should be professionally developed with respect to his role in the integration

of ICT in the classroom. Peer coaching should be encouraged to ensure extensive participation of teachers. A classroom fitted with a computer and a multimedia projector is very useful to conduct lessons using computer based presentations. This is a well supported discovery of this study. A comprehensive monitoring and assisting system should be implemented at zonal level to ensure the longevity of ICT integration.

Non functional requirements at the national level

The professional development programs for teachers on the integration of ICT should be designed and developed by the NIE that is the apex state body that specializes in curriculum and instruction. Implementation may be deployed to provincial level conducted by the master teachers trained by the NIE. School curriculum should be reviewed to identify and suggest feasible ICT integration areas by the NIE. Development of CAL material may be decentralized to provincial levels under the purview of the NIE. The NIE should be further strengthened to meet these demands.

Limitations of the study

The expected number of participants on the study has not responded to the questionnaires. Only one case study each was possible in the North-Western and Central provinces due to the conditions beyond the researcher's control during the data collection period. The effect, so far, on the cognitive development and motivation to learn of students who used ICT in learning could not be studied quantitatively. Due to the limited access of teachers to ICT laboratories, that resulted from the larger number of classes in grades 6-11, their experience in the use of ICT in instruction was not comprehensive. Therefore, hard evidence with respect to the cognitive development and motivation to learn in students as a result of interaction with ICT enhanced learning material, was not found in abundance.

Further research

The effectiveness of the model proposed in this study can be evaluated only after a lapse of time after implementation of the ICT solutions derived from this model. The solutions should be carefully designed to suit the context variables stipulated in the non-functional component of the model. Although a quantitative approach could

be made for research to ascertainment of the efficacy of these solutions, it is desirable to provide space to accommodate qualitative data also. Further, it is useful to conduct separate research to determine how the context variables affect the effectiveness of integration of ICT in the instructional process.

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