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Margaret Wu[1]

[1] Victoria University, Melbourne, Australia

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Evidence-Based Policy Making in Education

Margaret Wu[1*]
[1] Victoria University, Melbourne, Australia

Abstract

In the current climate of "accountability" and "transparency" as demanded by the public, policy makers justify their actions by drawing on research findings and data collected by various means. There appears to be a belief that quantitative data provide more credible evidence than qualitative data. Hence the use of data has become pivotal in decision-making. More recently, education policy documents drawing on international student survey results have appeared around the world. This paper evaluates some of the evidences used by policy makers and shows that there is a great deal of uncertainty surrounding the data underlying these research findings. More importantly, the paper demonstrates that statistics alone cannot provide hard evidence. In fact, we need to draw on our own experience and a great deal of sense-making in interpreting data and drawing conclusions.

Key words: Evidence-based decision making, accountability, transparency.

Introduction

In recent years the rhetoric from politicians has often included words such as accountability, transparency and evidence-based decision-making. While accountability and transparency should be central in policy-making, there are cases where such processes are based on misguided evidence, and the proposed policies can be ineffective or even detrimental to public interests.

As an example, a New Zealand Treasury briefing paper released in March 2012 (New Zealand Treasury, 2012(a)), suggested that low student performance related to ineffective teaching. Therefore if the quality of teaching can be lifted, student performance will be raised. Further, the briefing paper recommended increasing class size to free up money to fund initiatives to raise the quality of teaching. The briefing paper cites numerous research papers and reports to justify the recommendations. Similarly, in a policy paper titled "Lessons from PISA" (Paine & Schleicher, 2011), the authors believe that investing in the improvement of teacher quality is the most important lesson for the United States from PISA (Programme for International Student Assessment). The article further cites an OECD report that an increase of 25 PISA score points will lead to a gain of $41 trillion for the U.S. economy, thus linking student achievement to GDP.

This paper examines some of the evidence used by policy papers such as the examples given above. The purpose of this paper is to bring a statistical viewpoint about data, to take a closer look at how research findings can be cherry-picked for shaping education policies for whatever reason, and to raise cautions for anyone using research findings. Some published data sources are used as examples to illustrate the pitfalls in putting too much trust in quoted research findings. These examples include findings from the OECD PISA project. The key issue relates to the complexity of the modern world where contributing factors to educational achievement are multi-faceted and intertwined. Data collected often have many caveats attached. The interpretation of data requires statistical literacy well beyond the knowledge of the layperson.

Notwithstanding the critical nature of this paper on the use of evidence, it should be made clear at the outset that the benefit of education is not disputed and that improving education should stay high on policy-makers' agenda. The aim of this paper is to highlight the complexity and potential misuse of data, and suggest that "numbers" alone do not provide hard evidence, but numbers must be interpreted with well-grounded theories. So, in fact, sense-making is essential in using evidence to shape policies. This paper concludes that while "consumers" of educational research need to be vigilant about the applicability of research findings, the ultimate

* Corresponding Author: *Margaret Wu, margaret.wu@vu.edu.au*

responsibility must reside with the researchers themselves to provide clear and solidly grounded results and recommendations. Thrupp's article (Thrupp, 2010) titled "The politics of being an education researcher: minimizing the harm done by research", clearly highlights the need to be aware of how research findings could be misused, and that the responsibility also falls on the researchers to prevent the misuse of their findings. This is really where accountability and transparency start. Unfortunately, many research reports still fall short of taking such cautions, as the following examples illustrate.

Linking education outcomes to economic and social benefits

As an example, the New Zealand Treasury illustrated the benefits of lifting student achievement by linking educational outcomes to economic growth. According to the Treasury:

"... if overall student achievement could be lifted by 25 PISA points ... GDP would be expected to be higher than it otherwise would be by 3-15% by 2070." (p.2, New Zealand Treasury, 2012(a))

The assertion that improving education will have economic and social impact seems plausible. However, it would appear equally believable to suggest that the causal relationship is the other way round, or in fact, bi-directional. That is, improving the economy will raise education standards. OECD PISA 2009 report (OECD, 2010a) states:

*"...*GDP per capita influences educational success, but this only explains 6% of the differences in average student performance.*" (p.3, OECD, 2010a)*

First, the PISA report casts the relationship between education outcome and GDP as one where GDP *influences* educational success, not the other way round. Second, PISA results show a tenuous relationship between education performance and GDP. Figure 1 shows a plot of GDP against PISA 2009 Reading mean score for 34 countries, where each data point in the plot is one country (Source: OECD, 2010a, p35).

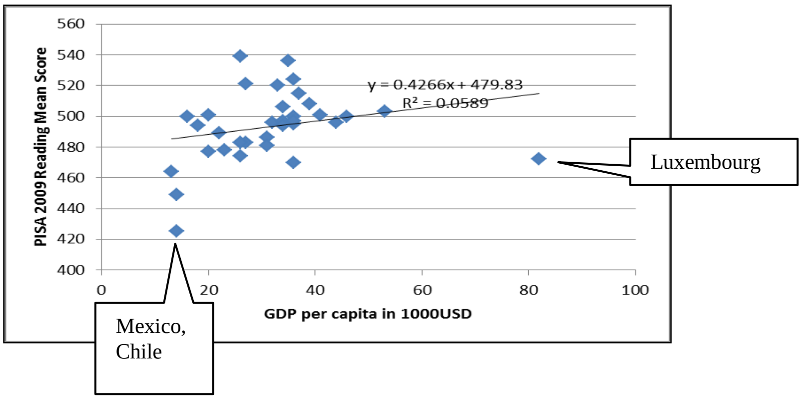

Figure 1. PISA 2009 Reading performance and GDP

Figure 1 does not show any discernible linear relationship between Reading mean score and GDP, at least not visually. For example, Mexico and Chile appear to have lower than expected Reading scores given their GDP values. Further, Luxembourg has very high GDP, but its Reading performance is not the highest in the group of countries shown. This shows that the relationship between Reading score and GDP depends very much on the set of countries being analysed, and the PISA data do not suggest a strong relationship between education outcome and GDP.

Despite the inconclusiveness of establishing a clear association between Reading performance and GDP, the PISA report (OECD, 2010a) makes the following claim on page 158:

*"...*bringing all students to Level 2 [on the PISA reading scale] could boost the combined economic output of OECD countries by around USD 200 trillion.*" (p.158, OECD, 2010a)*

But a cautionary note follows this claim:

"While such estimates will always be associated with considerable uncertainty, they suggest that the cost of educational improvement is just a fraction of the high cost of low educational performance." *(p.158, OECD, 2010a)*

So in this excerpt, the PISA report reverses the direction of the causal relationship and suggests that higher student performance could lead to much higher GDP. It is also surprising that such claims are made while stating that there is *considerable uncertainty*.

It is not surprising that policy-makers are confused by the recommendations made by OECD. Unless one pays attention to the caveats in the reports and carries out one's own analyses with the data, a person can easily begin to make big claims about how education outcomes can lead to GDP growth. In contrast, PISA data tell us that the relationship between education outcomes and GDP depends greatly on an individual country's context. Making forecasts on GDP growth based on students' test scores is extremely unreliable. Yet, policy-makers frequently made these claims, citing the OECD reports as evidence and ignoring any note of caution.

Making conjectures about the direction of causal relationships is not just confined to OECD reports. A report by Hanushek and Woessmann (2009) about education outcomes and economic growth also suggests that education achievement increases GDP. Hanushek and Woessmann attempted to establish that the relationship between international testing results and GDP was causal. They did this by controlling for possible mediating variables, and concluded that the association between test results and GDP was not likely due to other mediating variables, but there was a *real* association. Nevertheless, Hanushek and Woessmann never established the direction of the causal relationship. In fact, the test data used in the Hanushek and Woessmann report were mostly obtained in the past 20 years, while the GDP growth data were for the past 50 years. Any association established between test scores and GDP will likely suggest that higher GDP leads to higher test scores rather than the other way round. If high test scores lead to high GDP, then one would expect a time lag for the association, since today's students are tomorrow's workforce. If the students have high test scores, their impact on GDP will only be apparent after these students participate in the workforce. Notwithstanding these arguments, Hanushek and Woessmann suggest that high test scores lead to high GDP, as reflected in the title of their report.

The above example is not used to refute the claim that education level is related to economic growth. The relationship between education and economy may very well exist, but the particular set of OECD data shown in this paper does not lead to such conclusions. This could be because the analysis is too crude – perhaps other contextual factors need to be taken into account, or perhaps the sample size is too small to provide the power to establish a relationship. Nonetheless, there is an inconsistency between the data and the findings. In particular, putting a dollar figure (USD 200 trillion) based on a very tenuously established regression line is making a very far-fetched inference.

There have been many studies examining the link between education and economic growth. Bredt and Syez (2007) carried out an extensive literature review on this topic and reported that a large number of studies have found a positive association between education and economic growth, but the empirical work in these studies has not been able to establish any causal link between education and economy (p. 7). Bredt and Syez suggest a bi-directional relationship:

> *Not only will more technologically advanced economies require a higher skilled workforce, but they will also have the resources to invest in expanding their educational institutions and research sectors. (p.7, Bredt & Syez, 2007).*

The point of the above discussions is not so much about determining exactly how education will affect economy, but the examples demonstrate that, at least in some cases, researchers have not been particularly prudent in making claims of causal relationships. When an association is observed between two variables, it is tempting to draw conclusions of causal inference and make claims on the direction of the causal inference. The next section shows why statistics alone cannot be used to establish causal relationships. This is a common source of misunderstanding among people who are not familiar with statistical methods.

Establishing causal relationships

It is unfortunate that in regression analysis in statistics, the variables are termed explanatory (X) and dependent (Y) variables, in the regression equation $Y = a + bX$. Such nomenclature suggests a causal relationship, i.e., X has an impact on Y. But in fact if we reverse the equation and fit the model $X = a + bY$, we obtain exactly the same statistical significance result, as illustrated in the example below. Table 1 shows the data of GDP and Reading mean scores for 34 countries (data source: OECD (2010a), Table I.2.20, Annex B1, p219).

Table 1. PISA 2009 country Reading mean score and GDP

Country	PISA 2009 Reading	GDP (x1000USD)	Country	PISA 2009 Reading	GDP (x1000USD)
Australia	515	37	Japan	520	33
Austria	470	36	Korea	539	26
Belgium	506	34	Luxembourg	472	82
Canada	524	36	Mexico	425	14
Chile	449	14	Netherlands	508	39
Czech Republic	478	23	New Zealand	521	27
Denmark	495	36	Norway	503	53
Estonia	501	20	Poland	500	16
Finland	536	35	Portugal	489	22
France	496	32	Slovak Republic	477	20
Germany	497	34	Slovenia	483	26
Greece	483	27	Spain	481	31
Hungary	494	18	Sweden	497	36
Iceland	500	36	Switzerland	501	41
Ireland	496	44	Turkey	464	13
Israel	474	26	United Kingdom	494	34
Italy	486	31	United States	500	46

The results for a regression analysis with Reading as the dependent variable and GDP as the explanatory variable are given in Table 2

Table 2. Regression Reading = a + b GDP

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	479.828	10.310		46.542	.000
	GDP	.427	.301	*.243*	*1.416*	*.167*

a. Dependent Variable: Reading

For those who are not thoroughly familiar with regression analysis, the results (highlighted in *italics* in Table 2) of the analysis show that the (standardized) coefficient, Beta, in the regression equation is 0.243 and is not statistically significantly different from zero (Sig. is 0.167, greater than 0.05 for the 95% confidence level). So OECD's claim that GDP explains 6% of the variance of Reading mean scores should be revised to *there is no strong evidence that GDP is correlated with Reading mean scores*. Note the 6% comes from $(0.243)^2=0.06$, but 0.243 has been found to be not statistically different from zero.

When the dependent and explanatory variables are swapped, the results of a regression with GDP as the dependent variable and Reading as the explanatory variable are shown in Table 3.

Table 3. Regression GDP = a + b Reading

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	-36.464	48.202		-.756	.455
	GDP	.138	.098	*.243*	*1.416*	*.167*

a. Dependent Variable: GDP

Note that the significance level of the regression coefficient in Table 3 is exactly the same as that in Table 2.

In fact, the computation of the correlation coefficient produces exactly the same statistical significance results, as shown in Table 4.

Table 4. Correlation between Reading and GDP

Correlations

		GDP
Reading	Pearson Correlation	*.243*
	Sig. (2-tailed)	*.167*
	Sample size	34

Table 2, Table 3 and Table 4 show that regression analysis tells us only about correlations, despite the fact that we *hypothesise* a model with a causal relationship. When a statistically significant result is obtained from a regression, all we can say is that there is an association (correlation) between two variables. The regression analysis does not provide evidence of any causal relationship. Similarly, for more sophisticated regression analyses, such as path analysis and structural equation modelling, the causal relationship model is *hypothesised*, but the results are really estimates of correlations. The direction of a causal relationship is an interpretation made by the researcher, not suggested nor verified by the statistics.

It is difficult to estimate the number of researchers who misunderstand results of regression analysis. But judging from the number of papers and reports where the authors make assertions of causal relationships based on regression analysis, it is worthwhile highlighting these statistical facts.

There are further complications in establishing causal relationships between variables. A classic (and somewhat absurd) example in statistics for demonstrating the invalidity of drawing conclusions about causal relationships is that ice cream sales have been found to be positively correlated with the crime rate. It has been found that there is more crime in summer, and, of course, there is more ice cream sold in summer. In fact there is no real association between crime rate and ice cream sales, although there is a statistical correlation. In this case, “the time of the year” is called a mediating variable in the sense that crime rate and ice cream sales are mediated by “the time of the year”.

So how does one identify causal relationships if statistics alone cannot? Let’s consider the case of cigarette smoking and lung cancer. If a statistical correlation is observed between smoking and the incidence of lung cancer, three propositions can be made. The first is that lung cancer causes smoking; the second is that smoking causes lung cancer; the third is that there is no real relationship between smoking and lung cancer as there are mediating variables at play. The first proposition is clearly illogical. The second and the third are likely. Since there are other evidences to demonstrate that smoking damages the lungs, the second proposition is entirely a reasonable one, so we conclude that (it is most likely) smoking causes lung cancer. In other words, the conclusion is not based on statistics alone. Additional evidences and a great deal of reasoning are required in making causal inferences. So, it is essential to have a theoretical model that underpins the interpretation of statistical results. Not only that the hypothesised models need to be plausible, there need to be well-grounded theories to explain data. Currently, a problem with the use of evidence is that people often believe “numbers” have more status as evidence and they draw conclusions based on statistics alone, even when the conclusions are contrary to their good judgment. The proposal to increase class size is such an example.

Some reported causal relationships in Education

The OECD PISA study produces a set of student outcome measures in Reading, Mathematics and Science. In addition, PISA provides measures of student and school characteristics in each country. Linking the two sets of measures is not an easy task and it is always a conjecture to draw conclusions about which educational characteristics influence student education outcomes. In fact, OECD states the following:

> "While PISA cannot identify cause-and-effect relationships between inputs, processes and educational outcomes, it can highlight key features in which education systems are similar and different, sharing those findings with educators, policy makers and the general public." *(Vol. V, p18, OECD, 2010c)*

If PISA data are to be used for shaping policy, there need to be a great deal of reasoning and other evidences to form propositions for good policies. The problem is that PISA data also have limitations. In particular, not all salient factors to the success of education outcomes are included. For example, the prevalence of coaching schools and parental pressures in the top performing Asian countries has not been captured as part of the education environment. Conclusions are drawn based on what are provided by the PISA data set. It is quite possible that the key reasons for success in achieving, say, high mathematics test scores, have a great deal more to do with the sheer number of study hours outside schools, than with teaching methods and school management. Students' lives outside the school are not typically captured in many educational surveys.

Bearing in mind the above cautions about establishing causal relationships, we turn our attention to the suggested impact of "prioritising teachers' salaries over smaller class sizes" by OECD:

> "…many successful school systems share some common features: … spending in education that prioritises teachers' salaries over smaller classes." *(Vol. IV, p29, OECD, 2010b)*

There is actually no statistical evidence of the above statement from the OECD PISA data. Table 5 shows a summary of class size and teacher salary data from PISA (Vol. IV, p85, OECD, 2010b, Figure IV.3.7).

Table 5. Number of Countries by Class Size and Teacher Salary

	Small class size and/or *low* teachers' salaries	*Large* class size and *high* teachers' salaries	Number of countries performed higher than OECD average in reading / Total number of countries
Low cumulative expenditure on education	3 out of 31 countries performed higher than OECD average in reading.	3 out of 12 countries performed higher than OECD average in reading	6/43
High cumulative expenditure on education	8 out of 20 countries performed higher than OECD average in reading	2 out of 2 countries performed higher than OECD average in reading	10/22
Number of countries performed higher than OECD average in reading / Total number of countries	11/51	5/14	16/65

To test whether countries with large class size and high teachers' salaries tend to perform better in reading, a binomial test can be carried out. That is, if, overall, there are 16/65 (about 1 in 4) countries with higher than OECD average performance, is it unusual to have 5/14 (about 1 in 3) countries with higher than OECD average performance in the "large class/high salary" category? The significance level from this test has a p value of 0.11, which is not statistically significant at the 95% confidence level.

(As an aside, in contrast, a statistical test for whether countries with high cumulative expenditure in education perform better in reading has a p value of 0.01, which is highly statistically significant. That is, about half the countries with high expenditure in education performed above the OECD average, while only a quarter performed higher than the OECD average for all countries in the OECD study.)

In short, based on this data set, there is no strong statistical evidence that "prioritising teachers' salaries over smaller class sizes" leads to a better educational outcome. Further, it is unclear why the OECD report directly links teacher salaries and class size and regards this as a trade-off choice made consciously by the countries. The countries with large class size and high teachers' salaries are Brazil, Chile, Colombia, *Hong Kong*, Indonesia, *Japan*, Jordan, *Korea*, *Macao*, Mexico, *Shanghai*, *Singapore*, *Taipei* and Thailand. The high performing east Asian countries are all in this group (italicised country and city names). These countries generally have high population density and share similar cultural backgrounds. The teaching styles in these countries are in general compatible with large class sizes. Further, the demands on resources (such as land, buildings and infrastructure) of highly populated countries may necessitate large schools and large classes, and it is not a matter of choice to have large class size for the single purpose of increasing teachers' salaries.

Thus we need to question the claim of the impact of "prioritising teachers' salaries over smaller class sizes", and further question whether such a policy is compatible with the valued pedagogy of Western countries in particular, noting that no Western country has yet "chosen" to take on this priority.

Some comments about trading priorities

The difficulty about prioritising policy measures is that the trade-offs are not quite as easily evaluated. For example, the effect of having larger classes is not only a reduction in the number of teachers, but there will also be an increased workload on current teachers. Teachers will need to spend more time marking assignments, for example. If individualised learning is implemented, there must be more work for the teacher if there are more students in a class. Even if there is funding (saved from hiring fewer teachers) for teacher professional development to raise teaching quality, teachers will have less time to participate in such professional development owing to the added workload. Further, many quality teaching practices are not compatible with large class size. Thus the idea that priorities can be easily traded is flawed, since many policy measures are interrelated. One danger of the misuse of statistical information is the belief that net effect size of factors contributing to educational achievement can be computed using simple arithmetic. For example, if class size has a smaller effect size than teaching quality, then it is assumed that we can prioritise teaching quality over class size, and have a net positive effect. This is not to mention that effect sizes of various factors depend greatly on the contexts in which they are measured, and there are wide variations from different studies, so that in fact effect sizes are not reliably measured in the first place.

Conclusion

This paper has demonstrated that data often do not have the reliability and validity the public generally perceive, particularly when inferences are made from the data about causal relationships. In fact, statistics alone should not be used to draw conclusions about causal relationships. We need to bring a great deal of well-grounded theories to bear in using data. Simplistic interpretations of data can only lead to ineffective or even damaging policy measures.

Politicians, like the public, are end-users of research findings. One can hardly put blame on their misconstrued interpretations of data if the authors of research reports are careless in drawing conclusions. While there may be cautionary words about the reliability and validity of data, sometimes authors are not always consistent with heeding their own cautions in making claims of research findings. Consumers of research findings are not all familiar with statistical procedures. They will have little chance of unravelling the complexities of the data so they can be easily misled by such research reports. Like "Chinese whispers", when a major report has been used and quoted by several researchers in succession, the cautions and caveats stated in the original report are often lost, and the claims of research findings become unequivocal.

Consequently, the ultimate responsibilities must reside with the researchers to ensure that only valid conclusions are drawn. Policy-makers and the public need to understand that not all data present evidence.

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The Effects of Reading Strategy Instruction via Electronic Storybooks on EFL Young Readers' Reading Performance

Yu-Ju Fu[1], Shu-Hui Chen[2], Shyh-Chyi Wey[1], Shu-Chu Chen [1]
[1] National Yunlin University of Science and Technology
[2] National Taipei University of Education

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The Effects of Reading Strategy Instruction via Electronic Storybooks on EFL Young Readers' Reading Performance

Yu-Ju Fu[1], Shu-Hui Chen[2], Shyh-Chyi Wey[1], Shu-Chu Chen [1*]
[1] National Yunlin University of Science and Technology
[2] National Taipei University of Education

Abstract

The prevalence of web-based applications and the use of multimedia in school make learning and teaching through the Internet a popular method in education (Ferdig, 2005). To keep in line with the trend, the purpose of the study was to explore the effects of reading strategy instruction via electronic storybooks on EFL elementary school students' reading comprehension, their strategy use and their viewpoints toward electronic storybooks-based reading strategy instruction. Fifty-seven Taiwanese EFL fourth graders from two intact classes were chosen, and assigned as an experimental group and a control group. The experimental group received a ten-week reading strategy instruction whereas the control group did not engage in any strategy training. The experimental group were taught seven reading strategies, which were practiced in small groups. The instruments included one STYLE proficiency test, five reading comprehension tests, and questionnaires of strategy use and an attitude questionnaire toward e-books based reading strategy instruction. Results indicated that after reading strategy instruction, the experimental group performed better than the control group in story comprehension, but without significance. However, they significantly outperformed the control group in strategy use. Also, the experimental group had positive attitude toward e-books based reading strategy instruction. Pedagogical implications were provided.

Key words: Electronic storybooks, Reading strategy instruction, Reading Strategy Use, Reading comprehension

Introduction

With the advance of modern technology, web environments offer possibilities to combine visual, verbal and auditory modes in multimedia presentations. The effectiveness of these capabilities available to L2 learner via multimedia has been the focus of modern technology. Therefore, the channels of learning are not limited to printed material, but extended to other modes of multimedia. Children may be exposed to books not only through parents' and teachers' printed storybooks reading, but also though the reading of electronic storybooks (e-books) which are available on the internet or on CD-ROMs (Korat, 2010).

As a valuable tool in educational settings, e-books have been widely used in classroom literacy learning in early school years (Ertem, 2010), and provide forms of comprehensible input. With the integration of texts, graphics, sound effects, animations, music and other multimedia components, they bring support to the story line (Chen, Ferdig, & Wood, 2003; Ertem, 2010) so that children can easily grasp the meaning of stories. Researchers showed that e-books not only enhanced students' reading comprehension but also developed their positive attitudes toward reading (Korat, 2010; Lin, 2010).

Even though there are positive effects of e-books reading on learners' reading comprehension, many students still struggle with reading due to the lack of efficient reading strategy use. In traditional reading instruction, teachers often spend most of the class time explaining the texts by centering on vocabulary teaching and grammar exercises, and seldom teach strategies directly in class. Students did not learn how to use various strategies to actively interact with the text (Deng, 2009; Lau, 2006). Furthermore, due to their low level of reading strategy knowledge and lacked of metacognitive control, they often select ineffective and inefficient strategies with little strategic intent (Yang, 2010).

* Corresponding Author: *Chen, Shu-Chu, chensc@yuntech.edu.tw*

In order to remedy the flaws, many strategy instructions practitioners advocated the implementation of reading strategy. The results showed that strategy instruction was a powerful approach to foster reading comprehension (Chamot, Barnhardt, El-Dinary, & Robbins, 1999; Cohen, 1998; Dole, Duffy, Roehler, & Pearson, 1991; Paris, Wasik, & Turner, 1991; Pressley, Goodchild, Fleet, Zajchowski, & Evans, 1989), increase students' autonomy in language learning and enhance learners' language proficiency (Green & Oxford, 1995; Griffiths, 2003), and strategy use for L1 English-speaking students (Bereiter & Bird , 1985; Palincsar & Brown , 1984), and for L2 learners (Hsiao, 2011, Luo, 2009). For instance, Bereiter and Bird in the L1 contexts (1985) using four strategies like restatement, re-reading, demanding relationship, and problem formulation, conducted a study to compare the effects of two types of instruction: "modeling-plus-explanation" and modeling. The "modeling-plus-explanation" instruction included an explanation of situations in which the four strategies could be used as well as the modeling of these strategies. Results showed that the experimental group receiving modeling and explanation performed significantly better on the comprehension post-test than the control group receiving only modeling.

Hsiao (2011) explored the effects of reading strategies instruction on Taiwanese junior high school students' reading comprehension in testing situations. It was found that participants became better in their awareness of reading as well as their reading ability, and the effective strategy use improved significantly after the reading strategy instruction. Also, participants held positive views toward the reading strategy instruction. The study suggested that instructors incorporate reading strategy instruction in normal English curriculum.

Moreover, the effectiveness of reading strategy instruction was also reported for EFL low proficient learners. Luo (2009) investigated the effects of reading strategy instruction, implemented with inferring and story grammar strategies, to help improve low-achievers' reading performance and reading strategies usage. It was found that the low-achievers had positive attitudes toward the reading strategies instruction concerning vocabulary knowledge, reading strategies usage, self-confidence, English test scores, and reading behavior. The results of this study also indicated the effectiveness of the reading strategies instruction in enhancing the low-achievers' reading performance, reading strategies usage, as well as learning motives.

Previous studies on multimedia have mostly focused on the comparison of the differences between the presentation form of electronic storybooks and printed storybooks. Limited research has been conducted to explore the specific effects of using e-books as digital teaching materials in reading strategy instruction for young EFL learners (Deng, 2009). In addition, early intervention research usually focused on the effects of teaching a single comprehension strategy, such as question, generation, mental imagery, or summarization, taught in controlled experiments. Relatively little is known about the issue of how multiple strategies can, and should, be combined in comprehension instruction (Guthrie, Wigfield, Barbosa, Perencevich, Taboada, & Davis, 2004). Therefore, in order to fill in the gap, this present study aims to explore the effects of reading strategy instruction via electronic storybooks on EFL elementary school students' reading comprehension, students' strategy use and their attitudes toward reading strategy instruction. In view of the preceding research purpose, three research questions to be addressed in this study are as follows:

1. What are the effects of reading strategy instruction via electronic storybooks on EFL elementary school students' reading comprehension?
2. What are the effects of reading strategy instruction via electronic storybooks on EFL elementary school students' strategy use?
3. What are Taiwanese EFL elementary school students' attitudes toward reading strategy instruction via electronic storybooks?

Literature Review

Studies of Reading Strategy Instruction

The goal of primary school education is to educate learners to achieve successful reading comprehension, which provides the basis for a substantial amount of learning in school education. In order to reach this goal, many reading studies have been undertaken to search for effective ways to foster children's comprehension (National Reading Panel [NRP], 2000). Among the various approaches used to increase L2 learners' comprehension, successful use of reading strategies has been recognized as an effective way to help increase reading comprehension (Karami, 2008).

Good reading strategy use constitutes a key to successful reading comprehension. It can help increase students' autonomy in language learning, in improving their language proficiency and reading comprehension (Green & Oxford, 1995; Griffiths, 2003). A number of researchers have advocated the employment of reading strategy instruction to facilitate students' reading comprehension, reading proficiency, strategy use, and develop positive attitudes toward reading (e.g., Chamot et al., 1999; Cohen, 1998). For instance, Song (1998) investigated the impact of strategy training on the reading ability of EFL university students. Results showed that the reading strategy training improved EFL college students' reading proficiency. The amount of gains made by the low and the intermediate reading proficiency group was also found to be significantly greater than that made by the high proficiency reading group. Finally, the students' ability of grasping main ideas and of making inferences from given passages was significantly enhanced. These findings suggested that strategies could be taught, which helped EFL tertiary students improve their reading comprehension ability.

Lim (2009) investigated the impact of strategy training on the reading abilities of EFL high school students. The study also aimed to obtain answers for the differential effect of the strategy training on students' reading proficiency level. Research findings showed that the reading strategy training improved EFL high school students' reading proficiency. Specifically, intermediate and high proficiency readers benefited more from the training than low readers. The study implied that reading was a high-order skill which could be automatized when the provision of sufficient linguistic input and strategy training was accessible.

Sporer, Brunstein, and Kieschke (2009) investigated the effects of three different forms of strategy instruction (i.e., reciprocal teaching, instructor-guided teaching and traditional instruction) on 210 elementary-school students' reading comprehension. It was found that at both the post- and follow-up test after the intervention, students attained higher scores on an experimenter-developed task of reading comprehension and strategy use than the control group who received traditional instruction. Furthermore, students who practiced reciprocal teaching in small groups outperformed students in instructor-guided and traditional instruction groups on a standardized reading comprehension test. The results of study corroborate the view that explicit instruction of multiple reading strategies was a feasible tool to enhance students' reading comprehension and strategy use and that third-to sixth-graders benefited most from explicit reading instruction supplemented with practice in small groups' reciprocal teaching activities.

Cotterall (1990) replicated Palincsar and Brown's (1984) study in the L1 context to analyze the effects of metacognitive strategy in reading instruction on four Japanese and Iranian ESL learners in L2 context. The findings indicated that the L2 learners benefited from the strategy instruction in their strategy use and reading comprehension. Nevertheless, a review of these studies showed that they mostly focused on the presentation form of printed storybooks, while use of electronic reading materials, a digitized form of multimedia, in reading strategy instruction were seldom explored.

E-Books and Reading Strategy Instruction

E-book is a digitized form of a book, and usually includs multimedia effects, such as written text, oral reading, oral discourse, music, sound effects, and animations. The oral reading of the text by the narrator, accompanied with the highlighted text, can provide the users insights into the nature of the written text by allowing the readers to conveniently follow the written words, phrases, or passages which are being read out to them. Electronic storybooks are designed to integrate texts, graphics, sound effects, animations, music and other multimedia components in order to bring support to the story line (Chen et al., 2003; Ertem, 2010). They can help children develop visual recognition and enhance story comprehension with rich context in the reading process (Ertem, 2010). In addition, multimedia features of e-books not only support processing and memory, but also develop readers' positive attitudes toward reading because their formats are more engaging, interesting, more enjoyable, and motivating to readers (Ertem, 2010; Korat, 2010; Park & Kim, 2011).

Because of the usefulness of e-books, many educators and researchers believe that the lively and attractive features of e-books and e-storybooks might present a useful means for supporting young children's literacy and language development (de Jong & Bus, 2003; Lefever-Davis & Pearman, 2005) based on the premise that the e-book type of software provides a more authentic reading experience rather than the more traditional drill or exercise method of fostering literacy (Ertem, 2010; McKenna, Reinking, Labbo & Kieffer, 1999; Korat, 2010). Also, reading storybooks to young children is regarded as an important activity that fosters young learners' literacy development and helps them develop positive attitudes toward foreign language learning (Ellis & Brewster, 1991; Krashen, 1981; Korat, 2010).

For instance, Korat (2010) investigated the effectiveness of an electronic book designed to support kindergarteners' and the first graders' vocabulary, story comprehension and word reading development. The results showed that the use of e-books increases students' reading comprehension, and the word knowledge. Also, children evaluated this e-book reading experiences as enjoyable and fruitful.

Ertem (2010) compared and explored the effects of the medium of storybooks presentations on struggling readers' reading comprehension. Each student was randomly assigned with one of three conditions: (1) computer presentation of storybooks with animation; (2) computer presentation of storybooks without animation; and (3) traditional print storybooks. The results of statistical analysis indicated that there was significant difference in the students' comprehension scores. When the student controlled the animation functions of electronic storybooks, the animated illustrations were shown to result in significantly higher improvement of comprehension scores, both in terms of the students' ability to retrieve information and to make inferences from the stories. The results of the research also indicated that electronic storybooks can improve reading comprehension and can be beneficial for struggling readers.

Although numerous studies have reported the encouraging findings of e-books, few studies focused on the effects of using e-books as teaching materials in reading strategy instruction. Specifically, few researchers implicitly linked the missing relationship among e-books, young readers, and reading strategy instruction by demonstrating that e-books could be applied in reading strategy instruction for young readers.

Therefore, in order to fill in the gap, this present study aims to explore the effects of reading strategy instruction via electronic storybooks on EFL elementary school students' reading comprehension, students' strategy use and their attitudes toward reading strategy instruction. Reading strategy instruction used in this study is based on a three-phase approach(i.e., pre-reading, reading, post-reading) proposed by many scholars (Brown, Pressley, Van Meter, & Schuder, 1996; Chen, 2009; Easterling-Adams, 2009; Houtveen & van de Grift, 2007; Pesa & Somers, 2007; Saricoban, 2002; Texas Education Agency, 2000).

Method

Research Design and Procedure

The study employed a quasi-experimental design to investigate the effects of E-Book based reading strategy instruction on EFL elementary school students' reading comprehension, and strategy use and attitudes toward reading strategy instruction. In terms of the research procedure, the study was conducted from October in 2011 to January in 2012. Two intact classes taught by the researcher herself were assigned into an experimental and a control group. The experimental group received reading strategy instruction integrated with e-book whereas the control group did not engage in any strategy instruction in their e-book reading.

In order to make sure that the two groups were similar in their English reading proficiency and their strategy use before the intervention, all participants in the two classes took the reading proficiency pretest and the strategy use questionnaire before the experiment. In the formal study, the experimental group received a training program for 10 weeks. After the training program, posttests on their reading comprehension, and strategy use questionnaires were given to the participants so as to compare the results in the pre- and post-tests. Finally, the quantitative data obtained were analyzed through statistics by using SPSS 17.

Participants

The participants were 57 Taiwanese EFL fourth graders from two intact classes in one elementary school. They both received instruction from the same teacher so that the instructor variable could be eliminated. The experimental group consisted of 28 students, with 14 males and 14 females, while the control group included 29 students, with 15 males and 14 females. Students' average age was about 10, and all of the participants have learned English as a required subject since the third grade. Therefore, they had at least 1 year of English learning at school.

In order to exclude the possibility that the participants' English reading proficiency may influence the results of the study, all participants in the two classes took a pretest before the experiment to ensure the homogeneity in reading proficiency. The pretest was adopted from a commercial English proficiency test-STYLE (Saxoncourt Tests for Young Learners of English). An independent-sample t-test using SPSS 17 was performed to examine if there was any difference in the proficiency test between the two groups. The two classes did not yield any significant difference ($t = .309$, $p > .05$), indicating that the participants in both groups were homogeneous and were at similar English reading proficiency level.

Reading Materials for Both Groups

The control group and the experimental groups read the same set of e-books. The experimental group, however, received an additional training on reading strategy instruction. The reading materials were from an on-line English learning website e-yep, which provided numerous English songs and English stories. The five stories chosen from the website e-yep were Wake up, Nancy!, Where's My Pencil?, Dinner Time for Pam & Bob, Bob Goes to the Dentist, and Clown School. The stories on the websites were assessed and analyzed by the electronic storybook selection criteria suggested by Shamir and Korat (2006). The on-line storybooks were chosen as teaching materials in this study because they met the following criteria: (1) clear story structure, (2) reading options (forward and backward buttons), (3) technical features (animation and sound). The five e-books used as teaching materials for the experimental group were the same as those used for the control group.

Training Program for the Experimental Group

Through the use of the electronic storybooks reading materials, the experimental group received 10-week reading strategy instruction from November, 2011 to January, 2012 with one period of class each week and 40 minutes per period. The procedure for the strategy instruction was divided into three phases: pre-reading, reading and post-reading.

In the pre-reading phase, prediction and the activation of learners' background knowledge were the two strategies introduced in this phase. The teacher asked the students to read the story title and pictures on cover page, and then the students had to predict which characters they would see and what would happen in the story. The students were required to share their experiences so that their background knowledge could be activated to facilitate their story predictions.

In the reading phase, inferring was the focus of strategy instruction. The teacher and the students browsed the story page by page. Students were encouraged to infer the meaning of unknown words based on the context, illustrations, or word structures. They were also asked to infer the story content and story ending from their prior knowledge, experience and clues.

In the post-reading phase, strategies like questioning, generation and question answering, identifying story structure, and summarizing. The students asked questions about the story that they didn't understand and the teacher asked the students questions about the story structure including who the characters were, when the story took place, where the story took place, what happened, why happened, and how the characters solved the problem. Finally, they were asked to summarize the main idea of the story. After each instruction of the story, the students took an immediate story comprehension posttest.

Training Program for the Control Group

The control group received electronic storybook reading program without any reading strategy instruction. In pre-reading phase, the teacher presented new words and sentence patterns with pictures through Power Point for students before reading the story. Students followed the teacher and read the new words and sentences patterns aloud. While reading, the teacher browsed the story page by page and explained the content of the story for the students. Students read the story aloud together and reviewed the story by role play in post-reading phase. After each instruction, the students took an immediate story comprehension posttest, and the content of which was the same as that taken by the experimental group.

Instruments

The instruments used in the study included one Style reading proficiency test, five immediate reading comprehension posttests, strategy use questionnaires and attitude toward e-books based reading strategy instruction questionnaire. The descriptions of each instrument were illustrated in the following sections.

Reading Proficiency Tests

STYLE (Saxoncourt Tests for Young Learners of English) is an international proficiency test for children. There are 6 levels in STYLE, suitable for students of approximately 6 to 12 years of age, or those attending Primary (Elementary) school and the first year of Secondary (Junior High) school. According to the English proficiency level criteria of STYLE, Level 1 is for learners who have studied English for at least one year, which is suitable for the participants in this study. Because the purpose of the tests were to measure the participants' reading proficiency, the total 18 items used in each test were adopted from the reading part of the STYLE Level 1, with 6 items in each part. One STYLE reading proficiency test was administered to evaluate the participants' proficiency before the 10-week training period.

The test contained three parts. Questions in Part A were designed to ask students to read the sentences and choose the right pictures that corresponded to the sentences. Questions in Part B were designed to instruct students to read the picture descriptions and mark sentences right or wrong according to the picture. Questions in Part C were designed to ask students to match the answer sentences with the question sentences. The maximum score for the three parts was 90 points, with 30 points for each part and 5 points for each item. The Cronbach alpha values of reading proficiency pretest and reading proficiency posttest were .87 and .90, respectively, suggesting the reliability of these instruments could be accepted.

Reading Comprehension Tests

The five reading comprehension tests were designed by the researcher, and were provided for both groups after each story's instruction. The goal of these immediate posttests was to measure participants' reading comprehension about the stories. Each test included three parts. Part 1 contained four matching questions, and students were asked to match vocabulary with correct pictures. Part 2 contained four true-or-false comprehension questions. Part 3 contained four comprehension multiple-choice questions. The score of each item was 5 and the total score was 60.
Five reading comprehension tests were used to investigate the comprehension of the participants. The test contained four matching questions, four true-or-false comprehension questions and four comprehension multiple-choice questions. The score of each item was 5 and the total score was 60. The Cronbach's alpha values of the five tests were all higher than 0.80 with αvalues 0.83, 0.87, 0.89, 0.92, and 0.91 respectively. It indicated the tests were reliable.

Strategy Use Questionnaires

A 16-item strategy use questionnaire was implemented before and after the intervention in order to discover participants' opinions toward e-books based reading strategy instruction. The participants were asked to self-report their strategy use in a five-point Likert scale ranging from 1 "never true of me" to 5 "always true of me." The Cronbach alpha value of strategy use questionnaire was 0.91, representing the feasible reliability of the instruments.

Attitude Questionnaires

After the intervention, participants in the experimental group were also asked to complete the attitude questionnaire. It contained 5 items designed to investigate participants' attitudes toward electronic storybook reading strategy instruction after the intervention. The participants were required to rate the items to the extend that they agree or disagree with the statement by using the five-point Likert scale ranging from 1 "strongly disagree" to 5 "strongly agree". The Cronbach alpha values of strategy use questionnaire and attitude questionnaire were .908 and .775, respectively, representing the reliability of these instruments were feasible.

Data Analysis

The data collected in this study included one Style reading proficiency test, five immediate reading comprehension posttests, strategy use and attitude questionnaires. The computer software package SPSS 17.0

for windows was used to analyze the data. Independent-samples t-tests were conducted to see if there were any significant between-group differences, while paired–samples t-tests were conducted to see if there were any significant within-group differences in the outcome measures.

Results and Discussion

In this section, the results of the statistical analysis were presented to answer the three research questions of the study.

Results of Research Question 1

1: What are the effects of reading strategy instruction integrated with e-book on EFL elementary school students' reading comprehension?

As shown in Table 1, the results indicated that although the mean scores of experimental group were higher than those of the control group in all of the reading comprehension tests, there were no significant between-group differences in overall performance of reading comprehension test. Nevertheless, among the tests, the experimental group (EG) statistically outperformed the control group (CG) in reading comprehension test 3 ($t = 2.570$, $p < .05$) and test 4 ($t = 2.382$, $p < .05$), but not in reading comprehension test 1, 2, 5.

Table 1. Between-group comparison for the reading comprehension posttest

Measure	The experimental group (n=28)		The control group (n=29)			
	M	*SD*	*M*	*SD*	*t*	*p*
Test 1	43.93	14.17	40.52	14.78	.889	.378
Test 2	44.29	13.79	38.45	13.50	1.615	.112
Test 3	50.89	9.53	41.38	17.42	2.570	.014*
Test 4	49.64	7.81	42.93	12.92	2.382	.021*
Test 5	45.36	13.67	44.83	11.30	.160	.874
Overall performance	46.88	9.06	42.01	11.49	1.77	.082

Note: Maximum score = 60; *$p < .05$

Though evidence from many other studies indicated that the intervention with strategic approaches enhanced students' reading comprehension effectively (Chamot et al., 1999; Cohen, 1998; Deng, 2009; Hsiao, 2011), the results of this study did not lend full support to the findings of previous research. The failure to achieve statistical differences in the 3 tests may be due to the following reasons. Firstly, many unknown words appeared in the texts of the electronic storybooks, and each story was taught only for two periods of classes. Therefore, young readers were unable to learn those unfamiliar new words effectively within the instructional period to lead to significant improvement. Secondly, compared with these young readers' textbooks, which were composed of short and simple dialogues, the three electronic storybooks were longer than their textbooks. Thus, it is possible that though reading strategy instruction integrated with e-book helped improve reading comprehension in the experimental group, the familiarity of the vocabulary, the length of texts, and text difficulty may be possible sources resulting in the insignificance of the improvement in reading comprehension.

Results of Research Question 2

2. What are the effects of reading strategy instruction via electronic storybooks on EFL elementary school students' strategy use?

The data collected from both groups' reading strategy use were calculated and analyzed statistically with independent-samples and paired-samples t-test.

In terms of the between-group comparison of their reading strategy use (see Table 2), independent-sample t-tests showed that there was no significant difference in the pretest overall and in any category. However, there was significant increase on the posttests in their overall strategy use, and in the categories of *Predicting, Inferring, and Identifying of strategy use, but not in Monitoring comprehension*, between EG and CG. Possible reason may be for the reason that monitoring comprehension is a higher-order strategy, which might require more strategy training. Generally speaking, reading strategy instruction integrated with e-book did help significantly increase EFL elementary school students' strategy use in this study.

Table 2. Between-group comparison of strategy use

Construct		*M* (EG)	*M* (CG)	*t*	*p*
Predicting	pretest	3.14	2.72	1.522	.134
	posttest	3.52	2.99	2.337	.023*
Inferring	pretest	2.87	2.65	.782	.438
	posttest	3.11	2.60	2.025	.048*
Identifying main ideas	pretest	2.69	2.59	.411	.683
	posttest	3.09	2.53	2.327	.024*
Monitoring comprehension	pretest	2.61	2.55	.202	.840
	posttest	3.13	2.74	1.189	.240
Overall Performance	pretest	2.81	2.63	.821	.415
	posttest	3.18	2.66	2.396	.020*

Note: $*p < .05$

For within-group comparison of their reading strategy use, the treatment effects between the pretest and the posttest for the experimental group and the control group were examined by paired-samples t-tests. The results indicated that the experimental group had a significantly improvement between the pretest and the posttest in overall strategy use and in all constructs, except in the construct of Inferring (see Table 3). This implied that for the experimental group, strategy instruction was more effective in improving the 3 strategies compared with Inferring strategy. On the other hand, the control group did not make significant increase between the pretest and the posttest in overall strategy use and in all constructs, except in the construct of Predicting. It seemed that only via e-books story reading, without further strategy instruction, the control group could still improve their Predicting strategy, but not other strategies. Generally speaking, based on the findings, we could find that reading strategy instruction integrated with e-book positively affected EFL elementary school students' strategy use. The findings were consistent with previous studies (Hsiao, 2011; Luo, 2009), which also showed the positive effects of reading strategy instruction. The participants increased their overall use of the reading strategies, and have learned to apply the target strategies after the instruction.

Table 3. Within-group comparison of strategy use

Construct		*M* (pretest)	*M* (posttest)	*t*	*p*
Predicting	EG	3.14	3.52	2.308	.029*
	CG	2.72	2.99	2.110	.044*
Inferring	EG	2.87	3.11	1.324	.197
	CG	2.65	2.60	.372	.712
Identifying main ideas	EG	2.69	3.09	3.110	.004**
	CG	2.59	2.53	.538	.595
Monitoring comprehension	EG	2.61	3.13	2.611	.015*
	CG	2.55	2.74	.813	.423
Overall Performance	EG	2.81	3.18	4.811	.000***
	CG	2.63	2.66	.423	.675

Note: $***p < .001$; $**p < .01$; $*p < .05$

Results of Research Question 3

3. What are Taiwanese EFL elementary school students' attitudes toward reading strategy instruction?

After training, the experimental group completed the attitude questionnaire, intended to tap their viewpoints toward the reading strategy instruction via electronic story books As shown in Table 4, the participants had positive attitudes toward reading strategy instruction, with the average mean of 3.8, higher than the neutral level of 3.00. The highest mean fell in item 3 "I think reading strategy instruction via electronic story books increase my reading ability', followed by item 2 I think reading strategy instruction via electronic story books arouse my interests of learning English.", and item 1 "I think reading strategy instruction via electronic story books help me comprehend the story better." The lowest mean was found in item 5 "I hope that teacher will implement reading strategy instruction via electronic story books in their English class." In sum, we could observe that the students generally held positive attitudes toward e-books based reading strategy instruction.

The results were in consistence with the findings of Hsiao (2011) and Deng (2009), which reported that L2 learners were more motivated toward English reading and displayed preference for more electronic storybooks based reading strategy instructions in English classes. Also, most of the participants acknowledged the importance of the reading strategies in story reading, which they could apply in new story reading.

Table 4. The experiment group's responses in attitude questionnaire

Item Descriptions	The experimental group (*n* = 28)	
	Mean	*SD*
1. I think reading strategy instruction via electronic story books help me comprehend the story better.	3.75	1.08
2. I think reading strategy instruction via electronic story books arouse my interests of learning English.	3.96	0.96
3. I think reading strategy instruction via electronic story books increase my reading ability.	4.11	0.96
4. I feel more confident in reading story after reading strategy instruction via electronic story books	3.64	0.83
5. I hope that teacher will implement reading strategy instruction via electronic story books in their English class	3.54	1.35
Total	3.8	0.76

Conclusion

Based on the result of the present study, it was found that after reading strategy instruction, the experimental group performed better than the control group in story comprehension, but without significance. However, they significantly outperformed the control group in strategy use. Also, the experimental group had positive attitude toward e-books based reading strategy instruction. Some pedagogical implications can be drawn as follows. First of all, electronic storybooks in a digitized form had multimedia effects like written text, oral reading, oral discourse, music, sound effects, and animations. The text orally read by the narrator and accompanied by the highlighted text helped the readers conveniently understand the written words, phrases, or passages. The effect could potentially enhance the reader's knowledge of the text by adding information that did not appear in the original text. Because of the useful e-books rather than less authentic reading in printed pages, they might help children's literacy and language development (McKenna, Reinking, Labbo & Kieffer, 1999; de Jong & Bus, 2003; Lefever-Davis & Pearman, 2005). Therefore, applying more multimedia in L2 language learning could help develop children's literacy and language development (McKenna, Reinking, Labbo & Kieffer, 1999; de Jong & Bus, 2003; Lefever-Davis & Pearman, 2005).

Secondly, traditional reading instruction centers on vocabulary teaching and grammar exercises. Teachers often spent most of the time in text explaination and seldom taught strategies in class; students did not learn how to apply various strategies actively in the text reading (Deng, 2009; Lau, 2006a). Although it is hard to change the English learning environment in short time, the results of the present study revealed that effective reading strategies incorporated with appropriate electronic storybooks could help EFL young readers build up better reading strategies use. In addition, the well use of strategies not only assisted learners in promoting their own strategy use in language learning but also has potential reading comprehension to foster students' autonomy in language learning (Green & Oxford, 1995; Griffiths, 2003).

Another pedagogical implication derived from the present study concerns the students' attitude. The result indicated that participants showed positive attitudes toward electronic storybooks based reading strategy instruction. With the lively and attractive features of the e-book, it was regarded as a possible mean for supporting young children's literacy development and developing positive attitudes toward foreign language learning (Korat & Shamir, 2008). Therefore, it was suggested that EFL teachers provide technological educational tool such as electronic storybooks for their students. Besides, students should know what reading strategies were and how to apply them because reading could be more meaningful and efficient if reading strategies were used. Once the students gained the confidence and became interested in reading process, they could be more willing to learn.

Despite some valuable findings of the present study for the possibilities of integrating electronic storybooks in strategy based instructions, there are several limitations. The first limitation of the study was the small sample size. There were only fifty-seven students chosen from an elementary school. The findings may not be generalized to other EFL elementary school population. Therefore, a larger sample of elementary school students could be recruited in future L2 studies to validate the outcomes of this study.

Another limitation is related to the teaching time of this study. Although there were significant changes between pretests and posttests of reading strategy use, a ten-week intervention was not sufficient to guarantee significant reading comprehension improvement, and could not ensure that students will really consolidate their reading strategy in their future reading and develop lifelong reading habits. Thus, in future studies, the instructional period could be implemented with longer duration in consideration of L2 learners' proficiency levels.

The third constraint was the self-rated nature of the questionnaire. The results from the questionnaires might not reflect the students' real psychological status toward e-books reading strategy instruction. The participants may dishonestly respond to the questionnaire based on the teacher's expectation. Therefore, in future research, both quantitative and qualitative methods such as interviews, classroom observations, or tape recordings could be employed to gather a more complete profile of participants' English reading attitude. Such enriched and triangulated data could facilitate to interpret the results more validly and reliably.

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Zemenu Mihret[1]

[1] Debre Markos College of Teacher Education

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Exploring the Gap between College Cluster Natural Science and 1st Cycle Primary School Environmental Science Curriculum

Zemenu Mihret [1*]
[1] Debre Markos College of Teacher Education

Abstract

The purpose of this study was to explore the gap between college cluster Natural Science and School Environmental Science Curriculum. It was conducted realizing the fact that primary level science education is a corner stone to lay a foundation to get young citizens who are interested and attracted towards natural science and other technology fields as these fields determine greatly the advancement of a nation. The study analyzed different documents like college cluster natural science curriculum guide and school environmental science curriculum guide, environmental science textbooks, environmental science MLC document, and primary school science kit manual. In addition, the study included 14 Debre Markos & 7 Injibara Teacher Education Colleges' natural science instructors and 28 school environmental science teachers working in and around Debre Markos Town as human participants of the study. Objectives, contents, teaching learning methods, assessment techniques, and learning experiences were investigated in the documents mentioned earlier. Sample units were selected using availability sampling technique. Data relevant to the study were collected using open ended & closed ended questionnaires from college and school science teachers, document analysis, and discussions with college and school science teachers. Quantitative and qualitative data analyses techniques were employed. Data collected from closed ended questionnaires and some part of the document analysis were analyzed quantitatively whereas data collected from open ended questionnaires, some part of document analysis, and discussions were analyzed qualitatively. Based on the analyses of the data from the multilevel sources, conclusions were drawn and recommendations were forwarded to concerned authorities.

Key words: Primary School Science Education, College Cluster Natural Science Curriculum, School Environmental Science Curriculum,

Introduction

Science is a discipline that builds and organizes knowledge systematically using scientific methods to try to explain the events and phenomena of nature in a reproducible way. Science is thought to have two dimensions: the body of knowledge that has been accumulated by scientists and the process by which knowledge is acquired (Kaushik, and Sharma, 2002; Nanda, 2002). It is essentially a practical subject where a systematic approach to studying phenomena, including careful observation, accurate measurement and careful experimentation and collection of data is used. Realizing that science and technology are the bases for development in today's modern world, the Ethiopian Federal Democratic Republic Ministry of Education prepared strategies for improving science and mathematics education in Ethiopia (Eshetu, et al., 2009; MoE, 2009). In this strategy, the Ministry of Education underlined that sustainable and all-round development of a country depends on availability and mobilization of scientifically and technologically literate work force.

Several criticisms were made on Ethiopian science education since the beginning of the first modern school in Ethiopia in 1908 (Temechegn, 2001). Some science educators argue that science education in Ethiopia like other subjects was not for improving the life of people in science and technology. In a national conference held in Addis Ababa from 31 January to 3 February 2011 concerning the familiarization of strategies for improving science and mathematics education, it was pointed out that science education at the start was for administrative purpose (MoE, 2009). On the other hand, during the reign of Emperor Haile Sellasie I, for example, there were no official curricula as well as textbooks from Ethiopia; Students were expected to reflect; Teachers were neither fully qualified nor appropriately trained; These teachers mostly came from India and Peace Corps

* Corresponding Author: *Zemenu Mihret, zmihret@gmail.com*

Programme and were not trained to meet with the specific needs and problems of the Ethiopian society (Messay, 2006). In view of that, science education in our country until recently was discarding of reflecting the realities, interests and needs of the Ethiopian societies.

In general, low educational quality, irrelevance, inefficiency and low access to education were the features of Ethiopian education service before 1991 (TGE, 1994). To alleviate these shortcomings, the New Education and Training (ETP) policy of Ethiopia was launched in 1994. Following this new policy, the national curriculum prioritized science and mathematics subjects at all grade levels in curriculum development and implementation programs. As a result the new curriculum framework indicated that it is the learner centered approaches and the constructivist epistemology that the teaching learning process should follow in order to be efficient and effective.

The objectives for teaching science in schools are found embedded in the Ethiopian science curriculum. These include science for meeting personal needs, for resolving current societal issues and problems, for developing student abilities to deal with the world around them, for assisting with career choices and for further study (MoE, 2009). Based on the above objectives, students are expected to develop critical thinking & creativity skills, making informed decisions on local and national societal and political issues, and for their further study.
When we talk about the objectives of science education and the approach to science teaching, we should again ask ourselves the way student science teachers are trained. Since children are curious and eager to explore the world around them, science teachers must be competent enough for developing students' interest in science. Moreover, teachers must be skilled enough to provide a greater variety of activities because students learn about science in a number of ways.

Following the launching of the new education and training policy, new science curricula and textbooks were developed for the two cycles (1st cycle and 2nd cycle) of primary school. These levels of schooling is very important to establish a foundation to get children who are interested to study engineering and other fields of natural science in their later age. To successfully achieve the 5 years growth and transformation plan of the country, the Ethiopian government has recently designed a strategy through which 70% of the students that join higher education are expected to study natural science and engineering (Eshetu et al, 2009). Consequently, measures should be taken to make students more motivated towards science. According to MoE (2009), there are many simple, interesting and non-hazardous experiments that can be used to make students attracted towards science in primary schools with equipments made from simple and locally available resources like plastic bottles, string, and meter rules.

Environmental science is one of the subjects offered to primary level 1st cycle schooling. This subject is the integration of social science, natural science, agriculture, hand-craft, environmental and health education, home economics, and art (ICDR, 2004). The general objective of 1st cycle environmental science education is to help children grasp basic education which is relevant to the age, physical and mental level so that it prepares them for the next grade level. Moreover, environmental science education acquaints children with their community production activities and services, help them to be problem solvers, and train them to work with farmers and crafts- men based on their interest and abilities (Ibid).

A child gains knowledge and experience in different aspects and it seeks to understand his /her environment using the experiences. Children understand their environment in integrated way. Therefore, it is necessary to help them relate the knowledge and experience they get in school to the knowledge and experience they get outside the school (ICDR, 2004). Consequently, school environmental science teachers must be competent to help children meet the baseline standards set for each grade level by using suitable teaching learning methods and approaching science as a process, evaluating students achievement and progress continuously, using the science kit manual and additional teaching aids from locally available materials, and recognizing that primary level science is based on materials available from the environment and can easily be prepared by teachers and the environment itself is a good source of teaching aid for this level (ICDR, 2004; ICDR, 2003; MoE,2008).
Consequently, teachers of science must be fully trained in all aspects mainly with subject matter knowledge & skills and pedagogical skills and teacher training institutions have to ensure that all science teacher trainees meet the expected criteria. The strategy document for improving science and mathematics education in Ethiopia emphasized the link between the school curriculum and the teacher training curriculum (MoE, 2009) and other sources promoted the symbiotic relationship between school education and teacher training institutions (NCTE, 2009). It was with this understanding that the present study was conducted. Thus, this study was designed to explore the perceived mismatch between college cluster natural science curriculum and school environmental science curriculum in Amhara Region.

Statement of the Problem

Even if the government of Ethiopia gives due emphasis for quality of education, many studies on the country's education publicize that quality education in Ethiopia is an issue not yet addressed (USAID, 2008; Derebssa, n.d). The national learning assessments conducted in the years 2000, 2004 and 2008 for grades 4 and 8 students show that the average score for mathematics was less than 40% while it was less than 50% for science subjects (NOE, 2008). Environmental science is one of the key academic subject areas selected for testing pupils' in the National Learning Assessment to determine the various levels of pupils' performances after completing grade four. The findings of the National Learning Assessments conducted in the years 2000, 2004 and 2008 for grades 4 and 8 students show that the average score for mathematics was less than 40% while it was less than 50% for science subjects. In addition, decline in achievement level was observed from findings of the third National Learning Assessment when compared with the first and second National Learning Assessments (NOE, 2008).

Low performance in science subjects is very aggravating as the country is striving to promote science education. Different problems can be mentioned for the low achievement of science subjects as there are different stakeholders and variables that contribute for quality science education. Thus, an intervention must be made by identifying problems that exist related to science education.

Discussion with in-service science teacher trainers and pre-service trainee science teachers who are working their practicum, independent teaching, mentioned that there is a mismatch between school natural science curriculum and college cluster natural science curriculum. These mismatches between school science and college cluster natural science curriculum are related to content, skills in handling hands-on and minds-on activities, the use of a wide range of teaching and learning strategies, the use of methods for continuous assessment and methods of meeting the needs of students with special educational needs. Especially, school environmental science teachers failed to do daily life science practical activities which promote indigenous or local knowledge. It is believed that students of science should know the practical applications of the science contents, the methods of science, and the resulting social implication and applications of science (Temechegn, 2001; Venkataiah, 2002).

Moreover, eye-boring examinations of contents and practical activities in 1st cycle primary school environmental science textbooks, cluster natural science curriculum guide, , environmental science curriculum guide and minimum learning competency document for grade one to four revealed that there are mismatches between the two curricula. On the other hand, from literature some science education researchers suggest that one of the main causes of crisis in science education is the failure of colleges and universities to do an adequate job of preparing future science teachers (Mc Dermott, 1990). In our context, colleges of teacher educations should assure that their training curriculum be in harmony with school curriculum. In addition, the MoE (2009) and Eshetu, et al. (2009) pointed out that one of the goals to avert the situation is to work to suit the existing teacher education curriculum with the changes made in the school curriculum. Thus, the researcher planed to explore the inconsistency between college cluster natural science curriculum and school environmental science curriculum to contribute his part in the campaign of taking interventions to keep quality of science education in primary level schooling.
Consequently, this study has been organized to answer the following four main questions:

- To what extent the objectives of college cluster natural science curriculum targeted to meet the objectives of school environmental science curriculum?
- Are the contents of the school science curriculum for each of the natural sciences (Physics, chemistry and biology) specified in detail in the college cluster science curriculum?
- Do cluster natural science student teachers get appropriate skills in making hands-on activities and teaching aids from locally available resources?
- Are student teachers of science trained in the use of a wide range of teaching and learning strategies?

Purpose of the Study

The general objective of this descriptive research was aimed at exploring the mismatch between school environmental science curriculum and college cluster natural science curriculum of the Amhara region. More specifically, the study has attempted to:

- determine the extent to which the objectives of college cluster natural science curriculum is in harmony with 1st cycle primary school environmental science curriculum.

- assess the extent to which the contents of the school science curriculum for each of the natural sciences (Physics, chemistry and biology) specified in detail in the college cluster natural science curriculum.
- investigate whether or not cluster natural science trainees get appropriate skills in making hands-on activities and teaching aids from locally available resources.
- assess the extent to which the would be science teachers are trained in the use of a wide range of teaching and learning strategies.
- suggest possible solutions to improve the link between school environmental science curriculum and college cluster natural science curriculum.

Significance of the Study

Primary school science education in our country is promoted this time than any time before. This is because primary level schooling is a level where foundation is laid for scientific inquiry. Upgrading of school science teachers to diploma (10+3) level is among the many activities undertaking to promote quality science education. Thus, this descriptive research is concerned with exploring the mismatch between college cluster natural science and school environmental science curriculum. The findings of this research are expected to benefit various individuals, groups, and institutions.

- It will enable college natural science teacher educators of the Amhara Regional State in acquainting them with mismatches between the two curriculums. For example, college natural science instructors will use the findings of this research to fill the gaps that exist between college cluster natural science curriculum and school environmental science curriculum during pre-service and in-service program of school science teachers training. More specifically, it will help college natural science instructors concentrate on practical activities which can be performed with simple and locally available materials.
- It presents valuable comments and recommendations for science curriculum experts, for teacher education colleges, and the Amhara Regional State Education Bureau to bring immediate solutions and for further update.
- Since science education has become a national as well as global issue, this research will be used as a starting point for other interested researchers who will conduct similar researches in the area to improve quality science education in primary schools.
- Governmental and non -governmental organizations working to promote quality science education in primary schools can use the findings of this research to fill the gaps identified.

Delimitation of the Study

Even if the research participants of this study were 14 Debre Markos and 7 Injibara colleges of Teacher Education Natural Science instructors and 28 primary school 1st cycle environmental science teachers in and around Debre Markos town, it can be said that the research is delimited geographically to Amhara Region. This is because the 10 teacher education colleges of the region are using the same curriculum and the schools too are implementing the same curriculum. It will be more useful, had it include the opinion of college natural science from other colleges of the region and school environmental science teachers working in other parts of the region. On the other hand the study is delimited conceptually to explore the gaps between teacher education cluster natural science curriculum and school environmental science curriculum in the specified cycle. It did not consider the relevance of the school environmental science curriculum. The study explored what is omitted in the college cluster natural science curriculum taking the school curriculum as a standard because one of the missions of teacher education colleges is to train competent teachers who will satisfy the demands of primary schools. However, since the main source of data for the study was document analysis it is believed that the samples taken might give reliable data to draw reasonable conclusions from findings of the research.

Limitation of the Study

Only limited human participants were taken as sample units of the study. Regular duties of the college along with financial and resource constraints were serious challenges confronted the researcher to complete the study. As a result it was difficult to undertake focused group discussions and interview with science curriculum experts. Nevertheless, since the main data sources were documents, the researcher set forth maximum effort to use the limited resources available effectively and collected relevant data using the sample units available to complete the study on time. On the other hand, the findings of this study would have been more comprehensive and trustworthy could these limitations have been tackled.

Conceptual Framework

Primary School Science Curriculum

Science encompasses knowledge and understanding of the biological and physical aspects of the world and the processes through which such knowledge and understanding are developed (NCCA, 1999). It is a way of exploring our environment in particular and the world at large using careful observation, accurate measurement, careful experimentation, and collection of data (MoE, 2009). On the other hand, effective science education results in citizens who are scientifically literate and better able to make informed decisions about issues involving science and technology that affect their present lives, the lives of future generations, and develop the problem solving capacity of citizens (ESTA, 2006; MoE, 2009; Thornton, 1999).

Primary school science curriculum involves helping children develop basic scientific ideas and understanding, which will enable them to explore and investigate their world. It helps to understand the key concepts and principles of science and be able to use this knowledge and ways of thinking in everyday life (Kober, 1993). The focus of science education in primary school will be on helping children to modify their ideas or alternative conceptions and develop more scientific understanding. To achieve this objective, science curriculum should be related to everyday life and teachers of science should receive proper training to make use of simple resources and science kit to do science (MoE, 1999).

The new curriculum framework of our country indicated that it is the learner centered approaches and the constructivist epistemology that the teaching learning process should follow in order to be efficient and effective in implementing the science education at all levels of schooling (MoE, 2009). Yager as cited in Temechegn (2001) defined constructivism as a model of how learning takes place, rather than a theory of how rationality develops. Thornton (1999) pointed out that listening to someone's talk about scientific facts and results is not an effective means of developing concepts. Students of all ages learn science better by actively participating in the investigation and the interpretation of physical phenomena. This implies that student science teachers must be educated in a way to apply active teaching learning methods.

Teacher education researches indicated that teachers teach in a manner consistent with their own way of learning (Chatterje, 2008). This implies that teacher education institutions play pivotal role to effective science education in the primary schools as this level is important to lay a foundation for further study. The natural curiosity of children, eager to understand their surroundings, is often diminished by instruction that discourages inquiry and discovery. In many countries science education in the lower grades has lacked a clear focus and has been provided by teachers ill- prepared to deal with science content (NCREL, 1995).

Teacher Training Curriculum

National Council for Teacher Education (NCTE) of India justified that teacher education and school education have a symbiotic relationship (NCTE, 2009). It further explained that developments in teacher education and school education mutually reinforce the concerns necessary for the qualitative improvement of the entire spectrum of education. The school curriculum is reformed to include priority areas and sectors of the country to satisfy community needs so that teacher education colleges should in turn satisfy the changing demand of schools. Thus, science teachers must be trained in the way to satisfy the demands of schools and the needs of the community at large. The strategy document for improving science and mathematics education in Ethiopia suggested different methodologies for orienting student science teachers on how to teach science. One of its approaches is that initial teacher training should be strengthening to ensure that student teachers are confident in their scientific subject knowledge and also a wide range of active teaching and learning strategies, including high quality practical work which promotes thinking skills (MoE, 2009). The document further explained that at present teachers lack confidence in subject knowledge, practical work and active teaching and learning so that student teachers need guidance and training in these aspects.

The link between Teacher Training Curriculum and School Curriculum

As the vision of teacher education colleges is to prepare human power that fulfils the demand of schools, the two curriculums must be in harmony. The National Council for Teacher Education (NCTE) argued this point as follows:

> *A teacher functions within the broader framework of the school education system-its goals, curricula, materials, methods and expectations from the teacher. A teacher education curriculum framework needs to be in consonance with the curriculum framework for school education, and a teacher needs to be prepared in relation to the needs and demands arising in the school context. As such, it needs to engage with the question of the learner, the learning process and the content and pedagogy of educating teachers. The expectations of the school system from a teacher change from time to time, responding to the broader social, economic and political changes taking place in the society. The issue of teacher education accordingly has to be discussed in the much wider and changing context and demands of school education (2009:5).*

From the above quotation it can be implied that the teacher training curriculum needs to be in congruence with the school curriculum. Teachers' education take an analytical and open-minded approach to their work, that they draw conclusions based on their observations, and experiences and that they develop their teaching and learning environments in a systematic way (Niemi and Jakku-Sihvonen, 2009). As professionals, teachers need a lot of practical skills that will enable them to mediate something to individual or groups and to construct knowledge jointly. The academic contents and practical skills must not be seen as separate or exclusively; they are always complementary in the teaching profession.

The strategies document prepared by the Ethiopian Federal democratic republic of Ethiopian to improve science and mathematics education in the country emphasized that it would be the responsibility of the teacher training institutions to insure that all trainee science students met the necessary content knowledge, understanding and skills (MoE, 2009). When science education is considered, the content of the school curriculum for each of the science subjects should be specified in detail in the teacher training curriculum for student science teachers. This does not mean that the courses that student science teachers take are only bounded to the contents of primary school science textbooks. There is a common consensus that primary school science teachers lack the necessary knowledge, skill, and understanding of the science concepts. Thus, an intervention must be made to fill these mismatches so that particularly difficult areas of subject knowledge could be taught in the Teacher Training Colleges, but students would be expected to master other areas through self-study (Ibid). Student science teachers must also become confident in their skills in carrying out, and managing, good quality practical work, including safety related aspects. They need training and guidance in making equipment and teaching aids from everyday resources and using these.

In addition, teachers of science must be fully trained in the use of a wide range of teaching and learning strategies. These active learning methods should be specified in the teacher training curriculum. There should be checks to ensure that teacher trainers use a wide range of methods with their students. Student teachers should be trained in the features of good teaching, including effective methods for continuous assessment, and in meeting the needs of students with special educational needs. There needs to be clear guidance on planning effective lessons and also in behavior management when classes are involved in active learning (ibid).

In general, teacher education colleges should design/revise their curriculum in line with primary school curriculum. This is because; the ultimate goal of teacher education colleges is to train competent manpower that will satisfy the demands of primary schools. The Ministry of Education in the strategies for improving science and mathematics education in Ethiopia (2009) and Eshetu, et al. (2009) explained that teacher education curriculum should be in harmony with school curriculum.

Research Methodology and Design

Research Design

The present study has attempted to explore the mismatch between college cluster natural science curriculum and school environmental science curriculum of the Amhara Region. To attain this objective, descriptive research design was used to investigate whether the two curricula are in consistence or not. The approach or methodology followed in this study was both qualitative and quantitative. The study proposed research questions and data were collected using closed-ended and open-ended questionnaires and different documents to answer the research questions.

Population and Data Sources

Sources of data for this study were 1st cycle primary school environmental science teachers, college natural science instructors, and the different documents shown in Table 1 below.

Table 1. Summary of Analyzed Documents

	Components Observed	Practical Activities	Contents	Objectives
Type of Document	School Environmental Science Curriculum Guide	-	✓	✓
	Teacher Training Curriculum Guide	-	✓	✓
	Grades 1 to 4 Environmental Science Textbooks	✓	✓	-
	MLC Document	-	-	✓
	Grades 1 to 4 Science Kit Manual	-	✓	-

As it can be seen in table 1 above, contents in school curriculum guide, grades one to four environmental science textbooks, and cluster natural science teacher training curriculum guide were categorized into units, subunits, and sections to see if there were missed contents in the college cluster natural science curriculum. Learning objectives in MLC document, school environmental science curriculum guide, and college cluster natural science curriculum guide (Course Outline) were assessed whether the objectives in these documents were in harmony or not. Moreover, practical activities in 1st cycle environmental science textbooks and grades 1 to 4 science kit manual were listed and counted whether or not these activities were included and covered in college cluster natural science curriculum.

The components in the documents (contents, practical activities, and objectives) were explored without taking samples. However, sampling techniques were employed to select the two groups of human participants of the study. Availability sampling technique was employed to take samples of school environmental science teachers who were working in and around Debre Markos town in 2011/2012. A total of 28 environmental science teachers were included in the study out of which 16 of them were graduates of diploma in natural sciences and 12 of them completed their 3rd year study in cluster natural science program. The researcher thought that the same curriculum was implemented in all of the 10 colleges of the Amhara Regional State in the cluster natural science (Amharic) modality.

In addition, Debre Markos College of Teacher Education and Injibara College of Teacher Education were selected purposely to get samples of natural science instructors. The former is selected since the researcher was working in this college whereas the latter was selected because of additional trainings in local language and its proximity. There were 22 and 8 natural science teachers working at Debre Markos and Injibara College of Teachers Education, respectively, out of which 6 of them were participated in the pilot study and 21 of them in the main study as it is shown in Table 2 below.

Table 2. Summary of Participants

School Environmental Science Teachers by Department		College of Instructors by Department			
Sex	Natural Science	Sex	Physics	Chemistry	Biology
Male	10	Male	6	0	7
Female	18	Female	0	0	2
Total	28	Total	6	6	9
			Total	21	

Two instructors from DMCTE were not participated since they joined the college in this academic year and as a result the researcher believed that they were novice in investigating gaps between the two curricula. From the 8 natural science teachers teaching at ICTE, 7 of them completed the questionnaires successfully and were participants of this study.

Data Collection Tools

Data relevant to this study were collected using both qualitative and quantitative data gathering tools. To collect quantitative data, questionnaires for both school environmental science teachers and college natural science instructors were used. In addition, science practical activities were counted from environmental science textbooks and science kit manual; contents and objectives were categorized from MLC document, grades 1 to 4 environmental science textbooks, and college cluster natural science curriculum guide. The qualitative data were collected using open-ended questionnaires and informal discussions prepared for teachers and instructors. Contents in environmental science textbooks were organized in grade level, unit, subsection, and section to investigate whether or not these contents are clearly specified in the college cluster natural science curriculum. Science practical activities were identified, counted, and categorized as physics, chemistry, and biology. Objectives in the college cluster natural science curriculum guide and school environmental science curriculum guide were categorized as cognitive, psychomotor, and affective.

Likert type closed ended questionnaires (ranging from 1 to 5 where the median was 3) were distributed for school environmental science teachers and college natural science instructors to explore whether or not college cluster natural science curriculum was in harmony with school environmental science curriculum. The number of items in the school teachers' and college instructors' questionnaires were 10. These items were prepared based on components of a curriculum. i.e. the questionnaire items contain questions related to objectives, contents, teaching learning methodologies and strategies, assessment techniques, instructional materials and resources. The open ended questionnaire items were presented to triangulate the data found from the closed ended items and to gather the opinion of school environmental science teachers and college natural science instructors.

Data collection Procedures

The first procedure in collection of data relevant for this study was to develop closed and open ended questionnaires based on components of curriculum. The questionnaire items and titles of practical activities were prepared in Amharic language for both the college instructors and school environmental science teachers in order to minimize language barriers. The questionnaires were given to colleagues for their scholarly comments and it is believed that this assures content validity. In addition, to assure the validation of the inferences made, some educational researchers like Erlandson, Harris, Skipper, and Allen cited in Stemler (2001) suggest that triangulation assurances credibility to the findings.

After including the comments given by colleagues, the open ended and closed ended questionnaires were administered for pilot study. Cronbach alpha coefficient was calculated to check the reliability of the questionnaire quantitatively. The reliability of school environmental science teachers' and college natural science instructors' questionnaires were found to be 0.74 and 0.87, respectively. Reliability coefficient values up to 0.65 are accepted for researches conducted to investigate attitude, opinion, interest, etc towards an issue (Yalew, 2006). Thus, the calculated values of the questionnaires items indicate that the tools were consistent. On the basis of the results found from the pilot study, the tools were refined further.

In addition, science practical activities were counted and categorized as physics, chemistry, and biology focus from science kit manual and environmental science textbooks. Accordingly, the numbers of science practical activities at the start were 52, 28, and 18 for physics chemistry, and biology, respectively. In the main study, after comments from colleagues, the number of practical activities was reduced to 46, 26, and 17 for physics, chemistry, and biology, respectively since there were repetitions. In addition, some modifications of titles of practical activities were made. Finally, by incorporating the comments from colleagues and feedback from the pilot testing, instructors were asked to identify the school science practical activities which were included and covered in the college cluster natural science courses.

Methods of Data Analysis

The open-ended and closed-ended questionnaires were initially administered for 21 college natural science teachers and 33 school environmental science teachers. All the 21 questionnaires from the college natural science participants were filled completely and appropriately, however; only 28 questionnaires were completely filled by school environmental science teachers. Data collected from open-ended questionnaires, unstructured interview with school environmental science teachers and college natural science instructors, and some part of the data from documents were analyzed qualitatively.

The quantitative data collected through the above data collection tools were coded into Microsoft Excel 2007. As a result percentages were used to compare to what extent objectives in MLC guide and college cluster natural science curriculum guide were in harmony. In addition, percentages and frequency counts were used to determine how many of the practical activities found in environmental science textbooks covered in the college curriculum. Descriptive statistics such as mean scores and standard deviations were again computed to explore the opinion of environmental science teachers and college instructors regarding mismatch between college cluster natural science and school environmental science curriculums. In addition, science practical activities which are physics focus, chemistry focus, and biology focus were counted and compared in percentages. Data obtained through open ended questionnaires and unstructured interview were organized into themes like opinions related to contents, objectives, science practical activities, teaching learning processes, assessment techniques, instructional materials and resources, special needs education, and science process skills.

Results

Based on the analyses made from collected data, the following results were obtained:

When the MLC guide and college cluster natural science curriculum guide were investigated, the objectives stated in the college cluster natural science curriculum gave much emphasis (94.3%) for scientific facts, principles, and theories (knowledge) but only 3.4% for skill related activities. On the other hand, the objectives stated in the 1st cycle primary school environmental science MLC document provided relatively fair emphasis to knowledge (42.1%), psychomotor (31.6%), and affective (26.3%) domains.

The mean linkage score between objectives of college natural science and school environmental science by college instructors and school teachers was found to be 2.1 and 2.6, respectively. This result indicates that objectives of the two curricula were found tenuous. According to NCTE (2009), a teacher needs to be trained to meet the demands of the school context and in turn teacher education curriculum needs to be in harmony with the curriculum for school education. Thus, the teacher training curriculum emphasizes the learning of scientific facts, principles, and theories. This approach does not promote school science teachers to help children learn and do science (MoE, 2009; Thornton, 1999; Kober,1993)

From analysis of contents by grade level, unit, and section from environmental science textbooks, the contents in the first cycle primary school environmental science textbooks were clearly specified in the college natural science courses except simple machines & their types and preparing inks from flowers and leaves. On the other hand, school environmental science teachers were asked to write environmental science contents which were not covered in the college cluster natural science courses and find difficult for them. Most of them responded that there are no difficult contents in the textbooks whereas some listed the topics which were already identified by the researcher as not specified in the college curriculum.

The mean score of the link between contents of college cluster natural science and school environmental science curriculum by college natural science instructors and school environmental science teachers was found to be 1.95 and 1.68, respectively. The results indicate that the contents found in environmental science textbooks were not covered in the college cluster natural science courses. The rating scores were found to be inconsistent with content agreement analysis of the researcher and responses of open ended questions. This might be because of the two groups of respondents belief that the contents covered in the college were by far difficult than the contents in environmental science textbooks. It is believed that the content of the school science curriculum for each of the science subjects should be specified in detail in the teacher training curriculum for student science teachers (MoE, 2009). That is, difficult areas of contents in the school curriculum must be covered in college courses where as student science teachers are expected to cover others through self study. Based on the above findings it can be concluded that the contents in environmental science textbooks were clearly specified in the college courses and there were no difficult contents which were not covered in the college courses except those mentioned above.

Environmental science textbooks were thoroughly investigated to list science practical activities which were related to physics, chemistry, and biology. Accordingly, in the cycle's environmental science curriculum more than 51.7% physics related, 29.2% chemistry related and 19.1% biology related practical activities were observed. Similar practical activities were observed in grade levels so that an attempt was made to summarize and present the activities. Based on the data collected, only 47.5% of the activities related to physics, 46.8% of the activities related to chemistry, and 40.5% of the activities related to biology were indicated and covered in the college natural science courses. To say it in other words, more than half of the science practical activities found in environmental science textbooks were found to be not indicated or covered in the college natural science courses. From this, it can be concluded that science teacher trainees do not get appropriate skills to teach children basic science process skills. Thus teacher training institutions failed to ensure that science teacher trainees met the necessary skills (MoE, 2009).

College natural science instructors thought that the courses offered in the college satisfactorily (mean score=2.62) help student science teachers to gain and develop different learning experiences whereas they were not satisfied (mean score=1.38) with the facilitation and guidance given at the college to help trainees prepare practical activities and hands-on activities from locally available materials. On the other hand, school environmental science teachers feel happy (mean score=3) about the cluster natural science courses offered in the college since the courses help them to gain and develop different learning experiences whereas the facilitation and guidance given by natural science instructors was found to be below average (mean score =2.04). Besides, school environmental science teachers reported that the laboratory courses offered in the college did not help them to do the activities indicated in environmental science textbooks. The college cluster natural science curriculum did not invite them to be acquainted with science kits and to practice other hands-on, minds-on activities, and to prepare & work real life practical activities by using locally available materials. It is concentrated on rote memorization of facts, principles, laws, and theories.

Some of the teaching learning methods and assessment techniques which were commonly used in the college were missed from the cluster natural science curriculum guide. In addition, even if there is no one effective method of teaching for every subject and topics, it is believed that some methods are more convenient than others depending on availability of resources, facilities, students' interest, etc. For example, even if laboratory method, lecture method, and assignment methods are out of the most commonly methods in physics and chemistry classes, they were not mentioned in physics and chemistry courses. The result indicates that the teaching learning methods and the assessment techniques indicated in the college cluster natural science curriculum guide were found to be written arbitrarily. Besides, the teaching learning methods and the assessment techniques were found to be a "paste" and "copy" in every course of a discipline. That is, discussion, survey, problem solving, peer teaching, individualized instruction, inquiry, and discovery methods were found to be repeatedly mentioned in each of the physics and chemistry courses. Even though there are problems in the type of active learning methods mentioned in the curriculum guide, data collected from closed ended questionnaires and reports of evaluative training of the college held in the college in 2011 revealed that there were gaps in applying active learning methods in teaching learning process. On the other hand, school environmental science teachers reported that they were not taught in the way they are expected to teach environmental science in primary schools.

No circumstance was observed either in main courses, lab courses, or method of teaching science course which gives some insights how student science teachers help children with special needs education. Both college and school science teachers thought that the science courses training in college did not help them to meet the needs of students with special educational needs.

College natural science teachers and school science teachers believed that the cluster natural science training given at the college did not help the student science teachers to identify the two approaches of science: Science as a product and science as a process. Investigation of college natural science curriculum guide showed that approaches to science teaching and science process skills were indicated in none of the natural science courses including methods of teaching natural science. Many evidences show that science process skills form the foundations for doing science; they remain for a relatively longer period, the child can use them repeatedly in life, help the child to be actively engaged in constructing her/his own understanding of science, technology, and the world which they live (Kaushik & Sharma, 2004; MoE, 2009; NCREL, 1995).

From open-ended questionnaires, college natural science instructors reported that college natural science curriculum and practical lab activities were not prepared in line with school environmental science textbooks and MLC document. In addition, college natural science instructors reported that the natural science curriculum was a direct copy of the linear one so that it had limitations in contributing to teach children science in an integrated and practical approach. The contents in the cluster natural science courses were found to be by far difficult than school environmental science contents so that it induced psychological problems and academic knowledge gaps upon student science teachers. Some of the opinions of college natural science instructors were found to be shared by school environmental science teachers. School environmental science teachers reported that contents were too difficult and not related, science kit training was not given in college, science courses were not supported by practical activities, and the lab experiments did not help to do practical activities in environmental science textbooks.

Conclusions and Recommendations

Conclusions

The purpose of this study was to explore the mismatches that exist between college cluster natural science and school environmental science curriculum in reference to colleges and first cycle primary schools of the Amhara region. Accordingly; based on the findings summarized above the following conclusions were made:-
The objectives in the college cluster natural science curriculum were not in harmony with the school environmental science curriculum. School environmental science teachers should be trained to help children learn and do science. However, the objectives indicated in the college cluster natural science curriculum guide were not designed in the way to promote environmental science teaching and learning skills. In other words, the objectives stated in the college cluster natural science curriculum did not promote student science teachers to use simple resources to do science as it demands.

The environmental science contents were found to be clearly specified in the college cluster natural science courses. This conclusion was drawn based on investigation of environmental science textbooks and contents in the college cluster natural science courses. Moreover, the opinion of school environmental science teachers have shown that there were no as such difficult contents in the textbooks except simple machines and their types, preparation of dyes from leaves and flowers. However, respondents' opinions revealed that the contents in the college cluster natural science courses were found to be by far difficult compared to the contents of school environmental science textbooks. These prominent gaps create psychological and academic knowledge problems upon student science teachers. Consequently, interventions must be made in alleviating such gaps especially in the first year courses.

Investigation of environmental science textbooks and science practical manual revealed that more than half of the activities were found to be not indicated and covered in college science courses. On the other hand, the lab courses in the college dealt with contents which have no immediate usage in teaching environmental science for children. Of course these higher level courses help student science teachers to broaden their knowledge, understanding and skills. However, since the cluster natural science program was designed to take intervention on the gaps that existed, priority must be given for practical activities which are indicated in the textbooks and science practical manual. It can be concluded that more sophisticated materials were used in the college. This emphasizes that there is a need of helping and guiding student science teachers in preparing locally available materials to meet the need of elementary schools.

Even if different active learning methods and assessment techniques were indicated in the college's cluster natural science curriculum guide, different problems were revealed in applying these active learning methods and assessment techniques in a way that school science teachers used to teach environmental science. In addition, it has been mentioned by school teachers that due emphasis was not given in preparing and using teaching aids along with the science courses in a way to encourage school science teachers. There was no well-organized school pedagogical resource center that helps school science teachers to teach environmental science. The science courses were not supported by learning experiences from grades 1 through 4.

The different cluster natural science courses and the training given in college help student science teachers to increase their academic knowledge; however, student science teachers thought that the cluster natural science curriculum was limited to help teach environmental science for children in an integrated way by using practical and hands-on activities.

Recommendations

In line with the results of investigation using data from human participants & various documents and the conclusions drawn, the following recommendations are forwarded so as to improve quality science education in primary schools.

The objectives of the college cluster natural science courses should be revisited to meet the demands of primary schools. Emphasis should be given to train student science teachers in a way to help children learn and do science, and to raise their curiosity.

The contents of environmental science textbooks are clearly specified in the college cluster natural science courses except contents related to simple machines & their types and preparing inks from leaves and flowers. These contents should be covered in the college training. Besides, there must be an intensive induction and orientation for novice student science teachers about the science courses they take in college. Since the contents of the courses they learn in college are by far difficult than the contents of environmental science textbooks, they may feel inconvenient and loose interest towards the science courses. On the other hand, some rearrangements should be made to bring into discussion about primary level contents and how they teach children using locally available resources. Since the cluster program is designed to take interventions for the existing gaps in academic knowledge and skills, the college courses should be revised to alleviate the trainees' psychological and academic readiness. The cluster natural science curriculum should not be a direct translation of the linear natural science curriculum.

College natural science teachers should look for practical activities in environmental science textbooks and inculcate them in the course as an immediate solution to practical inadequacy of school environmental science teachers. However, the Colleges and the Bureau should create conducive conditions to select and organize practical activities indicated in the textbooks and in the science kit manual so that they should be offered either with the courses or methods of teaching science course. Laboratory courses and activities should primarily focus on practical activities found in environmental science textbooks and science kit manual.

College natural science teachers should use a wide range of teaching learning methods, assessment techniques, techniques of helping and guiding students with special needs education when they teach science courses. The college and the bureau should arrange suitable conditions and organize science seminars which help to indicate and select appropriate teaching methods, assessment techniques, and learning experiences for teaching a certain course and topic.

There are new approaches to science teaching like constructivist approach. Consequently, science workshops and seminars should be organized in the college level and a debate should be held on different aspects to bring quality science education in primary schools as far as science is among the prioritized subject to bring sustainable development of this country.

Ultimately, the researcher would like to recommend all interested teachers to conduct a research which investigates problems and gaps in primary education and brings immediate remedial solutions either individually or with departmental collaboration.

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Shyh-Chyi Wey [1], Yeiu-Hsiu Lin [1], Shu-Chu Chen [1]

[1] National Yunlin University of Science and Technology

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Application of Interactive Whiteboard on Remedial Instruction for EFL Low Achievers

Shyh-Chyi, Wey [1], Yeiu-Hsiu, Lin [1], Shu-Chu Chen [1*]
[1] National Yunlin University of Science and Technology

Abstract

The purpose of this research is to explore the effect of the application of interactive whiteboard (IWB) on EFL fourth graders' remedial instruction by examining their English performance and learning attitude and confidence. A quasi-experimental method was employed in the present study. Participants were twenty low-achieving fourth graders in English subject. The remedial instruction was implemented for eight weeks. A proficiency test and a survey questionnaire were administered before and after the instruction. The findings indicated that (1) after receiving the remedial instruction with IWB, students made significant improvement in English reading and speaking; (2) comparing with the control group, students instructed with IWB showed better attitude and higher confidence in English learning.

Key words: Interactive Whiteboard, EFL, English learning.

Introduction

In Taiwan some researchers try to integrate multimedia programs into elementary English teaching (Chuang, & Shih, 2009; Huang, 2004). The integration of information and communication technology (ICT) and multimedia materials into English teaching could benefit students' learning effects (Lai, Tsai, & Yu, 2009; Tsai, 2011). Instructions through the use of multimedia could also raise students' learning motivation and interest (Agnew, Kellerman & Meyer, 1996).

The term "multimedia" refers to combination of multiple technical resources for presenting information in multiple formats (text, images, graphic, and video) through multiple sensory formality (Schnotz & Lowe, 2003). The multi-sensory capacity of multimedia enhances students' retention of the class (Burden, 2002). The learning becomes more memorable (Thomas, 2003). Students are easy to recall the contents in the class by the vivid images in their mind. This is not only because there is more information available, there is also a wider variety of information so that idea and concepts become more concrete and students find the concepts easier to understand (Levy, 2002).

According to the dual coding theory, visual information is organized so that different parts of an imagined object are available in the same time for further processing; whereas verbal information seems to be recalled, processed, and used sequentially and can only be mentally reorganized in remembered sequence (Clark & Paivio, 1991). However, visual images can be modified in a great variety of special context and sensory dimensions (for example, by rotation, size, and color). Therefore, it is reasonable to assume that when we learn information in both visual and verbal forms, each form is stored in a separate cognitive system.

Clark and Mayer (2003) stated that working memory is the center of cognition since all active thinking takes place there. Learning requires that new knowledge and skills in working memory become integrated with existing knowledge in long-term memory. After encoding new knowledge and skills into long-term memory, the learner must be able to retrieve those skills from the long-term memory back into working memory (retrieval). Without this retrieval learning fails to transfer. Applying multimedia to instruction must guide the learner's transformation of words and pictures in the lesson through the sensory and working memory so that they get incorporated into the existing knowledge in long-term memory. Interactive whiteboard (IWB) can connect well

* Corresponding Author: *Chen Shu-Chu, chensc@yuntech.edu.tw*

with multimedia materials. In 2006, MOE subsidized some schools building e-learning classrooms and started to use IWB in the classroom settings in Taiwan.

The IWB is a board which users can not only use it to project images with computers, but to operate the computers either by doing the actions on the board or the mouse of computers. IWB also packs some software so that the users can directly write on the board and use the tools to control the content (Beauchamp, 2004). IWB is attractive to students because it includes versatility, multimedia and fun (Hall & Higgins, 2005). Versatility allows students to access a wide range of resources through the technology (Levy, 2002). Multimedia increased students' motivation and attention span in the class since IWB makes learning more enjoyable and fun in the class (Wishart & Blease, 1999; Levy, 2002).

When teachers begin to use IWB as a teaching tool, there are some different stages that they need to go through before they can really manipulate well of IWB. Glover and Miller (2004) stated three levels of using IWB by teachers in their research: 1. Supported didactic: where the IWB is used to enhance traditional board-focused didactic teaching. 2. Interactive: where the teacher recognizes some of the additional benefits of the technology and endeavors to stimulate interactivity by questioning and involvement of pupils. 3. Enhanced interactive: where the teacher moves from the instructional to the involvement role and uses the technology to stimulate, integrate and develop interactive learning. When teachers start to use the IWB, they may use it as only a projector or a writable screen. After they get familiar with the functions and software, they begin to know the convenience of interaction. At the last stage, if teacher is not the only authority in using IWB, students can have more time and involvement on their learning through IWB.

For the low achievers of English learning, it is important to arouse and maintain their learning motivation through the process of teaching and learning. IWB can motivate students because the courses are more enjoyable and interesting (Beeland, 2002). The multimedia aspects of IWB also helps students engage in several authentic activities which is visual, audio and touchable (Hall & Higgins, 2005) and children learn best through the senses of seeing, hearing and touching (Walker-Tileston, 2004). IWB incorporates all these three elements at the same time.

In Taiwan, IWB in the classroom has increasingly widely used in recent years but the majority of research of IWB has focused on the domains of mathematics and natural science and little research has been studied on its effects in the English classroom, especially on low achievers. Thus, this study attempts to know whether IWB can help improve low achievers' performance in English learning.

Purpose of the Study and Research Questions

The purpose of this study was to know the effects of integrating IWB into English remedial instruction for elementary school low achievers and investigate the changes of students' learning motivations. Given the theoretical positions taken for the study and the status of the field as briefly reviewed above, the study aimed to provide an answer to the following questions:

1. Is IWB beneficial to low achievers of primary schools in English learning?
2. Among four language skills (e.g., listening, speaking, reading and writing), which skill can IWB help the learners improve the most?
3. Can the application of IWB improve low achievers' attitude in English learning?
4. Can the application of IWB enhance low achievers' confidence in English learning?

Method

This study was conducted to know how IWB benefits English learning of low achievers in elementary schools; therefore, an experimental research was designed. It consisted of an experimental group and a control group. The students who were taught with IWB remedial instruction were arranged into the experimental group and those who did not accept the instruction with IWB was placed into the control group. The independent variable was the IWB remedial instruction and the dependent variables were students' learning motivations and performances. A pretest and a posttest as well as a survey questionnaire were administered on both groups before and after the experiment.

Participants

The participants in this study were 20 low achievers of fourth grade from an elementary school in Chiayi County. They had studied English for one year since they were in grade three, two classes (80 minutes) per week and were selected out of 60 fourth graders by a pretest. Those who got the scores below the mean were considered as the participants. Ten of the 20 students who received IWB remedial instruction were assigned into the experimental group. The other 10 students who received traditional remedial instruction were grouped into the control group.

Instruments

The instruments used in this study were IWB, an English learning motivation questionnaire (ELMQ), and an English proficiency test. The questionnaire was adopted to measure the participants' learning attitude and confidence. The pretest and posttest were used for identifying their English performance.
Interactive Whiteboard (IWB)
According to different software and induced technology, IWB can be categorized into three kinds: electromagnetic, analog resistive and ultrasonic, laser and infrared. The types of IWB commonly used in Taiwan are SMART Board, Active Board and It-Board. In this study, the research used SMART Board as a teaching and learning tool.

English Learning Motivation Questionnaire (ELMQ)

The English learning motivation questionnaire (ELMQ) focused on participants' attitude and confidence of English learning. The ELMQ consisted of 10 items and used a 5-point Likert scale, ranging from strongly agree, agree, neutral, disagree and strongly disagree. The more scores they got from the ELMQ, the higher learning attitude and confidence they held. As to the test for internal consistency, the reliability coefficients were .87 for attitude and .83 for confidence.

English Proficiency Tests

The English proficiency test was designed according to students' textbook that they had learned in grade three. Those students were given a pretest identify their proficiency level before the instruction and a posttest after receiving the IWB remedial instruction. The tests contained four parts, listening, reading, writing and speaking. The scores were calculated into five categories: listening, reading, writing, speaking and total.

Results and Discussion

The purpose of this study was to examine the effect of IWB integrated into English remedial teaching of fourth graders. In this section, the results of the study are presented in terms of participants' test performances, motivations toward English learning. The results from ELMQ and English proficiency tests were analyzed by ANCOVA.

Results of the Posttest of English Proficiency: Total Score

The mean score of the posttest of experimental group was 69.5, and of the control group was 67.6. To inspect precisely the effect of English remedial instruction on participants' English performance, ANCOVA was utilized to control initial differences in participants' pretest. Before the analysis of ANCOVA, tests of homogeneity of with-in regression was conducted to know if it was workable to examine the data by ANCOVA. The interactions of the independent variable (group) and the covariate (English proficiency pretest) was not significant ($F=.83$, $p >.05$), suggesting that the assumption of with-in regression homogeneity was supported. Therefore, the effect of English remedial instruction on participants' English proficiency could be analyzed by ANCOVA.

In Table 1, the result of ANCOVA presented that after excluding the interference of covariate (English proficiency pretest), the effect of independent variable (English Remedial Instruction) on the dependent variable

(English proficiency posttest) was significant (F= 5.03, p < .05). The results indicated that scores of the proficiency posttest were significantly different between the two groups because of different experimental condition. The adjusted mean score of the experimental group (M= 70.73) was significantly higher than that of the control group (M=66.36). The results supported that after English remedial instruction, the scores of the experimental group were significantly higher than those of the control group. More specifically, the findings supported that IWB is beneficial to low achievers of primary schools in English learning.

Table 1. ANCOVA of English Proficiency Posttest

Source	SS	DF	MS	F
Proficiency pretest	1276.84	1	1276.84	69.11
Group	93.05	1	93.05	5.03*
Error	314.06	17	18.47	
Corrected Total	1683.95	19		

**p*< .05

Results of the Posttest of English Proficiency: Four Skills

Listening

The listening scores of English proficiency posttest were presented in Table 2. The mean score of the experimental group (M=25.50) was nearly the same with the mean score of the control group (M=25.20), resulting in that there was no significant difference of participants' listening scores (F=2.39, p >.05) after English remedial instruction. In other words, the listening performance of the experimental group and that of the control group were not significantly different. Through the remedial instruction, the teacher of control group improved participants' listening and speaking abilities by playing games while the teacher of IWB groups used multimedia materials to help students learn. Therefore, there was no significant difference between the two groups in listening.

Speaking

The speaking scores of English proficiency posttest were presented in Table 2. ANCOVA analyses showed that there was a significant difference of participants' speaking scores (F=9.08, p <.05) after English remedial instruction, with the mean score of experimental group (M=6.70) higher than that of control group (M=5.60). To sum up, the experimental group had a better performance in speaking than the control group.

Reading

The reading results of English proficiency posttest were presented in Table 2. ANOVA analyses showed that there was a significant difference of participants' reading scores (F=14.72, p<.05) after English remedial instruction, with the mean score of the experimental group (M=22.50) higher than that of the control group (M=18.60). That is, the experimental group had a better performance in reading than the control group.

Writing

The writing performance was presented in Table 2. Although ANCOVA analyses presented that there was a significant difference of participants' writing scores (F=11.47, p <.05) after English remedial instruction, the mean score of experimental group (M=15.00) was lower than that of control group (M=18.20). Therefore, the control group had a better performance in writing than the experimental group. IWB allowed only one or two students to come up and write at the same time; therefore, it took too much time if the teachers asked all the participants to practice on the broad. And the electronic pens of IWB also affected participants writing. Martin

(2008) also finds similar problem and states that the tools for touching on the screen were inconvenience to operate and students had difficulties to write what they wanted.

Table 2. Descriptive Statistics of Four Skills of English Proficiency and ANCOVA Analyses

	Experimental Group Mean (SD)	Control Group Mean (SD)	ANCOVA F
Listening	25.50 (4.30)	25.20 (2.89)	2.39
Speaking	6.70 (.95)	5.60 (1.71)	9.08**
Reading	22.50 (2.54)	18.60 (5.25)	14.72**
Writing	15.00 (3.91)	18.20 (3.42)	11.47 **

** *p*< .01

Results of the Posttest of ELMQ

After receiving English remedial instruction, the mean score of the experimental group was 35.40 while that of the control group was 28.60. To accurately assess the effect of the English remedial instruction on participants' learning motivation, an ANCOVA was utilized to control initial differences in participants' ELMQ pretests scores. In addition, a test of homogeneity of with-in regression was conducted to examine if it was suitable to conduct the ANCOVA. The interactions of the independent variable (group) and the covariate (ELMQ pretest) was not significant (F=.14, p >.05). The result of the homogeneity test was correspondent with the assumption of with-in regression homogeneity. Therefore, ANCOVA could be used to evaluate the effect of English remedial instruction on participants' learning motivations.

ELMQ—Attitude

The results in Table 3 showed that there was a significant difference of participants' scores of English learning attitude (F= 42.04, p<.05) after English remedial instruction, with the mean score of experimental group (M=20.10) higher than the mean score of control group (M=15.50).That is, the experimental group had more positive attitude in learning English than the control group after remedial instruction.

ELMQ-- Confidence

The result in Table 3 showed that there was a significant difference of participants' scores of English learning confidence (F= 9.19, p<.05) after English remedial instruction, with the mean score of experimental group (M=15.30) higher than that of control group (M=13.60).That is, the experimental group had more confidence in learning English than the control group after remedial instruction.

Table 3. Descriptive Statistics of ELMQ and ANCOVA Analyses

	Experimental Group Mean (SD)	Control Group Mean (SD)	ANCOVA F
Attitude	20.10 (2.42)	15.50 (2.49)	42.04 ***
Confidence	15.30 (4.57)	13.60 (2.87)	9.19 *

p* <.05, * *p* <.001

Conclusion

This study aimed to investigate the effect of IWB as a teaching and learning tool on elementary school low achievers in English remedial instruction and examine their motivational change after the remedial instruction. The research was conducted by an experimental instruction of 20 fourth graders.

First of all, the findings indicated that even both groups made progress after eight-week instruction; the IWB group had more significant effect on students' English proficiency. The use of IWB for teaching and learning in EFL remedial class helped improve students' speaking and reading abilities significantly, but concerning with students' listening ability, students' improvement in these two groups did not show much difference. As to writing ability, on the contrary, students in the group without IWB have a better performance than those in the

IWB group, since without interacting with the IWB, the students in the control group had more time to practice writing.

Secondly, participants' learning and confidence toward English learning were significantly changed in IWB group than in the control group. The results of this study indicated that IWB integrated into English remedial instruction changed students' personal interest in English learning.

After eight weeks of English remedial instruction, participants' attitudes of English learning changed positively, which is consistent with the result studied by Weiner (2001) showing the improvement of students' motivation in an IWB class. The remedial instruction with IWB of the study also helped improved the low-achieving students' English reading and speaking since using IWB could motivate students because the instruction became more interesting so that students' attention in the class was improved (Beeland, 2002). In brief, teachers can make good use of IWB which is considered fun, interactive to attract students' attention and thus enhance their retention.

Limitations of the Study

In this study, several limitations existed and affected the result. First, the school administration policy affected the English remedial instruction. The schedule of remedial instruction was adjusted two times because of the field trip and county English competition. The researcher needed to spend some time in reviewing the lessons. Especially during the period of county English competition, because researcher responded for the training in school, so the instruction was suspended about two weeks.

The second one is the technical problem. The materials that used for the IWB group needed to be interactive so that can reflect the feature of IWB. But because teacher lacked the skill of making interactive material, so the material that used for IWB group came from the textbook publisher. Therefore, when researcher designed lesson plan, the content of interactive software must be concerned. There are also some functions of IWB software; however due to the software is not user friendly, the teacher can't manipulate it very well. Thus teacher and students only use the functions of pen and eraser that can write on the IWB most of the time

Third, the participants in this study were limited to 20 fourth graders from two classes in elementary school in Chaiyi County. The results may not be inferred to all the elementary school students.

Pedagogical Implications

This study presented that participants benefited significantly through ICT integrated instruction. According to the classroom practice, the study has the following implications:

First, the participants in this study were low achievers; therefore, the learning material was based on what they had learned in third grade. In order to keep the learning easy and simple for those students, the content was focused on alphabet, phonics, vocabulary and sentence patterns. Simple learning material can make students not to feel frustrated in learning English. When students can read the vocabulary and sentence patterns by themselves gradually, they can build up their confidence of learning English and then improve their English performance.

Second, there was a problem that most of the low achievers would forget what they have learned easily. So in the beginning of every class, teacher would review the vocabulary and sentence patterns that they had learned each time. The participants could have the chance to review the content and through the repetitions of every time, they would not forget the materials easily after learned new things.

Third, the participants were interested in using IWB and teaching through IWB could enhance participants' learning motivation. However, by the teacher's limited ability of designing interactive learning materials, the interactive material that used in this study was made by textbook publisher. The whole units were made by the same pattern. Participants were easily to get bored after four or five units. However, if the interactive material could have different kinds of activities or games, there would be more teaching benefit for students.

Suggestions for Further Research

There are some suggestions for further researchers. First, a large scale IWB integrated into English remedial instruction study may extend the findings of current study. In this study the subjects were only 20 low achievers in an elementary school of Chiayi County. A larger sample from different school is needed.

Second, the remedial instructions in this study were taught during the morning studying time and afternoon break time individually. Because of school's activities, the remedial needed to be canceled sometimes; therefore researcher needed to postpone the schedule and made up the class first. Further researcher maybe can consider starting the remedial instruction before the beginning of the semester and hold the remedial instruction for a whole semester, in this way researcher will have more time to teach the instruction.

Third, the participants in this study were fourth graders, and the time of remedial instruction fell on the second semester. For those low achievers, most of them felt frustrated in the regular English class from third grade. Thus if the remedial instruction can be implement from the second semester of grade three that would be much helpful to those students.

Fourth, to see the IWB integrated into remedial instruction really affect participants' performance and motivation, or just because IWB was a new learning tool for them, a follow-up study is suggested to trace whether those participants can continue to make progress in the English class and maintain the motivations of English learning.

Fifth, teacher and students need to practice more often of how to use the IWB. Especially teachers had better to have the skill of designing their own interactive software for their class. The software of IWB should be more user friendly as well so that both teachers and students can make the most benefit of IWB.

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Thaísa Jacintho Müller[1], Helena Noronha Cury[2], José Valdeni de Lima[3]

[1] Pontifícia Universidade Católica do Rio Grande do Sul,
[2] Centro Universitário Franciscano,
[3] Universidade Federal do Rio Grande do Sul

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A Discussion about Errors in Algebra for Creation of Learning Object

Thaísa Jacintho Müller[1], Helena Noronha Cury[2*], José Valdeni de Lima[3]
[1] Pontifícia Universidade Católica do Rio Grande do Sul,
[2] Centro Universitário Franciscano,
[3] Universidade Federal do Rio Grande do Sul

Abstract

This Article reports the results of a research with 333 freshmen students of Differential Calculus, for whom it was applied a test with questions about basic mathematics. The question analysed in this article involves basic algebra. The students made mistakes in operations and algebraic properties that are essential for the continuity of their studies in Calculus, especially to solve exercises of limits and derivatives. Then, we sought to some theoretical constructs to discuss the errors, such as concept image, symbol sense, structure sense and algebraic insight. The main difficulties observed are related to the distributive property of multiplication over addiction. In this paper we propose the creation of a learning object, in accordance to the principles of multimodality to help students overcome their difficulties in algebra.

Key words: Error analysis, Distributive property, Algebra learning, Elementary school

Introduction

Freshman students in higher education courses in the field of Exact Sciences have shown several difficulties in Differential and Integral Calculus. Studies carried out in several institutions of Higher Education, in Brazil and in other countries, indicate that the contents studied in the previous years are the main source of errors in resolution of exercises and problems (Tall, 1992; Porter & Masingila, 2000; Artigue, 2004; Cabral & Baldino, 2004; Hardy, 2009). The researchers reported the problems to work with Differential Calculus presented by the students, who study in a private university in Rio Grande do Sul state, Brazil. An investigation was developed to analyze the learning difficulties the students presented in the Differential Calculus classes and the possibilities to overcome those difficulties through technological sources.

In the first classes of Calculus, first term of 2013, a diagnostic test was administered to evaluate the students' knowledge that is needed in the limits and derivatives studies. The results showed that difficulties have origin in the algebra learnt in elementary school, mainly in the use of distributive property of multiplication over addiction. The analysis of the mistakes made by the students in the first question of the test are presented and discussed in this article. A learning object is suggested to help the students to overcome their difficulties.

Since the analysis of the responses revealed the prevalence of errors related to the distributive property, we sought some constructs, developed by researchers of algebra teaching, to discuss the results obtained. Among these constructs, we highlight transparent and opaque representation (Zazkis, 2005), visual salience (Kirshner & Awtry, 2004), symbol sense (Arcavi, 1994), structure sense (Hoch & Dreyfus, 2004) and algebraic insight (Pierce & Stacey, 2001, 2004), later presented.

Theoretical Contributions to the Discussion

The main probable cause of errors in the correct application of distributive property of multiplication over addiction is due to how the student was taught this property. When the teachers want to introduce algebra to the students in elementary school, they usually present the definition and the schematic model shown in Figure 1.

* Corresponding Author: *Helena Noronha Cury, curyhn@gmail.com*

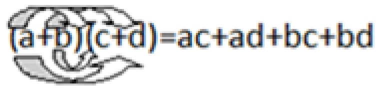

Figure 1. Schematic of distributive property

Thus, each student is able to form an individual concept image, including a scheme as the Figure 1, some definitional elements (more or less memorized, according to the time devoted to study) and some examples. It is important to explore examples that include difficulties for the application of distributive property, so that in another moment of the learning process the student do not remember only notions of concept image, which become potential factors of cognitive conflict. The notion of concept image is used as defined by Tall and Vinner (1981, p . 152): "[...] The total cognitive structure that is associated with the concept, which includes all the mental pictures and associated properties and processes. It is built up over the years through experiences of all kinds, changing the individual meets new stimuli and matures".

The pedagogical approach to present a concept, as the distributive property, should include a large variety of representations. According to Tall (2000, as cited in Giraldo, 2004), each representation draws attention to a specific characteristic of the concept and obscures others. Zazkis (2005) distinguishes between transparent and opaque representation. In the representation of distributive property, as shown in Figure 1, there are transparency in the way the terms should be operated, but the representation is opaque about the signal of the terms.

Kirshner and Awtry (2004) presented the constructor named visual salience; it was characterized by them as “aesthetic sense of form”. According to them, students tend to make incorrect transformation patterns of the expressions, as the following: $(a+b)^c = a^c + b^c$; $\sqrt[c]{a+b} = \sqrt[c]{a} + \sqrt[c]{b}$; $a^{m+n} = a^m + a^n$; $\frac{a}{b+c} = \frac{a}{b} + \frac{a}{c}$. Authors consider that these errors seem to have a superficial character and, instead of showing a misunderstanding of correct rules, they demonstrate an incorrect perception of those correct rules. In fact, according to the authors the incorrect rules are due to a overgeneralization of the correct rules explained in regular mathematics classes.

The visual salience rules have a coherence that makes both sides of the equation seem to be related. Besides, Kishner and Awtry (2004) consider that the repetition of the elements and their visual separation in both sides of the equation also contribute to the visual salience. For example, once students know the distributive property scheme they might overgeneralize it to any other equality which its elements seem to be distributed related to the others. That is the case of the pseudodistributive of the first wrong rule, mentioned earlier in this paper, which is a overgeneralization of (a+b)c=ac+bc.

Symbol Sense is another expression mentioned in several articles about algebra. Pierce and Stacey (2004) consider that there were two relevant attempts to describe the symbol sense. Those were made by Fey (1990) and by Arcavi (1994). Arcavi goes beyond Fey describing and discussing examples that illustrate the symbol sense. Some considerations and examples are shown later in this study.

The student needs to be familiar with the symbols, which requires an understanding of what and how the symbols have to be used to solve the problems, and also, when to choose other solutions, not algebraic. It was also mentioned by Arcavi (2004) the importance of not use algebraic manipulation when other representations show simpler solutions. This case is the problem: *what values can x take in* $|x-2|>|x-6|$? An algebraic solution which involves inequalities demands a technical work and it has a high probability of mistakes to occur. In this case a draft of the graph of the functions given by $f(x)=|x-2|$ and $g(x)=|x-6|$ allows an immediate solution.

Moreover, Arcavi (1994) said that knowing the algebraic manipulations to solve problems it is not enough, in some cases it is necessary to understand the meaning of the symbols. The author also identifies four key behaviors: reading instead of manipulation of the symbols; reading and manipulation; reading as the goal for manipulation, reading for reasonableness.

The first behavior can be illustrated with the data from an investigation made by Hoch and Dreyfus (2004), in which high school students were asked to solve the equation $(1-\frac{1}{n+1})-(1-\frac{1}{n+1})=\frac{1}{132}$. They found the common denominator of the terms of the first member of the equality and made use of algebraic manipulation, instead of notice that the first member of the equation is zero, so there is no solution. Thus, interrupt the manipulation, read and understand the symbolic relationship in this case is part of the symbol sense.

To the second behavior, Arcavi (2004) presents an example: if a student has the symbol sense, he or she can notice that the equation $\frac{2x+3}{4x+6}=2$ has no solution, because the algebraic fraction numerator of the first member is half the denominator. If the student insists on manipulate the equation, he or she will get to $=-\frac{3}{2}$, which is exactly the value that may not be used to replace x in the equation.

The third behavior can be illustrated with an exercise of demonstration by induction. We asked to algebra students in a mathematics teachers training course to solve the following problem: "The proposition $n!>n^2$ is not valid to any natural number greater than zero. From what value of $n \in N$ it becomes real? Express the real relationship and prove it by induction." The resolution requires more than just the standard procedure of induction method, it is necessary to read to understand what is being asked, and then follow the procedures of induction to show that the inequality holds for $n \geq 4$.

The 4th behavior, according Arcavi (1994), is to develop the habit of rereading and testing (for replacements, for example) a particular expression obtained when trying to solve a problem rationally. In a test of the Integrated Algebra of Regents High School Examination 2010, there is the following problem: "Find three consecutive positive even integers such that the product of the second and third integers is twenty more than ten times the first integer ". (p. 22). If the student is in doubt about the algebraic expression that represents the situation, he or she can test values to check if the answer is correct, since the passage from natural language into mathematical language is a source of error in this type of problem. The algebraic manipulation is a skill that we aim to develop when we teach algebra. The cases reported by Arcavi (1994) help us to reflect on the proposed mechanic resolution from a list of standard exercises, which do not always develop the symbol sense.

Hoch and Dreyfus (2004) bring the concept of " structure sense ". They start asking if two algebraic expressions that have the same structure are equivalent and give, as an example, 30x 2 -28x+6 and (5x-3) (6x-2). As we can see, the first is a quadratic expression and the second is a product of two linear factors. However, they both have the same structure and find out which of them use in a specific context is part of what these authors define as structure sense. That can be described as a set of skills that include, among other aspects, the vision of an algebraic expression or sentence as a single entity, the recognition of an algebraic expression as a structure previously studied and manipulations that can be used on it.

Another construct that has been discussed among researchers of algebra teaching is the one Pierce and Stacey (2001) call "algebraic insight". The authors refer to the work as Computer Algebra System (CAS) and consider that the algebraic insight is a subset of symbol sense that can be defined as "the algebraic knowledge and understanding which allows a student to correctly enter expressions into the CAS, efficiently scan the working and results for possible errors, and interpret the output as conventional mathematics". (Stacey, 2001, p. 418-419).

According to Pierce and Stacey (2004), the algebraic insight, has two aspects: "algebraic expectation" and ability to link representations. The term algebraic expectation is used "to name the thinking process that takes place when an experienced mathematician considers the nature of the result they expect to obtain as the outcome of some algebraic (and symbolic) process". (p. 5). For example, when it is decided that two expressions are possibly equivalent without doing any calculation or algebraic manipulation.

In a framework with elements and common instances of algebraic insight , Pierce and Stacey (2004), divide the algebraic expectation into three elements: a) recognition of convenctions and basic properties, which common instances are the knowledge of the meaning of the symbols, the order and the properties of operations; (b) identification of structure, which common instances are the identification of objects and of strategic groups of components and recognition of simple factors ; c) identification of key features, related to the identification of the form and the dominant term, as well as the union of the form with the type of solution.

Pierce and Stacey (2004) commented that fundamental mathematical difficulties may be better detected by the teacher when the student works in a CAS. The authors mention the example of a student who worked with the function given by $f(x) = \frac{x^2+1}{2-x}$ and that typed x^ 2 +1/2-x, obtaining, on the computer screen, the image of the function x^2 + ½ - x, which surprised her. Later, working with the expression $\frac{x^2-1}{x-1}$, the student, after finding her mistake, entered correctly the parentheses, by writing (x^ 2-1) / (x-1). However, she was once again surprised, when obtained, as result shown by the machine, the binomial x+1.

Arcavi (1994) remade the list proposed by Fey (1990) and considers that the symbol sense must include, among others, an understanding of and an aesthetic feel for the power of symbols, which brings the idea of visual salience, by Kirshner and Awtry (2004); an ability to manipulate and to "read" symbolic expressions as two complimentary aspects of solving algebraic problems. This meets aspects presented by Hoch and Dreyfus (2004) when they define structure sense: the awareness that one can successfully engineer symbolic relationships which express the verbal or graphical information needed to make progress in a problem, which recalls the definition of algebraic insight (Pierce & Stacey, 2001). Thus, we can say that these different constructs presented by algebra teaching researchers form the framework for the work with the difficulties of the students.

Methodology

In this investigation it was used qualitative methodology. A probing test was planned, composed of five open questions regarding the content of mathematics in elementary education. The test was applied to 333 freshmen students of Differential Calculus, by the teachers responsible for the classes, on the first day of class. After the application of the test, the answers were the object of analysis of the content of the errors, performed based of the proposal of Bardin (1979), in three phases: pre-analysis, material exploration and treatment of results.

In the first phase the question chosen was: *Solve, in* ℝ, *the equation:* $\frac{2(x+3)}{3} - \frac{x-4}{2} = 2 - \frac{x+1}{4}$. Each response was indicated by a letter and a number, the initial letter of the teacher's name and the student´s number. The answers were corrected and classified into correct, partially correct, incorrect and blank.

In this first phase of the analysis, the 333 answers to the question chosen formed the *corpus* to investigate the types of errors (Bardin, 1979). In the second phase, the exploration of the material, the incorrect answers were unitarized and classified. In the third phase, the treatment of the results, the categories were described and illustrated.

Results

Among the 333 answers, 46 (14%) were correct, 9 (3%) parcially correct and 252 (76%) were incorrect. To analyse the 252 incorrect answers, we chose to classify only the first error committed by the student. Many times there was, for example, an initial error in the reduction to the same denominator and then the same student has committed an error of calculation, but the type of error classified is related to the reduction to the same denominator.

The categorisation of incorrect responses was made in two stages; initially 16 classes were created, and after the review of the types of errors, those were refined, obtaining at the end, five classes, herein after described and exemplified. The answer was typed as it was presented, so that, with the initial error and the expanding, that may be correct or present more errors.

Class I: the answers which the student shows difficulty regarding to the distributive property of multiplication over addiction are part of this category of answers. As an example, we have the answers of students T20 and G49, indicated, respectively, in Figures 2 and 3, below. All the examples were typed, because the answers were written in pencil and were not legible on scanning.

$$\frac{2(x+3)}{3} - \frac{x-4}{2} = 2 - \frac{x+1}{4}$$

$$2x + 2 - x - 2 = 2 - \frac{x+1}{4}$$

Figure 2. Student T20 answer

$$\frac{2(x+3)}{3}-\frac{x-4}{2}=2-\frac{x+1}{4}$$

$$\frac{4x+12-3x-12}{6}=2-\frac{x+1}{4}$$

$$\frac{x}{6}=2-\frac{x+1}{4}$$

$$\frac{2x+3x+3}{12}=2$$

$$\frac{5x+3}{12}=2$$

$$5x+3=24$$

$$5x=27$$

$$x=\frac{27}{5}$$

Figure 3. Student G49 answer

Class II : are part of this category the responses in which the student shows not knowing reduce fractions to the same denominator , such as, for example, the student G33 answer, indicated in Figure 4:

$$\frac{2(x+3)}{3}-\frac{x-4}{2}=2-\frac{x+1}{4}$$

$$\frac{2x+6}{3}-\frac{x-4}{2}=\frac{-x+1}{8}$$

$$\frac{4x+12-3x-12}{6}=\frac{-x+1}{8}$$

$$\frac{4x-3x}{6}=\frac{-x+1}{8}$$

$$\frac{16x-12x=-24x+24}{24}$$

$$4x+24x=24$$

$$28x=24$$

$$x=\frac{24}{28}\quad\frac{12}{14}\quad\frac{6}{7}$$

Figure 4. Student G33 answer

Class III: the answers that present calculation errors are understood as errors in operations in elementary operations. An example is the C27 student's answer, in Figure 5, which was wrong at the beginning, the product 4.2.3, indicating as 48.

$$\frac{2(x+3)}{3}-\frac{x-4}{2}=2-\frac{x+1}{4}$$

$$\frac{8x+48}{12}-\frac{6x-24}{12}=\frac{24}{12}-\frac{3x+3}{12}$$

$$8x+48-(6x-24)=24-(3x+3)$$

$$2x+48+24=24+3x-3$$

$$3x-2x=48+3$$

$$x=51$$

Figure 5. Student C27 response

In this case, the error is arithmetic and shows difficulties with the number sense.

Class IV: the incomplete responses are in this class, in which the student solves only one of the two members or both, but is not able to complete. Also the answers in which the student, after solving correctly both members, moved all the terms for the first member and did not equal it to zero, leaving only an expression and not an equation. For example, the student M40 presented the response indicated in Figure 6:

$$\frac{2(x+3)}{3}-\frac{x-4}{2}=2-\frac{x+1}{4}$$

$$\frac{4x+12-3x+12}{6}=\frac{8-x-1}{4}$$

Figure 6. Student M40 answer

Class V: here are the answers that present errors committed by only one student, so they do not constitute a separate category, but present some detail that deserves to be analysed. The example below is the student I2 answer, indicated in Figure 7:

$$\frac{2(x+3)}{3}-\frac{x-4}{2}=2-\frac{x+1}{4}$$

$$4\left(\frac{(2x+6)}{3}-\frac{x-4}{2}\right)=2-x-1$$

Figure 7. Student I2 answer

According to this classification, we found that 60% of the incorrect answers were in Class I, 23% in Class II, 9% in Class III, 6% in Class IV and 3% in Class V.

Discussion

Analyzing the answers exemplified, we observe that the student T20 "canceled" the fractions on the left side of equality, the number 3 of the numerator with the 3 of the denominator in the first fraction, respectively, and the

number 4 of the numerator with the 2 of the denominator in the second fraction. It means that the student did not understand that to "cancel" a term in a sum or difference, it is necessary a common factor that can be placed in evidence. Possibly the unexpected result of this first error led the student to leave the question, and only reducing (incorrectly) the similar terms on the left side.
The right side of the equation as indicated in Figure 1, which represents the law of distributive property, is not often used in class, and sometimes this property is not even identified. More specifically, the equality is rarely read from right to left, so that " factor out the common terms" is not seen as distributive property but as a case of factorising. On the left side of the equation $\frac{2(x+3)}{3} - \frac{x-4}{2} = 2 - \frac{x+1}{4}$, the student T20 did not recognize the lack of the number 3, in the first fraction, nor the lack of number 2, in the second fraction, as common factors to make the "cancellation" possible with their respective denominators. Thus, T20 shows not having algebraic insight, because does not recognize conventions and basic properties that allow the "cancellation" of terms.

The student G49 committed the first error reducing the fractions on the left side of the equality to the same denominator 6, therefore, to multiply the second fraction by 3, the student did not realise that the minus sign in front of this fraction indicated (-1) (x-4). We can assume that the separation between the minus sign and the fraction led the student G49 to consider that this operation indicated by the minus sign is relative to the entire fraction. Thus, it emphasizes visually the fraction, in detriment of the binomial x-4. Perhaps there had been a mechanic learning of distributive property in Elementary School and the student remained a scheme as in Figure 1, but without understanding their meaning. As the student did not recognize that $-\frac{x-4}{2}$ indicates $(-1)\left(\frac{x-4}{2}\right)$, the student shows that did not recognize the possible operations, so that, does not have the structure sense.

In the example of Class II, we observed that the main error of this resolution appears in the second member, when the student G33 multiplies the integer number 2 by the denominator 4, obtaining a denominator equal to 8. G33 seems to have formed a concept image to reduce to the same denominator that requires the multiplication of the denominator for each numerator, without realizing that number 2 is an integer, equivalent to rational $\frac{16}{8}$.

In the example of Class IV, despite presenting correctly the first steps of the solution, the student M40 does not know what to do with the resulting equation, perhaps because the denominators are not equal on both sides. It lacks, perhaps, the structure sense, because it does not recognize the manipulations that could do to continue the resolution.

In Class V, student I2´s answer is interesting because it shows that he wrongly assumed that the denominator of the fraction of the second member could multiply the entire first member. It seems that this student has a mistaken concept image about the "cross multiplication".

Proposal to create a technological resource

Due to the large percentage of errors categorized in class I, there is concern about understanding and preparing some resources to help the students to overcome these difficulties. After all, the students are freshmen in Differential Calculus and algebraic manipulation is a necessary condition to work with limits and derivatives. Face the difficulties regarding the content of the Elementary School but often found in higher education students' answers, it is suggested the use of some technological resource to assist the teacher to detect the errors and the students realize their difficulties. In the case of mathematics, when we mention technology to support the teaching and learning processes, it is quite common the reference to Dynamic Geometry Systems (DGS) and Computer Algebra Systems (CAS). In fact, the use of Dynamic Geometry Software in math classes is enriching, since enables experimentation, allowing a reversal of the traditional order of teaching, starting with research and then leaving for theorizing (Borba & Penteado, 2007). Experimentation is a key step in the knowledge construction, because it stimulates research. Furthermore, through the use of software, it is possible to promote interactivity, creating rich environments for learning.

Besides the Dynamic Geometry software, Learning Objects (LOs) have been widely used nowadays, as an essential resource for classes. The definition of LO is given by several authors, and may have some differences, but with a common base. McGreal (2004, p. 21) comments that "LOs are sometimes defined as being educational resources that can be employed in technology supported learning." More specifically, a LO can be reused a number of times in different learnings and can "combine text, images and other media or applications to deliver complete experiences, such as a complete instructional event." (Wiley, 2000, p. 7).

In this perspective, it is very convenient create a LO which is able to assist the student in the difficulties encountered in the study presented. This object, in turn, should contain characteristics of multimodality. According to Roswell and Walsh (2011, p. 55-56), "Multimodality is the field that takes account of how individuals make meaning with different kinds of modes." In the case of this proposal, LO should simultaneously use two modes of presentation: verbal and nonverbal. Its base should be the distributive property, given the errors found in the issues discussed. However, this property will be addressed generically, applied to many operations in which it is valid, not only addition and multiplication (as, for example, conjunction and disjunction in Logic, as well as union and intersection in Set Theory).

In the current phase of the research reported here, the object is under construction, both the content and the implementation of technological resources needed. It is called "Real Numbers: operations and properties", since that, to the distributive property be worked, it is necessary to pass by the other properties of addition and multiplication, paying attention to the fact that the distributive property "connect" both operations in the set in question. In the introduction, there will be the student's awareness about the importance of the study of real numbers, operations and properties, since this will be his universe of work in Differential Calculus. After this step, we proceed to a brief interactive, which presents the blocks of the object. At this point, it is suggested a navigation order, through a path created with arrows, but leaves it clear to the student that if he deems appropriate, may visit only one of the blocks, change the order or return a block already considered. The steps (or blocks) are organized as follows:

1. Test your proficiency level: at this stage, besides exercises of addition and multiplication with integer and rational numbers, as well as roots, it will be explored the meaning of some words in the context involved, as commute, associate, distribute, and so on. If the student does not have a good performance, will be given materials that can serve as reinforcement to these studies and obtainment of the necessary prerequisites for the study of the content.

2. Addition and multiplication of Real Numbers: this block will present a historic part on the addition and multiplication, as illustration, since the formal definition of operation is not the object of study in Calculus courses.

3. Properties of addition and multiplication: with respect to the properties, there will be a brief review of the specific properties of the operations involved, such as associative, commutative, neutral, and so on.

4. The distributive property: this is the "key block" of the object, in which will be studied the distributive property in several instances in which it appears, with theory and examples.

5. Extending the idea: this time, the concepts presented will be extended to other sets and situations. As previously mentioned, will be used, for example, sets and propositions.

6. Exercises: this is the stage of testing the knowledge acquired, in which the student can verify if he or she understood what was presented and back to the theory if it is appropriate.

Finally, it is emphasized that, in order to ensure the best educational use of the object, all screens should be allowed to control the pace by the user, which can pause, go back or change the navigation order as it deems most appropriate, although it is suggested a logical order. At all times, there will be a combination of visual and additives stimulus, as well as the use of verbal and nonverbal modes, avoiding, however, to overload cognitively the learner.

Final remarks

In this article, we present a report of a survey that aimed to analyze learning difficulties presented by students of Differential Calculus and possibilities to overcome these difficulties by technological resources.

We sought to support the analysis of mistakes in ideas of authors who have worked with the teaching and learning of algebra. To create a technological resource that can help students overcome their difficulties, it was planned to build a Learning Object with features mentioned in the literature and based on the highest difficulty, related to the distributive property of multiplication over addiction.

It is believed that with the creation of the LO through the difficulties presented by the students, it will be possible to contribute to other students also entering in courses which have mathematics in their curricula; they can expand their knowledge about properties of operations with real numbers. In this aspect, the errors the students could undertake in studies of Differential and Integral Calculus involving this base could be overcome.

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