Mathematics Self-efficacy among Secondary Level Students

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Abstract: Low level of mathematical self-efficacy in students lessens their drive to study, which could culminate to poor mathematical outcomes. The objective of the paper was to figure out the level of mathematical self-efficacy among secondary level students. For this study quantitative paradigm was adopted, data were collected from the survey from 402 secondary school students of grade 9 to 12, randomly selected from two institutional and two community schools of Kathmandu. To measure the level of mathematics self-efficacy, the 14 items pertaining to mathematics self-efficacy were borrowed from MSEAQ prepared by May (2009). The alpha coefficient of the Self-efficacy scale was 0.91 and from the component matrix, each items have a factor loading greater than 0.4. A medium level of math self-efficacy but the lack of uniformity in mathematics self-efficacy was found. The mean mathematics self-efficacy score of male students was higher than female; the self-efficacy was slightly higher in institutional school than community school students. The mean self-efficacy score of grade 12 students was found highest and grade 9 was found least. The math self-efficacy was statistically significantly different based on gender and based on grade, but not based on types of school. The findings of this study indicate the need of stakeholders sustaining a support system that includes counselling, motivation, parental and teacher support, and other means to enhance students' mathematics self-efficacy.

Introduction

Self-efficacy is an indispensable component of individual attributes, which are pivotal significantly to learners' achievement. A person's self-efficacy reflects self-confidence in one's own competency. Mathematics self-efficacy is generally considered a person's perceptions about the capabilities in mathematics. Lower mathematics self-efficacy of learners decreases the drive to study and ultimately may result into poor competence in mathematics, and self-efficacy appeared as the most consistent and dominant predictor of competence from amongst the motivation variables (Jiang et al., 2017). Mathematics self-efficacy, according to Higbee and Thomas (1999), besides other causative aspects like exam anxiety and perceived practicality of mathematics, impacted learners' mathematics outcome. Further, they suggested to teachers that emphasizing on instructing mathematics content exclusively is inadequate for a group of children to study mathematics. Apart from this, emotional or attitudinal factors that influence the way learners learn mathematics must also be considered. National Assessment of Student Achievement (NASA, 2020) indicated the achievement level in mathematics is 32.1%, which is below the average. This shows that the learning outcome of students in mathematics in the secondary schools in Nepal is disappointing. In this context, the study of self-efficacy in mathematics is essential to better the teaching learning situation.

The objective of this research was to identify the level of mathematical self-efficacy of secondary level schoolchildren. For this purpose, the below mentioned questions have been set:

(1)   What is the level of mathematics self-efficacy among secondary level students?

(2)   Is there any association between school students' mathematical self-efficacy and their gender, grade level, and school type?

Empirical and Theoretical Foundation

Students' mathematics self-efficacy is significant due to its well-established relationship with achievement, that has been demonstrated across a variety of educational situations employing different approaches such as simple correlation (Schunk & Hanson, 1985) and by using latent growth modeling (Dicke et al., 2014) as well.

Betz and Hackett (1983) discovered that students' mathematical self-efficacy predicts their major course and choice of profession. Schoolchildren having high level of mathematical self-efficacy seemed significantly more willing to select science related university courses and science based careers than the students with low self-efficacy. They further found that learners constantly consider their competencies imprecisely. Perceptions of a large proportion of boys and a substantial minority of girls regarding the mathematical capabilities were not consistent with their actual outcomes.

Regarding gender differences and self-efficacy, researchers have come up with mixed findings. Researchers, like Pajares and Miller (1994); Lent, Lopez, and Bieschke (1991), and Betz and Hackett (1983) have obtained a significant gender based difference regarding the mathematics self-efficacy, and it was in favor of boys; while some other researchers, including Cooper and Robinson (1991), and Hall and Ponton (2002), did not find any variations in self-efficacy in terms of gender.

Bandura (1977) originally used the word "self-efficacy" in his article "Self-Efficacy: Towards a Unifying Theory of Behavioral Change," which defined it as the extent to which an individual's confidence in their own abilities influences their performance under real-world conditions. Indicating mathematics achievement as the greatest source of self-efficacy, Bandura (1977) highlighted that pupils having higher self-efficacy tended more driven to study and more willing to persevere with difficult assignments. Bandura asserts that *mastery experiences*, *vicarious experiences*, *social persuasion*, and *physiological conditions* are primary causes of self-efficacy. The majority of students' self-perceptions are based on their mastering experiences. Learners having consistently performed well in mathematics in the past are likely to think they can perform well in mathematics in the future. When children witness peers who resemble them doing well in mathematics, they will feel more confident with the subject. Positive and negative reinforcement from parents, instructors, and peers is referred to as social persuasion, whereas physical conditions such as weariness, pain, or nausea are referred to as physiological states in students.

The empirical and the theoretical literature indicated that self-efficacy is a crucial factor for academic performance of students. Although there are a number of works conducted on this topic at global arena, such studies at the context of Nepal are limited. Thus, additional study is required, to identify the level of mathematics self-efficacy and allied demographics, which might help fulfill the research gap.

Methodology

The data for this study was gathered using a survey method. The quantitative design, as suggested by Creswell and Creswell (2017) was used for the collection of quantitative data. Since, the primary objective of quantitative research is to assess causal relationships within a value-free framework as stated by Johnson and Onwuegbuzie (2004). Total 402 secondary school students' participants were randomly selected from two institutional and two community schools of Kathmandu. The following Table 1 represent the demographic structure of sample in the study.

Table 1: *The demographic structure of sample of the study*

Gender		Type of Schools		Grade			
Male	Female	Community	Institutional	9	10	11	12
229	173	185	217	125	91	116	70

Tools and validation

The present study was descriptive survey type and a quantitative approach was applied in this study to investigate the students' self-efficacy level. Students' mathematics self-efficacy levels were measured by the mathematics Self-Efficacy items adopted from 'Mathematics Self- Efficacy and Anxiety Questionnaire (MSEAQ)' prepared by May (2009). The modified form of opinionnaire from Hackett and Betz (1989) and Glynn et al.(2007) were used to developed the mathematics self- Efficacy. Altogether, 14 item based on 5-points Likert scaled ranges from 1 (never) to 5 (always) type opinionnaire such as like "*I feel confident enough to ask questions in my mathematics class"; "I believe I can do well on a mathematics test" etc.* were used throughout the collection of data. Rosly et al. (2016) has tested the optionaire and found the overall Cronbach alpha 0.763 for the instruments and recommended it for further use in the research as a reliable and valid tool.

To ensure the respondent friendly questionnaire items in Nepalese context, they were translated into Nepali and necessary modifications were made in the language keeping the essence intact. With the help of the translators, the Nepali version was translated back to English to confirm to the accuracy of the translation. Then, the scales were prepared for a pilot study. Through the piloting of the tool among 50 secondary level mathematics students who were excluded from the study's sampling, the internal consistency reliability i.e., the alpha coefficient of the Self Efficacy scale was 0.91. This shows that the scale was highly reliable. The item mean was 3.58 and the item variance was 1.15. Each value of the correlated item-total correlations was greater than .3, and each of the values in the Cronbach's alpha if item deleted was less than the test reliability. Therefore, each item of the questionnaire was suitable for this study. The extension range drawn via the principal component analysis was .62 to .90, i.e. none of the values is less than 0.3. Therefore, each item has no problem. From the component matrix, all have factor loading greater than 0.4. These results allowed to use the instrument in this study context without further modification of the scale. Surveys were carried out during regular classroom hours.

Analysis and Interpretation Procedure

The researchers applied the Statistical Package for the Social Sciences (SPSS- 20) in order to analysis the gathered data. The descriptive statistics (Min, Max, Mean, Standard Deviation and Variance) and the inferential statistics (Independent Samples t-test) were computed for the analysis of the data. The results, thus, obtained were interpreted with the help of the findings of the previous empirical researches and theoretical inputs.

Results
Level of Mathematics Self-efficacy

In self-efficacy scale, the scores of all questions were summed up to find the aggregate self-efficacy score. The possible value of mathematics self-efficacy scale score is between 14 to70. The greater value indicates more self-efficacy and the lower value indicates lower self-efficacy. The study found the mean self-efficacy, maximum and minimum values with corresponding standard deviation, Skewness and Kurtosis as exhibited in Table 2.

Table 2: *Descriptive statistics of mathematics self-efficacy*

	N	Min.	Max.	Mean	SD	VAR	Skewness	Kurtosis
Mathematics Self-Efficacy	402	19.00	70.00	48.79	11.082	122.82	-0.377	-0.436

The table 2 shows that the students' mean mathematics self-efficacy was 48.79 that indicated there was an average level of mathematics self-efficacy. The standard deviation was 11.082 and the score ranged from 19 to 70, further revealing the lack of uniformity in math self-efficacy. Some of the students had a very low level of math efficacy, whereas others had medium and an extremely high level.

Levels of Math Self-efficacy Based on Gender
The mean, standard deviation, and coefficient of variation of female and male students mathematics self-efficacy were computed and presented in Table 3.

Table 3: *Mathematics self-efficacy of female and male students*

Content		Gender	N	Mean	Std. Deviation	CV(%)
Mathematics	Self-	Female	173	46.58	11.56	24.82
Efficacy		Male	229	50.45	10.43	20.67

Table 3, demonstrates the mean self-efficacy of female and male students was 46.58 and 50.45 respectively. This exhibits that the self-efficacy was different in relation to gender. The mean self-efficacy score of male students was higher than female. The fact that the C.V. of female students was greater than the C.V. of male students suggests that females exhibited inconsistent math self-efficacy relative to male. At this point, independent sample t-test was used to test the self-efficacy of female and male students.

Table 4: *Independent samples test between female and male students*

Content	t-test for Equality of Means						
	t	Df	p	Mean Difference	Std. Error	95% Confidence Interval	
						Lower	Upper
Mathematics Self-Efficacy	-3.52	400	.00	-3.87	1.11	-6.03	-1.71

In the above table, the t – statistic was found -3.52 and with 400 degree of freedom. Since p = 0.000 (< 0.05), shows that the mean mathematics self-efficacy was statistically significant. Thus, it can be inferred that there existed disparities in self-efficacy between male and female learners. The observed effect size (Cohen's d) was found (d=0.352< 0.8) for female and male students showed a statistically significant difference in math self-efficacy was medium. Math self-efficacy levels were found higher in males than females.

Level of Math Self-efficacy in Different Types of Schools
The mean, standard deviation, and the coefficient of variation of two types of schools: community and institutional were computed and shown in Table 5.

Table 5: *Mathematics self-efficacy in community and institutional schools*

Content		School Type	N	Mean	SD	CV
Mathematics	Self-	Institutional	217	49.25	10.70	21.72
Efficacy		Community	185	48.39	11.40	23.56

Table 5 shows that the mean self-efficacy of institutional school and community school students' were found 49.25 and 48.39 respectively. This shows that the self-efficacy was slightly different in terms of types of school. The mean self-efficacy score of students' Institutional schools was higher than community schools. The fact that the C.V. of community school was greater than the C.V. of institutional school that represent the students of community showed inconsistent in mathematics self-efficacy in comparison to institutional. At this point, we used the independent sample t-test to test the self-efficacy of institutional and community school students.

Table 6: *Independent samples test between community and institutional schools*

Content	t-test for Equality of Means						
	t	Df	p	Mean Difference	SD Error	95% Confidence Interval of the Difference	
						Lower	Upper
Mathematics Self-Efficacy	.79	400	.44	.86235	1.109	-1.319	3.044

Here, the t – statistic is 0.79 and the degree of freedom is 400. As p = 0.44 (>0.05), the mean math self-efficacy was not statically significantly different between institutional and community school students.

Levels of Math Self-efficacy in Different Grades

The study found the mean self-efficacy, with corresponding standard deviation, and coefficient of variation in different grades 9, 10, 11, and 12 were presented in Table 7.

Table 7: *Math self-efficacy in different grades*

Contents		Grade	N	Mean	Std. Deviation	CV
Mathematics	Self-	9	125	46.49	10.89	23.42
Efficacy		10	91	49.24	9.57	19.44
		11	116	48.54	11.27	23.22
		12	70	52.71	9.48	17.99

Table 7 indicated that the mean self-efficacy according to grades 9, 10, 11, and 12 were found 46.49, 49.24, 48.54, and 52.71 respectively. The mean self-efficacy levels between grades were different. The mean self-efficacy score of grades 12 students was found highest and grade 9 was found least. The standard deviation showed that the anxiety level was different within each grade. The C.V. indicated that the self-efficacy level of the students of grade 9 was more diverse than other graders and grade 12 have more consistence math self-efficacy. We used an ANOVA to check whether the level of mathematics self-efficacy in different grades is significant. The ANOVA findings have been shown in table 8.

Table 8: *One-way ANOVA summary table comparing four grade levels on math self-efficacy*

	Sum of Squares	df	Mean Square	F	p
Between Groups	1761.950	3	587.317	4.922	.002
Within Groups	47489.077	398	119.319		
Total	49251.027	401			

Table 8 shows P – value = 0.002 (< 0.05) with an indication of the significant grade differences in mathematics self-efficacy of the students. Similarly, the Post Hoc analysis for multiple comparison of mathematics self-efficacy is presented with the following Table 9.

Table 9: *Post Hoc test (Tukey HSD) for multiple comparisons of mathematics self-efficacy*

(I) Grade	(J) Grade	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
9	10	-2.746	1.505	.263	-6.629	1.138
	11	-2.039	1.408	.470	-5.672	1.595
	12	-6.219*	1.631	.001	-10.425	-2.011
10	9	2.746	1.505	.263	-1.138	6.629
	11	.708	1.530	.967	-3.240	4.654
	12	-3.472	1.737	.190	-7.953	1.008
11	9	2.039	1.408	.470	-1.595	5.672
	10	-.707	1.530	.967	-4.654	3.239
	12	-4.180	1.653	.057	-8.445	.086
12	9	6.218*	1.631	.001	2.011	10.426
	10	3.472	1.737	.190	-1.008	7.953
	11	4.180	1.653	.057	-.086	8.445

*. The mean difference is significant at the 0.05 level.

Post Hoc test (Tukey HSD) for multiple comparisons found that the mean value of the math self-efficacy score was significantly different between grade 9 and grades 12. However, there was no statistically significant difference in mathematics self- efficacy between grades 9 and 10; 9 and 11; 10 and 11; 10 and 12; 11 and 12. The math self-efficacy of grade 12 students was found higher compared to the other grades.

Discussion

The present study showed that the mean math self-efficacy of the students was 48.79, whereas the probable range of the scale was 14-70, that indicated there was a medium level of mathematics self-efficacy. Some of the students demonstrated a very low level of math efficacy, whereas others had medium and an extremely high level. Bandura (1977) explained that self-efficacy is crucial attribute to motivation to learn as well as cope with challenging tasks. NASA (2020) indicated the secondary level mathematics achievement is below average, *i.e.* 32.1%. Furthermore, Zhang and Wang (2020) revealed that the positive association between mathematics achievement and interest is mediated in part by math self-efficacy. In addition, Du et al. (2021) obtained a reciprocal association between anxiety and self-efficacy in mathematics. So, to elevate the achievement in mathematics we should increase students' self-efficacy.

The present study investigated a significant difference regarding students' math self-efficacy with respect to their gender. The self-efficacy of male students exhibited a higher level in comparison to that of female students. This finding aligned with findings from prior researches (Pajares & Miller, 1994; Betz & Hackett, 1983). But this finding negated the findings of Cooper & Robinson (1991) and Hall & Ponton (2002), who investigated that the relationship between gender and mathematics self-efficacy in is not statistically significant.

Moreover, the study revealed that the mean self-efficacy score of the students of the institutional schools was higher than the students of the community schools. However, such difference is not

significant. This indicated that self-efficacy level was not found to be satisfactory. The mean self-efficacy levels between the grades were also different. The mean self-efficacy level of grade XII students was found to be the highest and grade IX was least. Bandura (1986) reinforced the result that changes in the self-efficacy of the onlookers, such as their teachers and parents, rely on the perceived expertise and credibility of the models that convey the messages. Overall, the study signposted that having a teacher or parent who promotes effort, comprehension, and progress makes students feel more efficacious.

Therefore, based on the findings of the study, effective intervention is desirable that focuses more on increasing math self-efficacy. Either of the techniques that could be embraced to elevate learners' math self-efficacy is 'problem-based learning' (Masitoh et al., 2018) or 'brain-based learning' (Negara et al., 2022).

Conclusion

In a nutshell, mathematics self-efficacy remains a crucial aspect and has been extensively explored by researchers focusing on its impact in mathematics education. It has a significant impact on pupils' achievement in mathematics as well as other cognitive and affective aspects. The finding of the study revealed a medium level of self-efficacy on mathematics of secondary level students of Nepal. Math self-efficacy is significantly subject to gender and grade of a learner. However, it is different depending on the types of schools, but not much significantly. It is recommended that a support system comprising counselling, motivation, parental and teacher assistance, be maintained to elevate the efficacy level in a student at the Nepalese context.

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