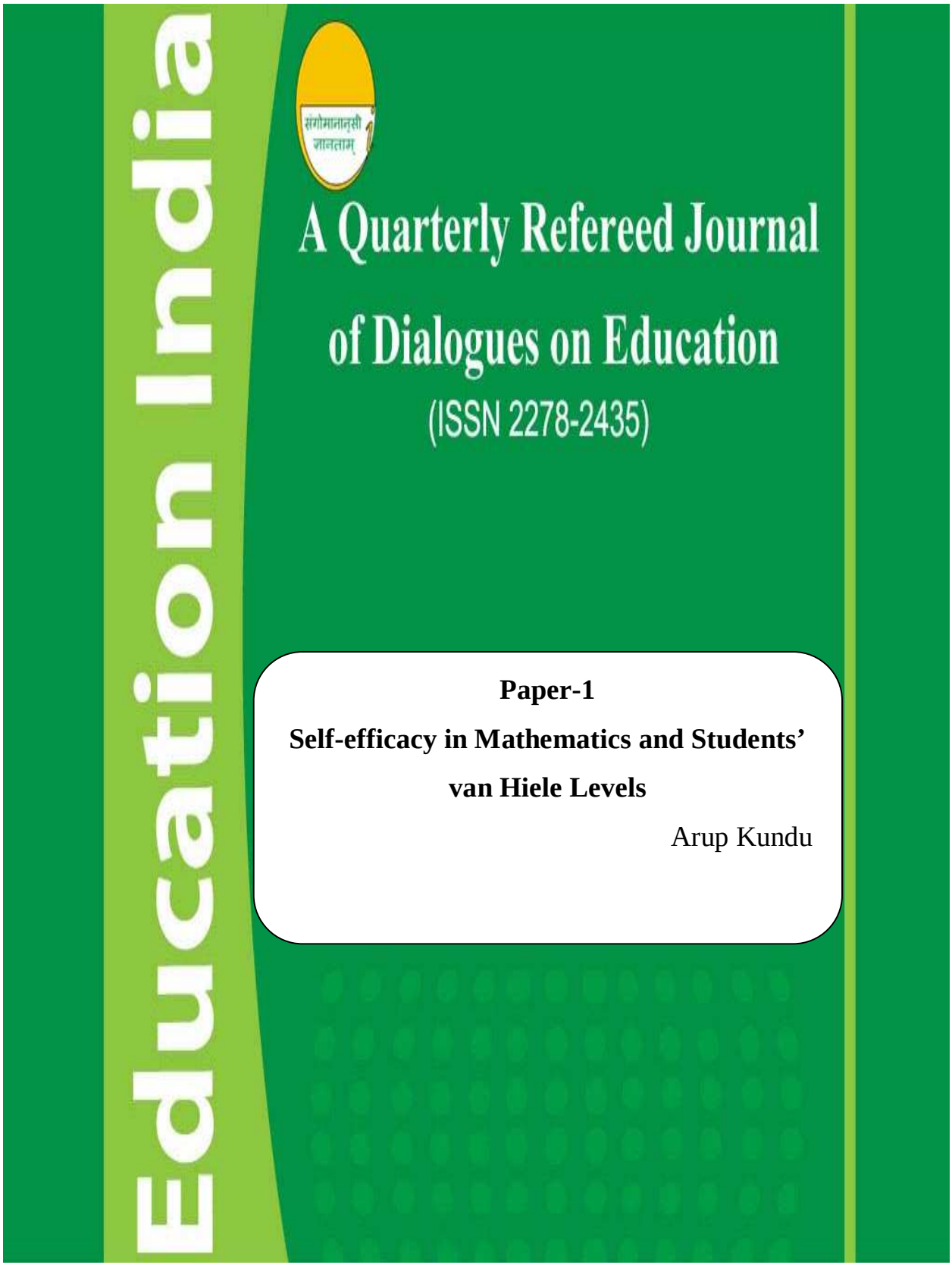

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Self-efficacy in Mathematics and Students' van Hiele Levels
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Abstract

The objective of the present study is to determine the relationship between Mathematics Self-efficacy and acquisition of van Hiele Level of Class XI students i.e., their geometrical thinking levels. The sample consisted of 779 students, both male and female of Class XI, selected from 25 schools from southern districts of West Bengal. The tools used were "Mathematics Self Efficacy Questionnaire" adapted from Mathematics Self Efficacy and Anxiety Questionnaire (MSEAQ), (May, 2009). The results show that the self efficacy differs among students with different van Hiele levels. In particular, the higher the van Hiele level of students, the better is their self efficacy. Thus, self efficacy in mathematics can be regarded as a factor in the acquisition of Geometry.

Keywords: Self efficacy, van Hiele Level;

Introduction-

Educators are entrusted to find way in which children may be better educated. This is none the less so for mathematics, which is often regarded as a 'bug-bear' by students. Foremost in the hierarchy of mathematics is geometry. School geometry is directly applicable to everyday life and the basis of many an interesting puzzle. Thus it has the potential of being attractive to students. Yet it is possibly the most feared aspect of mathematics. Ergo, it is often educational researchers' aim to find out what it is that deters children from acquiring geometric concepts (Chief Examiner Report, 2005, 2006 and 2007).

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Children are believed to refer to their own ideas and experiences in perceiving the world and evolving concepts regarding it (Rieber and Carton, 1987). Ensuing social interactions further contribute to their life experiences (Tobin and Tippins, 1993) and intervene in knowledge construction (Vogotsky, 1986). Thus perceptions of impending success or failure tinge academic achievement. Bandura's social cognitive theory (Bandura, 1986), in fact, points to the learner's judgment of their own ability in estimating academic success.

Bandura's term for this quality is 'self-efficacy' (Bandura, Barbaranelli, Caprara & Pastorelli, 1996). Bandura et al. (1996) have shown that self efficacy may be confirmed by traits like motivation, perseverance, resilience and analytic thinking (p. 1206). Self efficacy has been shown to be a forecaster of academic achievement (Fast et al., 2010; Pajaris, 2005). Thus high self efficacy implies confidence about academic skills, allowing the student to hone good skills, and allowing them to expect good results in the examinations and to work objectively for it. Conversely, low self efficacy relegates the student to expect failure even before attempting the task and subsequently low self esteem as per academics.

Research regarding mathematics achievement and self efficacy shows that high self efficacy induces students to compute accurately and display greater tendency in problem solving (Zimmerman, Bandura and Martinez-Pons, 1992; Pajaris and Miller, 1994). Betz &Hackett (1994) found mathematics self efficacy to be moderately, but positively correlated with scores in mathematics examination. Hendel (1980) & Hodge (1999) also found mathematics self efficacy, mathematics anxiety & mathematics performance to be highly correlated. Fast et al. (2010) found that students with low self efficacy yield easily when confronted with mathematical problems. Canturk-Gunhan and Baser (2007); Saracoglu and Yenice (2009); Usher (2009); Yenilmez and Uygan (2010) in different studies have

shown, among other factors, that enhanced self efficacy can improve the acquisition of geometric concepts, particularly when interventions involving creative activities were used.

The Van Hiele Theory-

How children improve their understanding of geometry and their spatial sense has been an area of research over the past 60 years (Usiskin, 1982; Burger & Shaughnessy, 1986; Fuys, Geddes & Tischler, 1988; Clements & Battista, 1992; King, 2003; Atebe, 2008). A theoretical perspective put forward by Dina van Hiele-Geldof and Pierre M. van Hiele at the University of Utrecht, explained the model of geometric thinking using three aspects: the existence of levels, properties of the levels, and the movement from one level to the next level. The van Hiele model consists of five levels of geometric thinking. These levels, as arranged from the lowest to the highest, are as follows:-

Level 1. Visualization: The student can merely recognize a shape.

Level 2. Analysis: The student is able to analyze a shape because he/she knows the properties of the shapes in Level 1

Level 3. Abstraction: The students have learned geometric properties after having attained the first two levels

Level 4. Deduction: The student is able to construct proofs of geometric properties after having attained the first three levels

Level 5. Rigor: The student is able to understand the implications of non-Euclidian geometry after having attained the first four levels. (Crowley, 1987; Kundu and Ghose, 2016)

Usiskin tested the ability of the van Hiele model to describe and predict the performance of students in secondary school geometry (Usiskin, 1982). Currently there are two lines of research based on the van Hiele theory in the world: one

transposing the van Hiele theory to other areas of mathematics (Boolean Algebra, Function-Analysis-Calculus), and another one using dynamic geometry to achieve higher van Hiele levels (De Villiers, 2010).

Emanation of the Problem-

Frequent expressions of apprehension about succeeding in mathematics and geometry in particular, pose a problem for educators. The reason for this inhibition and intimidation by geometry needs to be identified so that students can be assisted to acquire the basics of the subject. As students in Class XI are near to completion of school, they are expected to be acquainted with the geometry of basic ideas of culture and more intrinsically, geometry itself. Also, the apprehensiveness regarding geometry of so many people, point to a lack of self efficacy of individuals. Perhaps this is what impedes a student from succeeding in geometry. Thus this study aimed to examine whether students in Class XI with different van Hiele levels exhibited different extents of self efficacy.

Methodology-

The study consisted of a survey using quantitative technique.

Sample-

The sample consisted of 779 Class XI learners from 25 schools in southern districts of West Bengal, viz., Bankura and South 24 Parganas. These were urban schools and drew learners from middle socio-economic communities. Formal approval from the Department of Education and the school Head Teachers were obtained in order to access data from students in these schools. The sample is as follows:

Table 1. The sample

Male	Female	Total
405	374	779

Tools- "Mathematics Self Efficacy Questionnaire" adopted from "Mathematics Self Efficacy and Anxity Questionnaire" (MSEAQ), (May, 2009) consisting of 14 likert type items translated into Bengali from English. The Test-retest reliability coefficient of the scale is 0.97.

Van Hiele Geometry Test constructed by Usiskin (Usiskin, 1982). The test consisted of multiple choice questions, with five questions pertaining to each of the five van Hiele levels. The "Forced van Hiele Level" (VHL), was used to assign levels from 0 to 4, The Cronbach Alpha coefficient for reliability of the test ranged from .69 to .79.

Data Analysis-

The tools were administered on the sample, and the responses were duly scored, and tabulated. The results were subjected to descriptive statistics:

Table 2. Van Hiele level wise mean and standard deviation of self efficacy scores.

Forced Van Hiele Level	N	Mean (Self efficacy score)	Std.Deviation (Self efficacy Score)
0	174	42.89	11.77
1	247	49.74	12.25
2	163	53.80	10.26
3	131	56.46	09.47
4	063	59.14	09.72

Figure 1: Mean self efficacy of each van Hiele Level

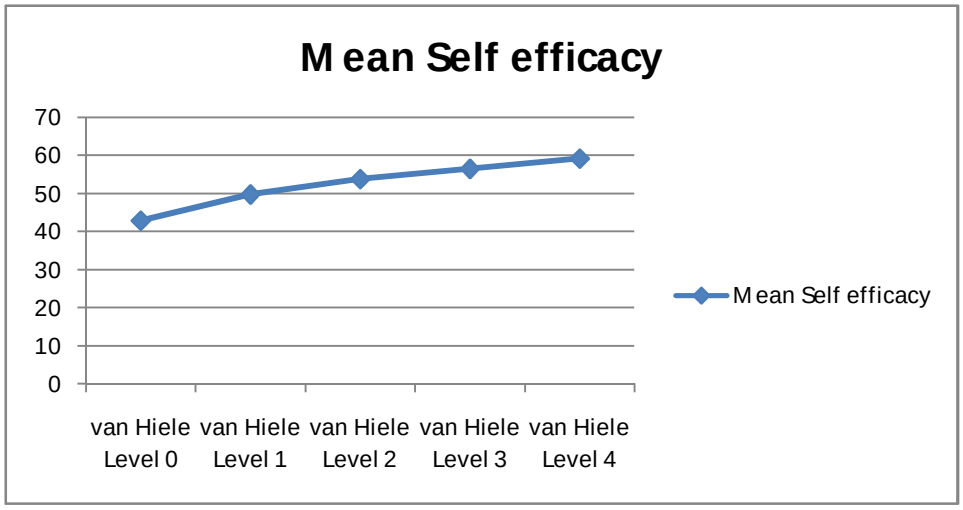


Table 2 and figure 1 show that mean self efficacy scores increase with rise in van Hiele level.

The data was subjected to inferential statistics. As appropriate examination of the data did not reveal normality of the distribution of self efficacy scores (pp test, Kolmogorov-Smirnov test) non parametric test, i.e., Kruskal Wallis Test was employed. The null hypothesis for this was

H_0: There is no significant difference in self efficacy in mathematics between students with different van Hiele levels of Geometry among Class XI students.

Table 3. Test Statistics of Kruskal Wallis Test and Grouping Variable: Forced VHL

	Self Efficacy
Chi- square	145.823
Df	4
Asymp. Sig.	.000

Table-3 shows that H_0 may be rejected. Self efficacy scores are significantly different among students with different van Hiele levels.

The result was further tested to check whether the self efficacy scores differed between van Hiele levels using Mann-Whitney U test.

Table 4. Mann-Whitney Test and Test Statistics

Ranks			Test Statistics Grouping variable: Forced VHL	
Forced VHL	N	Mean Rank	Mann-Whitney U	Asymp. Sig. (2-tailed)
Self Efficacy 0	174	170.32	14410.500	.000
1	247	239.66		
Self Efficacy 1	247	189.87	16269.000	.001
2	163	229.19		
Self Efficacy 2	163	137.58	9060.000	.026
3	131	159.84		
Self Efficacy 3	131	090.72	3238.000	.015
4	063	111.60		

Table 4 shows that self efficacy scores consistently increase for students with higher van Hiele levels.

Discussion-

The result shows that self efficacy in mathematics is indeed higher for students at higher van Hiele levels. This is indicative of the effect of self efficacy in acquiring geometric concepts. In other words, students who succeed in geometry may be expected to be endowed with self confidence regarding their ability in the process

of the subject. The studies reassert Bandura's (1997) claim that self efficacy is a predictor of academic outcomes. Other researchers, too, have reported significant relationships between self efficacy and the motivation for academic achievement (Hacket & Betz, 1989; Ma & Kishor, 1997; Middleton & Spanias, 1999). Focussing on mathematics, Hackett (1985) & Lent & Hackett (1987), Pajares (1996 b), have shown that self efficacy in mathematics and achievement in mathematics are strongly related.

The implication of this study is that teachers require motivating students so that their self confidence regarding mathematics and geometry in particular, can be raised. This will avert the inhibitions felt regarding the subject and serve to foster much needed geometric concepts (Bandura, 1997; Pajares, 1997, Schunk, 1991;). In day to day language, the teacher needs to tell students "you CAN!" rather than to just keep trying.

References-

- Atebe, H. U. (2008). Students' van Hiele Levels of Geometric Thought and Conception in Plane Geometry: A collective Case Study of Bigeria and South Africa. Ph.D. Thesis, Unpublished. South Africa: Rhodes University.
- Bandura, A. (1986). Social Foundations of thought and action. A social cognitive theory. Englewood Cliffs. Prentice Hall.
- Bandura, A. (1997). *Self-efficacy: The exercise of control.* New York: Freeman.
- Bandura, A., Barbaranelli, C., Caprara, G. V, & Pastorelli, C. (1996). Multifaceted impact of self-efficacy beliefs on academic functioning. *Child Development, 67,* 1206–1222. doi:10.2307/1131888

- Betz, N. E., & Hackett, G. (1994). Manual for the mathematics self-efficacy scale Forms A and B. *Mind Garden Press*.
- Burger, W.F. & Shaughnessy, J.M. (1986). Characterizing the Van Hiele levels of development in geometry. *Journal for Research in Mathematics Education,* 17(1), 31-48.
- Cantürk-Günhan, B. & Baser, N. (2007). Geometriye yönelik öz-yeterlik ölçeginin gelistirilmesi. *Hacettepe University Journal of Education,* 33, 68-76.
- Chief Examiners Report (2005, 2006, 2007). West African Examination Council (WAEC). Yaba Lagos.
- Clements, D. H., & Battista, M. T. (1991). Van Hiele Levels of Learning Geometry. In *International Group for the Psychology of Mathematics Education*. Assisi, Italy.
- Crowley, M. L. (1987). The van Hiele model of the development of geometric thought, in Learning and Teaching Geometry, K-12. M.M. Lindquist, ed., NCTM, Reston, Virginia, 1–15.
- De Villiers, M. (2010). Some Reflections on the Van Hiele Theory, Invited plenary from 4th Congress of teachers of mathematics. Zagreb, (available from: http://frink.machighway.com/dynamicm/vanhiele-reflection.pdf).
- Fast, L. A., Lewis, J. L., Bryant, M. J., Bocian, K. A., Cardullo, R. A., Rettig, M., & Hammond, K. A. (2010). Does math self-efficacy mediate the effect of the perceived classroom environment on standardized math test performance? *Journal of Educational Psychology*. doi:10.1037/a0018863.

- Fuys, D., Geddes, D., &Tiskler, R. (1988). An investigation of the Van Hiele levels of thinking in geometry among adolesents. *Journal for Research in Mathematics Education Monographs*, No.3, NCTM., Reston
- Hackett, G. (1985). Role of mathematics self-efficacy in the choice of math-related majors of college women and men: A path analysis. *Journal of Counseling Psychology*. doi:10.1037/0022-0167.32.1.47
- Hackett, G., & Betz, N. (1989). An Exploration of the Mathematics Self Efficacy Mathematics Performence Corresponding. *Journal for Research in Mathematics Eduction*, 20(3), 261-273.
- Hodge, M. B. (1999). Do Anxiety, Math Self-Efficacy, and Gender Affect Nursing Students' Drug Dosage Calculations? *Nurse Educator*, *24*(4), 36, 41. doi:10.1097/00006223-199907000-00010
- Hendel, D. D. (1980). Experiential and Affective Correlates of Math Anxiety in Adult Women. *Psychology of Women Quarterly*. doi:10.1111/j.1471-6402.1980.tb00958.x
- King, L. C.C. (2003). The Development, Implementation and Evaluation of an Instructional Model to Enhance Students' Understanding of Primary School Geometry. Doctoral Thesis, Unpublished Curtin University of Technology, Australia.
- Kundu, A. & Ghose, A. (2015). Van Hiele levels of geometry thinking among H.S. students from different streams of study. *Sihshachintan*, RKMSM, Howrah, Belur Math,Vol 9.

- Kundu, A & Ghose, A. (2016). Gender Related Difference in the Acquisition of Van Hiele Level in Geometry of higher Secondary Students in West Bengal. *International Journal of Multidisciplinary Educational Research*, Vol. 5, Issue 6(3), 74-87.
- Lent, R.W. & Hackett, G. (1987). Career self-efficacy: Empirical status and future directions. *Journal of Vocational Behaviour*, 30, 347-382.
- Ma, X., & Kishor, N. (1997). Assessing the Relationship Between Attitude Towards Mathematics and Achevement in Mathematics: A Meta-Analysis. *Journal for Research in Mathematics Education*, 28(1), 26-47.
- Middleton, A.J., & Spanias, A.P. (1999). Motivation for Achievement in Mathematics: Findings, Gereralizations and Criticisms of the Research. *Journal for Research in Mathematics Education*, 30(1), 65-88.
- May, D.,(2009). Mathematics Self-efficacy and Anxiy Questionnaire. Athens: University of Georgia. Retrieved from https://libs.uga.edu/pdfs/may diana k 200908 phd.pdf
- Parajes, F. & Miller, M.D. (1994). The role of self efficacy and self concept beliers in Mathematical Problems-solving. Apath analysis. *Journal of Educational Psychology*, 86, 193-203.
- Parajes, F. (1996b). Self-efficacy beliefs in academic setting. *Review of Educational Research*, 66, 543-578.

- Parajes, F. (1997). Current direction in self-efficacy research. In M.L. Maehr & P. R. Pintrich (eds.) Advances in Motivation and Achievement (Vol. 10, pp. 1-49). Greenwich CT: JAI Press.
- Rieber, R. W. & Carton, A. S. (1987). The Collected Works of L.S. Vygotsky (Vol. 1; Problems of general psychology). New York: Plenum Press.
- Saracaloglu, A. S. & Yenice, N. (2009). Investigating the self-efficacy beliefs of science and elementary teachers with respect to some variables. *Journal of Theory and Practice in Education, 5*(2), 244-260.
- Schunk, D. H. (1991). Self-efficacy and academic motivation. *Educational Psychologist*, 26, 207-231.
- Tobin, K. & Tippins, D. (1993). Consstructivism as a referent for teaching and learning. In K. Tobin (ed.) The practice of constructivism in Science Education (pp. 3-24). Washington, D.C. AAAS Press.
- Usiskin, Z. (1982). *van* Hiele levels and achievement in secondary school geometry.*(Final report of the cognitive development and achievement in secondary school geometry project)* Chicago: University of Chicago (ERIC Document Reproduction service Number ED220288).
- Vygotsky, L.S. (1986). Thought and Language Cambridge, M.A.: MIT Press.
- Yenilmez, K. & Uygan, C. (2010). Yaratici drama yönteminin ilkögretim 7. sinif ögrencilerinin geometriye yönelik öz-yeterlik inançlarna etkisi. *Kastamonu Education Journal, 18*(3), 931-942.

- Zimmerman, B. J. Bandura, A. & Martinez-Pons, M. (1992). Self-motivation for academic attainments: The Role of Self-efficacy beliefs and personal goal setting. *American Educational Research Journal*, 29, 663-676.

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