Assessing Myanmar Student Teachers' Reasoning and Problem Solving Abilities: An Analysis Based on Optimal Tests Development and Intervention Practice

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***Abstract*— The main aim of this study was to assess Myanmar student teachers' reasoning and problem solving abilities through the optimal tests development and intervention practice. A total of 1626 student teachers from Yangon University of Education, Sagaing University of Education and University for the Development of National Races of the Union participated in this study. Sequential explanatory research design was chiefly used. To achieve the main goal, a reasoning skill test and a problem solving ability test were firstly developed by using Item Response Theory (IRT) and Classical Test Theory (CTT). Based on the tests, findings revealed that the student teachers had higher reasoning skills and higher problem solving ability. The result showed that the reasoning skills accounted for approximately 28.6% of the variance of problem solving ability. The results of the regression advocated that four reasoning skills included in the reasoning skill test are best predictors and can enhance the problem solving ability of student teachers. Finally, an intervention practice was conducted to improve student teachers' reasoning skills and to confirm the predictive validity of the reasoning skill test based on the quantitative results. The results pointed that the reasoning skills of student teachers after intervention were significantly higher than before intervention. Therefore, this study highlighted the fact that reasoning skills can well enhance problem solving ability of student teachers and that their reasoning skills can be trained by using argument mapping technique based practice.**

Key Words: Reasoning, problem solving, optimal test, intervention practice

I. INTRODUCTION

In the living world, a chief characteristic which can distinguish human beings from other species including the higher animals is cognitive ability. It includes thinking, reasoning, problem solving and other aspects based on human brain functions. The challenges and problems faced by the individual, or by society, in general, are solved through serious efforts involving thinking and reasoning. The powers of thinking and reasoning may thus be considered to be the essential tools for the welfare and meaningful existence of the individual as well as society.

Moreover, Prof. Dr. Khin Zaw (1994) remarked that man's history on this planet earth is one of the change and achievement. From the cave to cosmos: emerging from the brutish existence of pre-man, he has managed in the span of some hundreds of generations to gain the present range of mastery of nature. He is now living in a world of fantastic scientific and technology achievements ranging from those which contribute to the maximum welfare and pleasure of man to those which are capable of his complete annihilation. This event is the best example of human's cognitive or reasoning ability.

Moreover, Prof. Dr. Khin Zaw (2001) pointed the fact that man has reason and imagination leading not only to the necessity for having a sense of his own identity, but also for orienting himself in the world intellectually. Additionally, he differentiated reason from intelligence. Reason is man's faculty for grasping the world by thought, in contradiction to intelligence, which is man's ability to manipulate the world with the help of thought. Reason is man's instrument for arriving at the truth; but intelligence is his instrument for manipulating the world more successfully; the former is essentially human, the latter belongs to the animal part of man. Therefore, human reasoning skill and problem solving ability are essential in daily life and they are interdependent like the head and tail of a coin.

At the present time, in the modern technological world, communications are sophisticated, and people have a variety of information to stimulate and inform their thinking. However, it is not just right information that is distributed in society. False and misleading information is also spread out to people too. People have to be able to analyze, discriminate and make good decisions on the basis of sound reasons. Education therefore has a crucial role to play in developing that ability.

Consequently, the teachers' tasks are getting more and more complex because of the technically, economically, socially, and politically changing world. Teachers have to face with increasing challenges (new ways of technology, motivation, team work, differentiation, classroom management, assessment connection with parents). Nearly every class has students facing integration problems, students who are under-motivated, aggressive or have other behavioural problem or students who have learning problems. For this reason, it is important that student teachers who will take responsibility for national education should have the problem solving ability about the issues.

As indicated above it can be argued that reasoning skills for problem solving ability have become more important for teachers and student teachers in the modern world because there is too much information, and too many choices that come into human's minds. Those who have made the right decisions or act in a more reasonable way are likely to have less of a problem. Moreover, reasoning skills become more important for more practical reasons because many organizations (both government and non government) test the candidates' reasoning skills before employing them in their particular association.

Accordingly, these facts become the reasons for the researcher to investigate the reasoning skills that can enhance problem solving abilities among Myanmar student teachers and explore the relationship between these skills and abilities. The researcher hopes that the results from this study will be able to contribute as the background factors in creating effective teaching learning environment especially in teacher education.

Aim of the Study

The primary aim of this study is to assess Myanmar student teachers' reasoning and problem solving abilities through the optimal tests development and intervention practice. The specific objectives can be expressed in detail as follows.

1. To develop a reasoning skill test by using Item Response Theory (IRT) and a problem solving ability test by using Classical Test Theory (CTT)
2. To examine the reasoning skills and problem solving ability of student teachers
3. To compare the student teachers' reasoning skills by gender and university
4. To compare the student teachers' problem solving abilities by gender and university
5. To explore the relationship between reasoning skills and problem solving ability
6. To find out the extent to which reasoning skills can predict problem solving ability
7. To improve student teachers' reasoning skills by using an intervention practice
8. To confirm the predictive validity of the reasoning skill test on problem solving ability.

II. Review of Related Literature

As the theoretical framework for reasoning skill, this study was based on Evans and Over's Dual-Process theory.

Evans and Over's Dual-Process Theory

Evans's (1989) heuristic–analytic theory provided the foundations for Evans and Over's (1996) current dual-process theory. Evans (1984) proposed that heuristic processes are preconscious, and their function is to select representations relevant to a particular problem space. Analytic processes are conscious, which means broadly that they are a type of deliberate, explicit thinking.

This theory divided reasoning into two systems. System 1, implicit or tacit process, which is essentially pragmatic, is based on prior experiences, beliefs, and background knowledge and achieves goals reliably and efficiently without necessarily accompanying awareness. System 2 is explicit, intentional, sequential, controllable, and makes high demands of working memory. System 2 does not typically operate according to normative logical conventions, but it is capable of achieving solutions to logical problems as well as a range of problem types.

On the other hand, reasoning involves both conscious (or explicit) and unconscious (or tacit) processes. For example, inductive reasoning largely depends on the retrieval and unconscious evaluation of world knowledge, whereas deductive reasoning depends on rule-based or conscious formal procedures.

In fact, reasoning refers to the process of drawing conclusions or inferences from information. Reasoning always requires going beyond the information that is given (Bruner, 1957). In logic, an inference is called *deductive* if the truth of the initial information (or premises) guarantees the truth of the conclusion. The inference is called *inductive* if the truth of the premises makes the conclusion probable but not certain. Many researchers have found that performance on deductive and inductive tests is strongly related (Wilhelm, 2005). Although there are several kinds of inductive reasoning, this research will focus on analogical and numerical reasoning.

Analogical Reasoning. The ability to reason analogically involves the ability to make judgments or predictions about unfamiliar problems on the basis of perceived similarities and relationships with familiar problems. This form of inferential reasoning also serves a variety of different functions ranging from drawing people's attention to already known relations to the reorganization and development of existing knowledge (Deloache, Miller, & Pierroutsakos, 1998).

Numerical Reasoning. It includes the ability to solve problems and arrive at answers, i.e., solution in a logical way and making generalization (Fatima, 2008). Numerical reasoning is about using numerical data to make reasoned decisions and solve problem. It relies on the ability to recognize how to go about solving a numerical problem, understanding the relationships between numbers, prior to completing the mathematical calculation required (Savill, 2011).

Like inductive reasoning, there are several kinds in deductive reasoning. However, this research will focus on analytical and abstract reasoning.

Analytical Reasoning. Analytic reasoning represents judgments made upon statements that are based on the virtue of the statement's own content. Analytical skill is the ability to visualize, articulate, conceptualize or solve both complex and uncomplicated problems by making decisions that are sensible given the available information. Such skills include demonstration of the ability to apply logical thinking to breaking complex problems into their component parts (Kant-Studien, 1987).

Abstract Reasoning. Abstract Reasoning is also known as fluid intelligence (Cattell, 1963) or analytic intelligence. Fluid intelligence is reasoning ability in its most abstract and purest form. It is the ability to analyze novel problems, identify the patterns and relationships that underpin these problems and extrapolate from this using logic (Carpenter, Just, and Shell, 1990).

To reveal the student teachers' problem solving abilities in this research, MacLellan, Langley and Walker's (2012) generative theory of problem solving was based.

Generative Theory of Problem Solving

The assumptions of generative theory of problem solving include:

- The primary mental structure in problem solving is the problem, which includes a state description and a goal description.
- A problem solution consists of a problem P; an applied intention or operator instance I; a right sub-problem, which is a sub-problem that has the same goals as P, but has a state that results from the application of I to P; a down sub-problem, which is a sub-problem that shares P's state but has preconditions corresponding to I's preconditions; and the solution to P's sub-problems. In the terminal case, a problem solution can also be a problem P that is marked as done.
- Problems and their (attempted) solutions reside in a working memory that changes over the course of problem solving, whereas operators and strategic knowledge reside in a long-term memory that changes gradually if at all.
- The problem-solving process operates in cycles that involve five stages: problem selection, termination checking, intention generation, failure checking, and intention application. Each stage involves changes to the problem structures in working memory.

- Alternative problem-solving strategies result from variations on these five processing stages, with their settings being entirely independent of each other.

Although the first three assumptions specify important commitments about representation and organization, the final two tenets are the most interesting and important. The postulation of five stages that take on orthogonal settings provides the generative power to explain the great variety of possible problem-solving strategies. Thus, problem solvers should consider each stage and its possible settings in more detail. The problem solving ability construct of the present study was based on this generative theory.

III. METHOD

Sampling

Sample chosen for the present study consisted of 1626 student teachers from first year to fifth year: male (n=746) and female (n=880). The participants for the study were chosen from Universities of Education in Myanmar: Yangon University of Education, Sagaing University of Education and University for the Development of National Races of the Union (Sagaing). A stratified random sampling technique was used.

Research Method

Sequential explanatory design from quantitative and qualitative mixed method approaches was taken as the primary design of this study. In the first part of this study, survey method was used. As the second part, an intervention based analysis based on the experimental method was also used.

Pilot Testing on Reasoning Skill Test and Problem Solving Ability Test

There were four subtests in reasoning skill test and each subtest comprised of 23 items. The test items were multiple-choice items. The test was administered to a sample of 220 student teachers (from first year to fifth year) in Sagaing University of Education. According to data analysis of non-speediness of the test, it could be confirmed that all tasks of the tests in current study were non-speeded. After carrying out the item analysis based on an IRT parameter estimation procedure with two parameter logistic model (2 PLM), 14 items which are very easy or very difficult were removed from the original 92 items. Moreover, other 15 items were selected to be improved and reused. Therefore, the number of test items for the field testing becomes 78 items.

There were three subtests in problem solving ability test. They are logical puzzles, mathematical puzzles and classroom problems. Each subtest has 5 items. All items were open-ended types and the response for each item will be scored from 0 to 4. After carrying out the item analysis procedure based on Classical Test Theory (CTT) for essay tests, all items were selected to be reused in the field testing.

Intervention Protocol

After testing the reasoning skills and problem solving ability of student teachers, Prof. Tim van Gelder's (2000) argument mapping technique was used to improve the reasoning skill of student teachers. There were six lessons in this protocol: (1) making your core argument, (2) countering objections, (3) making your CASE, (4) defending your assumptions, (5) finding your hidden vulnerabilities and (6) presenting with impact.

Data Collection Procedure

Participants had to complete Reasoning Skill Test and Problem Solving Ability Test during 2 hours. After administering the test, data analysis for test development was conducted. Then, based on the reasoning skill levels of student teachers, 60 participants who got the low, moderate and high reasoning skill were trained with an intervention practice during three weeks. After that, their reasoning skills were tested again to assure the predictive validity of the test and how the reasoning skills can be improved.

IV. DATA ANALYSIS AND FINDINGS

Developing Reasoning Skill Test

As the first part of the data analysis, a reasoning skill test development was conducted. The data analysis procedure followed the data analysis process of Hambleton et al. (1991) and Kolen and Brennan (2004).

Confirmatory Factor Analysis. Confirmatory factor analysis was used to establish the four factors structure of the reasoning skills test: analogical, numerical, analytical and abstract reasoning. In this study, the Kaiser-Meyer-Olkin measure of sampling adequacy was 0.856 that is indicating sufficient items for each factor. Then, Bartlett's Test of Sphericity was significant ($p < .001$) which means that the variables are highly correlated enough to provide a reasonable basic for factor analysis.

After conducting the principal axis factor analysis, 31 items of 78 items were eliminated because they had low or no loadings with any other factors. By taking out 31 items, the communalities were all above 0.2 and it indicated that the relation between each item and other items is satisfactory. Given these overall indicators, factor analysis was conducted with 47 items.

Checking for Non-speediness of the Test. According to the non-speeded (power) test method (Gulliksen, 1950), the variance ratios of the four sub tests were nearly zero: 0.001 for analogical, 0.009 for numerical, 0.005 for analytical and 0.003 for abstract reasoning. Therefore, it could be confirmed that all tasks of the tests in current study were non-speeded.

Checking the Assumption of Unidimensionality. To investigate the assumption of unidimentionality, a principal factor analysis was conducted. The values of eigenvalue 1, 2, 3, 4, 5, 6, 7 were 5.489, 1.499, 1.266, 1.149, 0.919, 0.825 and so on, and thus eigenvalue 1 was larger enough than other eigenvalues to determine that the test data satisfy the assumption of unidimensionality.

Checking the Conformity of Model and Test Data. Figure 1 clearly shows expected and observed test score distributions for two parameter model. It indicates that actual observed data score distribution is fairly close to theoretical distribution. Therefore, it is concluded that model-data fit is adequate enough to apply IRT model for this test.

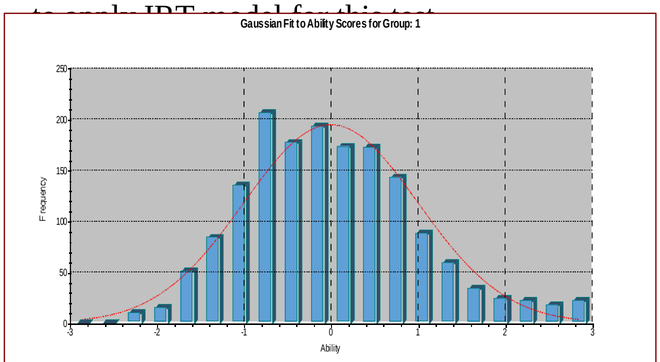

Figure 1. Frequency Distributions of Expected and Observed Scores

Estimation of Item and Ability Parameters. In order to obtain the information which items are appropriate for student teachers, an IRT parameter estimation procedure was carried out with two parameter logistic model (2 PLM) by utilizing BILOG-MG 3 software (Zimowski, Muraki, Mislevy & Bock, 2003). As the items were calibrated with 2 PLM, the characteristics of the items can be described by item difficulty (b) and item discrimination (a).

For item difficulty (b), easier items have lower (negative) difficulty indices and harder items have higher (positive) indices. The items with the difficulty b values within -3 to +3 were expected to be selected (Aye Aye Myint, 1997). In this study, all items have b values within the range of -3 to +3 and so they are selected as good items.

On the other hand, a higher value of item discrimination (a) indicates that the item discriminates between high and low proficiency examinees better. Since there are no items which have more than 2 (a value), all items can be acceptable.

Test Information Function. Based on the results of the parameter estimates of the test, test information curve (TIC) was also plotted. Figure 2 illustrates TIC of the 47-item test. SE is the standard error of estimation. The empirical reliability of the test was 0.902.

By looking at Figure 2, it is visually clear that the test is discriminating well among examinees with the range of ability level from -2.5 to +0.4 in the test. The maximum amount of information was I (θ) = 13.5 at θ = -1.15. These test items will be most suitable for student-teachers whose reasoning ability (θ) range is from -2.5 to +0.4. Therefore, it was judged that this test only can provide information well for student teachers with lower reasoning ability; however it may not provide enough information to assess student teachers with high and average reasoning skills.

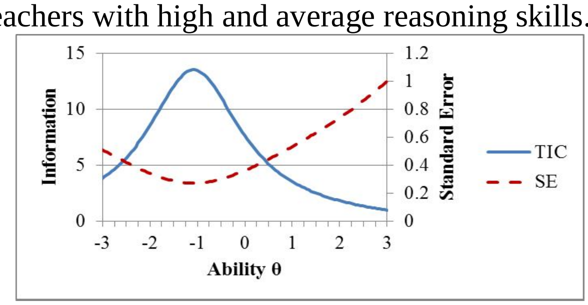

Figure 2. Test Information Curve for the Test with 47 items

Developing an Optimal Reasoning Skills Test

Since the present 47-item reasoning test is relatively easy, it is identified as an item pool and then an optimal reasoning skills test would be constructed by selecting some experimental items from that pool again. To construct systematically, a procedure to build test to meet any desired set of test specification outlined by Lord (1977) was followed.

According to Lord (1977), selecting and calculating the test items were continued again and again until the test information function approximates the target information function to a satisfactory degree.

Therefore, among 47 test items, 8 items from each subtest were selected to construct a new test. In Figure 3, a test information curve for an optimal reasoning skills test can be seen. It is visually clear that the test is discriminating well among examinees with the range of ability level from -1.9 to +1.2 in the test. The maximum amount of information was I (θ) = 5.4 at θ = -0.12. Moreover, its empirical reliability is 0.85. Therefore, it can be judged that this optimal test can provide information well for student teachers with normal reasoning ability.

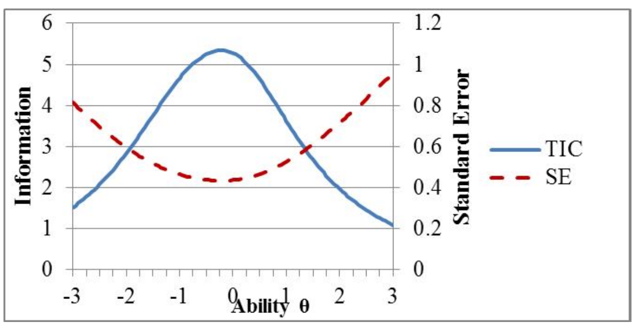

Figure 3. Test Information Curve for the Optimal Test with 32 items

Therefore, the format and content specifications of the optimal reasoning skill test become as follows:

Table 1 Table of Content Specifications for Optimal Reasoning Skills Test

No.	Names of Subtests	Tasks (Amount of Items)	Total Amount of Items	Time Limit (minute)
1.	Analogical Reasoning	Word (4), Figure (4)	8	3
2.	Numerical Reasoning	Word Problems (4), Data Interpretation (2), Mathematical Puzzles (2)	8	10
3.	Analytical Reasoning	Seating Arrangement (4), Combination (3), Ranking (1)	8	10
4.	Abstract Reasoning	Figure Addition/ Subtraction (2), Distribution of three values (3), Distribution of two values (3)	8	7
	Total		32	30

Developing Problem Solving Ability Test. This development followed the data analysis procedure of Hambleton, Swaminathan & Rogers (1991). Moreover, item analysis procedure for essay tests based on Classical Test Theory was used.

Confirmatory Factor Analysis. Confirmatory factor analysis was used to establish the three factors structure of the problem solving ability test: logical puzzles, mathematical puzzles and classroom problems. In this study, the Kaiser-Meyer-Olkin measure of sampling adequacy was 0.725 and Bartlett's Test of Sphericity was significant (p< .001).

Throughout the principal axis factor analysis, items with initial values of less than 0.2 and those without loadings were decided to be discarded. However, there were no items to be eliminated because they all had loadings with respective factor. Given these overall indicators, factor analysis was conducted with 15 items. After rotation, the first factor accounted for 8.18% of the variance, the second factor accounted for 5.39% of the variance and the third factor accounted for 3.54% of the variance.

Checking for Non-speediness of the Test. After the preliminary testing, the non-speediness of the test was investigated by the non-speeded (power) test method (Gulliksen, 1950). According to the results, the variance ratios of the three sub tests were close to zero. Therefore, it could be confirmed that all tasks of the sub tests in current study were non-speeded.

Item Analysis of Field Test Data. In order to obtain the information which items are appropriate for student teachers, an item analysis procedure for essay test items was carried out with difficulty index (P-value) and discrimination index (D).

Index of difficulty (P) can range from 0% (for a very difficult item) to 100% (for a very easy one). Therefore, moderate level of P is 50% (Technical Bulletin of University of Lowa, n.d, cited in Faradillah, 2012). Since P values of all problem solving ability test items were around 50%, exactly between 40% and 60%, they can be used confidently. Moreover, for classes larger than 30 students, 0.3 should be used as a desirable standard for index of discrimination (D) (Technical Bulletin of University of Lowa, n.d, cited in Faradillah, 2012). Since D values of the current test items were above 0.3, these items can be regarded as discriminating items. Therefore, based on the item analysis results, all items were selected to be reused in field testing. The reliability of the test was 0.78. Therefore, it has high reliability.

The format and content specification of the optimal reasoning skill test are as follows:

Table 2 Content Specifications of Problem Solving Ability Test

No.	Names of Tasks	Amount of Items	Time Limit (minute)	Marks
1.	Logical Puzzles	5	15	20
2.	Mathematical Puzzles	5	15	20
3.	Classroom Problems	5	10	20
	Total	15	40	60

Data Analysis and Findings for Reasoning Skills

To explore the reasoning skills of student teachers, descriptive statistics, mean comparisons by gender and by university were executed.

Descriptive Statistics for Student Teachers' Reasoning Skills. Table 3 showed that student teachers' analytical reasoning was the highest skill ($\bar{X}$=4.97) and the lowest skill was abstract reasoning ($\bar{X}$=3.58) among four skills. As described in literature review section, reasoning skills were categorized into two main kinds: inductive and deductive reasoning. At present, according to mean scores, it was found that their inductive reasoning was higher than deductive reasoning.

Next, the sample mean score of the total reasoning skill (17.41) is above the theoretical mean score (16). Therefore, it can be concluded that they have healthier reasoning skills concerned with the problems they faced.

Table 3 Descriptive Statistics for Student Teachers' Reasoning Skills

Reasoning Skills	**Mini mum**	**Maxi mum**	**Mean**	**Std. Deviation**
Inductive Reasoning	1	16	8.87	2.96
Analogical	0	8	4.75	1.73
Numerical	0	8	4.12	1.89
Deductive Reasoning	0	16	8.54	3.33
Analytical	0	8	4.97	2.12
Abstract	0	8	3.58	1.93
Total Reasoning	3	30	17.41	5.25

Comparisons of Student Teachers' Reasoning Skills by Gender. According to independent samples *t* test results, there were no statistically significant differences in reasoning skills by gender except inductive reasoning. In inductive reasoning skill, male student teachers' mean score was significantly higher than females ($p<$ .001 level).

Table 4 Independent Samples *t* Test Results of Reasoning Skill by Gender

Reasoning	Gender	Mean	Std. Deviation	*t*	*df*	*p*
Inductive	Male	9.18	2.91	3.874	1624	0.000
	Female	8.61	2.97			
Deductive	Male	8.40	3.30	-1.625	1624	0.104
	Female	8.67	3.34			
Total	Male	17.58	5.10	1.144	1624	0.253
	Female	17.28	5.38			

Note. * The mean difference is significant at the 0.001 level.

Comparison of Student Teachers' Reasoning Skills by University. ANOVA result showed that there were significant differences in reasoning skills among universities ($p < .001$ level) (see Table 5). To obtain more detailed information, Post-Hoc test was executed by Games-Howell method.

Table 5 ANOVA Result of Reasoning Skills by University

	Sum of Squares	***df***	**Mean Square**	***F***	***p***
Between Groups	9210.933	2	4605.466	209.919	.000
Within Groups	35607.341	1623	21.939		
Total	44818.273	1625			

According to Table 6, it became apparent that the reasoning skills of the student teachers in university 1 were significantly higher than those of others ($p < .001$ level). Moreover, the reasoning skills of student teachers in university 3 were significantly lower than those of others ($p < .001$ level). To confirm these results, a qualitative study was performed and will be described in the next section.

Table 6 Post-Hoc Test Result of Student Teachers' Reasoning Skills Across University by Games-Howell Method

(I) University	**(J) University**	**Mean Difference (I-J)**	***p***
University 1	University 2	2.238*	.000
	University 3	5.724*	.000
University 3	University 1	-5.724*	.000
	University 2	-3.486*	.000

Note. * The mean difference is significant at the 0.001 level.

Data Analysis and Findings for Problem Solving Ability

To explore the problem solving ability of student teachers, descriptive statistics, mean comparisons by gender and mean comparisons by university were executed.

Descriptive Statistics for Student Teachers' Problem Solving Ability. Table 7 showed that student teachers' logical problem solving ability was the highest ability among three abilities ($\bar{X}$=11.16). Besides, the sample mean score of the total problem solving ability (30.4) is above the theoretical mean score (30). Therefore, it can be concluded that they have better ability to solve several problems they faced.

Table 7 Descriptive Statistics for Student Teachers' Problem Solving Ability

Problem Solving Ability	**Mean**	**Std. Deviation**
Logical Problems	11.16	5.07
Mathematical Problems	9.27	4.49
Classroom Problems	9.97	3.92
Total	30.4	9.68

Comparisons of Student Teachers' Problem Solving Ability by Gender. It was found that there were statistically significant differences in problem solving abilities by gender. Specifically, all the scores on logical mathematical and total problem solving abilities were significantly higher in favour of male student teachers. However, females' classroom problem solving ability was higher than males' ($p < .001$ level).

Table 8 Independent Samples *t* Test Results of Problem Solving Ability by Gender

	Gender	**Mean**	**Std. Deviation**	***t***	***df***	***p***
Logical	Male	9.95	4.96	8.32	1624	0.000
	Female	7.89	4.97			
Mathe-matical	Male	7.65	4.31	2.68	1624	0.007
	Female	7.05	4.62			
Classroom Problem	Male	7.39	4.02	-4.80	1624	0.000
	Female	8.32	3.78			
Total Problem Solving	Male	24.98	9.16	3.59	1624	0.000
	Female	23.26	10.05			

Note. ** $p < 0.001$, * $p < .01$.

Comparison of Student Teachers' Problem Solving Ability by University. According to Table 9, ANOVA result showed that there were significant differences in reasoning skills among universities (p< .001 level). To obtain more detailed information, Post-Hoc test was executed by Tukey HSD method.

Table 9 ANOVA Result of Problem Solving Ability by University

	Sum of Squares	***df***	**Mean Square**	***F***	***p***
Between Groups	33259.147	2	16629.574	226.635	.000
Within Groups	119089.300	1623	73.376		
Total	152348.448	1625			

According to Table 10, it became obvious that the problem solving ability of the student teachers in University 1 and University 2 were significantly higher than that of University 3 (p< .001 level). Based on these results, qualitative study was performed and described in the next section.

Table 10 Post-Hoc Test Result of Student Teachers' Problem Solving Ability Across University by Tukey HSD Method

(I) University	**(J) University**	**Mean Difference (I-J)**	***p***
University 1	University 2	-.397	.734
	University 3	9.228*	.000
University 2	University 1	.397	.734
	University 3	9.626*	.000

Note. * The mean difference is significant at the 0.001 level.

Relationship Between Reasoning Skills and Problem Solving Ability

To inspect the relationship between reasoning skill and problem solving ability, correlation coefficients and regression analysis for predictor variables was explored.

Correlation Analysis Between Reasoning Skills and Problem Solving Ability of Student Teachers. According to Table 11, the components of reasoning skill and the components of problem solving ability are positively correlated (p< .01 level). Each component of reasoning skill is moderately correlated with problem solving ability. Similarly, total reasoning skill is moderately correlated with total problem solving ability.

Table 11 Inter-correlation Among Components of Reasoning Skill and Problem Solving Ability

Variables	Logical	Mathe-matical	Class-room	Problem Solving Ability
Analogical	.286**	.216**	.083**	.283**
Numerical	.436**	.367**	.107**	.442**
Analytical	.312**	.369**	.160**	.399**
Abstract	.203**	.319**	.115**	.301**
Reasoning	.452**	.469**	.173**	.524**

Note. ** Correlation is significant at 0.01 level.

Regression Analysis for Reasoning Skills as Predictors of Problem Solving Ability. To measure the influence of reasoning skills on problem solving ability, regression analysis was continued. A four-step hierarchical multiple regression analysis was used to assess how much additional variance in problem solving ability can be explained by incrementally adding predictor variables to the equation. Before this analysis was performed, the independent variables were examined for collinearity. According to results, the collinearity tolerances of all independent variables are greater than 0.714, ($1-R^2$). This indicated that the estimated βs are well established in the regression model. In step 1, problem solving ability was the dependent variable and analogical reasoning was independent variable. Then, numerical reasoning was additionally entered into step 2 equation. The process was repeated at step 3 with analytical reasoning and at step 4 with abstract reasoning.

In Table 12, the results revealed that analogical reasoning was able to account for merely 8% of the variance in problem solving ability. However, combination of analogical and numerical reasoning was able to account for

21.5% of the variance in problem solving ability. Then, the combination of analogical, numerical and analytical reasoning was able to account for 27.6% of the variance. Finally, the combination of four reasoning: analogical, numerical, analytical and abstract reasoning was able to account for 28.6% of the variance in problem solving ability. Therefore, the adjusted *R*-square increased from 0.08 to 0.286 with the addition of subsequent sets of variables. The multiple adjusted *R*-square (0.286) means that the total contribution by the combined set of reasoning skills accounted for approximately 28.6% of the variance of problem solving ability.

At step 4, the β results pointed out that analogical reasoning (β = 0.113, $p < .001$), numerical reasoning (β = 0.291, $p < .001$), analytical reasoning (β = 0.236, $p < .001$) and abstract reasoning (β = 0.112, $p < .001$) were positive and significant predictors of student teachers' problem solving ability. Therefore, it can be concluded that these four reasoning skills can enhance the problem solving ability of student teachers. By applying regression analysis, the resultant model of reasoning skill for problem solving ability can be defined as in the following equation in which PSA represents problem solving ability and X represents respective score of reasoning skills.

$$PSA = 7.564 + 0.633\ X_{analogical} + 1.489\ X_{numerical} + 1.074\ X_{analytical} + 0.563\ X_{abstract}$$

Table 12 Standardized Regression Coefficients from Hierarchical Multiple Regression Analysis of Reasoning Skills for Problem Solving Ability

Predictors	Step 1	Step 2	Step 3	Step 4
Analogical	.283**	.152**	.121**	.113** (0.633)
Numerical		.391**	.310**	.291** (1.489)
Analytical			.266**	.236** (1.074)
Abstract				.112** (0.563)
R^2	.080	.216	.278	.288
Adjusted R^2	.080	.215	.276	.286
F value	*F*(1, 1624)= 141.523 (*p*<.001)	*F*(2, 1623)= 223.624 (*p*<.001)	*F*(3, 1622)= 207.817 (*p*<.001)	*F*(4, 1621)= 164.066 (*p*<.001)

Note. $^{**}p < .001$. Numbers in parentheses of step 4 column are unstandardized beta coefficients (B).

Then and there, in order to find out the best reasoning predictors for each problem solving ability, multiple linear regression analysis was conducted. The results and standardized beta coefficients are described in Table 13. The R^2 values suggested that 23.5% of the variability in logical problem solving, 22.7% of the variability in mathematical problem solving and 13.3% of the variability in classroom problem solving can be explained by the four reasoning skills.

Specifically, the results of the regression advocated that among the four reasoning skills, analogical, numerical and analytical reasoning skills can significantly predict logical problem solving ability. However, it was found that all reasoning skills are the best predictors for mathematical problem solving ability and only analytical reasoning skill is the best predictor for classroom problems.

Table 13 Standardized Regression Coefficients for Four Reasoning Skills on Each Type of Problem Solving Ability

Predictors	Problem Solving Ability		
	Logical	Mathematical	Classroom Problems
Analogical	.136**	.016*	.033
Numerical	.328**	.223**	.039
Analytical	.161**	.221**	.120**
Abstract	.025	.165**	.055
Adjusted R^2	.235	.227	.133
F value	*F*(4,1621)= 126.082 (*p*< .001)	*F*(4,1621)= 120.565 (*p*< .001)	*F*(4, 1621)= 13.619 (*p*< .001)

Note. $^{*}p < .01$, $^{**}p < .001$.

V. Intervention Based Analysis and Results

Based on the quantitative data results, an intervention practice was conducted to improve student teachers' reasoning skills and to confirm the predictive validity of the reasoning skill test based on the quantitative results.

Participants: There were 30 participants from university 1 (highest reasoning) and university 3 (lowest reasoning) respectively and totally 60 participants in this practice. The participants for this study are specifically described in Table 14 by stratum.

Table 14 Number of Participants from Selected Universities of Education

University	Reasoning Groups	Gender		Total
		Male	Female	
University 1	High	5	5	10
	Moderate	5	5	10
	Low	5	5	10
	Total	15	15	30
University 3	High	5	5	10
	Moderate	5	5	10
	Low	5	5	10
	Total	15	15	30
Total		30	30	60

Research Method. As the research method, one group pretest-posttest experimental design was used.

Intervention Protocol. For intervention, a protocol is based on a technique for improving reasoning skills called argument mapping by Tim van Gelder (2000). The basic idea of the technique is that the participants create diagrams showing the parts of their reasoning, and how these diagrams are logically related. Myanmar contexts which may be familiar with them were supplemented to the lessons to be convenient for all Myanmar student teachers. Each lesson was managed with two parts: first 30-minute section was for lecture and second 30-minute section was for practicum. This intervention protocol comprised of six lessons and six periods were taken to practice.

Reasoning Skill Test for Posttest. To construct a posttest, 50% (16 items) of posttest items were taken from the pretest items as the common items and 50% of them were from the field testing results. Based on the item parameter estimates, a test information curve for reasoning skill posttest was drawn as in Figure 4. It is visually clear that the test is discriminating well among examinees with the range of ability level from -1.8 to +0.9 in the test. The maximum amount of information was I (θ) = 4.9 at θ = -0.35. Moreover, its empirical reliability is 0.83. Therefore, it can be judged that this posttest is similar to the pretest (see Figure 4) and can provide information well for student teachers with normal reasoning ability. Hence, the format and content specifications of the posttest were also similar to the pretest.

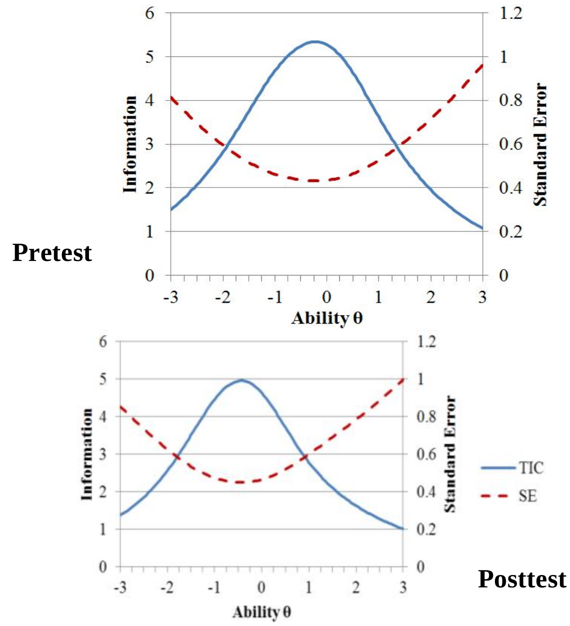

Figure 4 Comparison of Test Information Curves for the Reasoning Skill Pretest and Posttest

Problem Solving Ability Test for Posttest. In this study, problem solving ability pretest was an essay type and posttest was decided to be administered after 7 months of the pretest. Therefore, the problem solving ability pretest was used again for posttest.

Comparisons of Reasoning Skills Before and After Intervention. According to paired samples *t* test result, it can be perceived that their reasoning skills after intervention are significantly higher than before intervention ($p<$ .001 level). Moreover, the same results were also found in both University 1 and University 3. Therefore, it can be concluded that Argument Mapping Technique intervention practice could well increase the student teachers' reasoning skills.

Table 15 Paired Samples *t* Test Results of Reasoning Skills Before and After Intervention

University	Intervention	Mean	Std. Deviation	*t*	*df*	*p*
University 1	Before	17.30	7.77	-8.04	29	0.000
	After	20.23	7.36			
University 3	Before	15.30	7.64	-7.18	29	0.000
	After	17.93	7.22			
Total	Before	16.30	7.71	-10.82	59	0.000
	After	19.08	7.32			

Note. * The mean difference is significant at the 0.001 level.

Comparisons of Problem Solving Ability Before and After Intervention. According to paired samples *t* test result, it can be perceived that their problem solving ability after intervention are significantly higher than before intervention ($p< .001$ level). Moreover, the same results were also found in both University 1 and University 3. This may be due to the any effect of intervention and reasoning skills improvement.

Table 16 Paired Samples *t* Test Results of Problem Solving Ability Before and After Intervention

University	Intervention	Mean	Std. Deviation	*t*	*df*	*p*
University 1	Before	25.07	9.37	-2.63*	29	0.014
	After	26.33	9.63			
University 3	Before	23.27	9.96	-7.48**	29	0.000
	After	25.93	9.93			
Total	Before	24.17	9.63	-6.33**	59	0.000
	After	26.13	9.41			

Note. ** The mean difference is significant at the 0.001 level. * The mean difference is significant at the 0.05 level.

Regression Analysis for Reasoning Skills as Predictor of Problem Solving Ability. The result revealed that the model significantly explained the problem solving ability, $F(1, 58)=102.931$, $p< .001$. The R value (0.562) showed the significant positive correlation between reasoning skill and problem solving ability. Moreover, the adjusted R^2 (0.311) indicated that the reasoning skills contributed 31.1% variance to problem solving ability. Therefore, it can be reasonably seen that these results are closely fitting with the pretest results. Therefore, it can be concluded that Myanmar student teachers' reasoning skills can enhance and predict their problem solving abilities.

Table 17 Regression Analysis for Reasoning Skills as Predictor of Problem Solving Ability

Predictor	*B*	*β*	*t*	*R*	R^2	*Adj* R^2
Constant	6.514					
Reasoning Skills	1.028	0.562	10.156**	0.562	0.342	0.311

Note. **$p< .001$.

VI. Conclusion, Discussion and Recommendation

Confucius, a prominent Chinese philosopher, said that learning without thoughts is labor lost, thought without learning is perilous. This highlights the point that no one can learn without reasoning and thinking well. In this new millennium, the world is changing rapidly in science and technology and the changes have the greatest influence on economic, educational, environmental, cultural and social trends of the future. Consequently, these effects also fall on youths' thoughts and actions. They need to think correctly and to do properly. Reasoning skills have become more important in the modern world because there is too much information, and too many choices that come into human's minds. How can the new generation be educated to overcome the above mentioned challenges? Therefore, the tasks of teachers in the 21st century are not as straight forward as in the 20th century. They need to solve many problems and challenges reasonably inside and outside the classroom.

According to this study, it is obvious that reasoning skills were necessary for student teachers in solving many problems. The student teachers were better in inductive reasoning rather than deductive reasoning such as analytical and abstract skills. As mentioned above, a deductive reasoning is aimed to test the theory whilst an inductive reasoning is concerned with the generation of new theory emerging from the data. It is impossible for a teacher to possess only creation skill about new things. They should have to reason and critique a problem. This is also a caution for the teacher educators to train their trainees in order to gain both inductive and deductive reasoning.

The foremost responsibility would be the universities. After the students have selected to attend the respective university, they will study about specific knowledge which is expected to use for working in the future. Normally the Universities of Education teaches them academic and teacher education knowledge because this is their main duty. In the meantime, the challenges of the modern era would like the graduated students to have some other skills to work such as reasoning skills and problem solving ability.

Future professionals are no longer to satisfy with their own expertise only, however they need to constantly study, learn, review, analyze, and classify the thinking ability to fit the needs of society in the future world. For that reason, the Universities of Education should consider their teaching techniques on how to improve the students' working skills. They should also consider whether the assessment methods reflect sufficiently an emphasis on reasoning skill and problem solving ability. Then only, the student teachers would have confidence to face many inside and outside the classroom problems when they become teachers.

In order to fulfill the goal of teacher education programs and improve students' reasoning skill and problem solving ability, this study finally offers the following recommendations based on research findings and literature reviews:

- The aims of learning and teaching may need to be revised to improve the skills which are necessary for working after graduation.
- The curriculum contents and implementation of the courses need to foster students' in-depth understanding of subject knowledge, analyses of theoretical background, and higher order cognitive competencies. This emphasis of teaching strategy and curriculum materials can enhance teacher educators' and student teachers' recognition concerning "Thinking is learning".
- Teaching methods need to be revised to increase the reasoning skills, and problem solving ability.
- The culture of teaching and learning in the classroom should provide more opportunities for student teachers to discuss and give the reason to their teachers.
- Teacher educators should discuss and guide occasionally their trainees about how to solve classroom problems and how to reason methodically a problem.
- Assessment methods need to be examined to determine whether there is sufficient emphasis on reasoning and problem solving.
- Student teachers should be sporadically provided with the skills test, such as, reasoning skills test, problem solving ability test and so on, so that they know their levels of these skills since the beginning of their university life and it will help them to improve their working skills by practice.
- To improve the student teachers' reasoning skills, the teacher educators should use any practice like argument mapping technique performed in this study.
- A series of campus symposia for public discussions on academic issues and social events might assist students to visualize the functions of reasoning skills and create beneficial campus environment facilitating reasoning skills development. Additionally, these symposia can also evoke the interactive atmosphere between teachers and students for insightful and multifarious thinking.
- The internet technology must benefit and facilitate knowledge production and distribution; universities are certainly the center to the development of reasoning skills. The internet, therefore, can be utilized in universities for students to reach the social issues and understand multifarious viewpoints.

To sum up, since education is to prepare citizens with reasoning skills and to create more rational society or culture, it is hoped that the contributions of this study can not only provide insight to know about reasoning skill and problem solving ability but also be a support for upgrading teacher education in Myanmar.

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