DEVELOPMENT OF A COURSE ASSESSMENT PROTOTYPE REAL ANALYSIS THROUGH RMT (RIGOROUS MATHEMATICAL THINKING) APPROACH BASED ON SEX

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Abstract - This study uses the Research and Development (RnD) method with the aim of looking at the assessment sheet that has existed so far, developing a prototype assessment of the Real Analysis subject, and testing its validity, reliability and effectiveness. Development of assessment prototypes refers to the Borg and Gall model (2003). The assessment prototype consists of RMT ability test and a Real Analysis course assessment instrument designed to measure the subject cognitive domain with the RMT approach, and adjusted to the style of thinking according to gender. The technique of collecting data is by giving written tests for material in the real function line, followed by documentation, observation, interviews, and questionnaires. The initial product data analysis is validated by experts to obtain content validity. Furthermore, the instrument is tested on a limited basis to subjects who contracted 15 Real Analysis courses. The results of the trial assessment instrument with the RMT approach are measured by the product moment formula. While the reliability test uses alpha formula. The difficulty level of the test questions for the ability of the RMT and the distinguishing power are also measured. In the assessment instrument with the RMT approach adjusted to the subject's thinking style based on gender, it is the validity and reliability are measured. The results show that the Real Analysis course assessment instrument through a gender-based RMT approach that has been developed is valid, reliable, practical and effective.

Keywords: Prototype, Course Assessment, Real Analysis, RMT, Gender

I. INTRODUCTION

Assessment instruments development is one of the efforts to improve academic quality and subject learning achievement (in this case students). Before the assessment instrument is implemented, an analysis of the subject's learning needs and situations is carried out first. Then, it is so tested for its validity, practicality and effectiveness that produces an assessment product that can be useful for lecturers and subjects. The problems now is the assessment instruments in an educational institution are not optimally developed. So far, almost all assessments of lectures are only centered on the results of midterm (UTS), final examinations (UAS), and structural and independent assignments. However, these personal assessment indicators are not so well cared that lecturers are not able to assess objectively. This is in line with the opinion (James Beyers, 2011) which says that educators should make a structured and personal assessment system for students that starts from the maturity process in thinking mathematically so that it will look more just and wise. In addition, Muhammad.YM (2018) explained that the scoring system should pay attention to the mathematical mindset of the subject and one of these can be seen from his or her thinking habits according to gender.

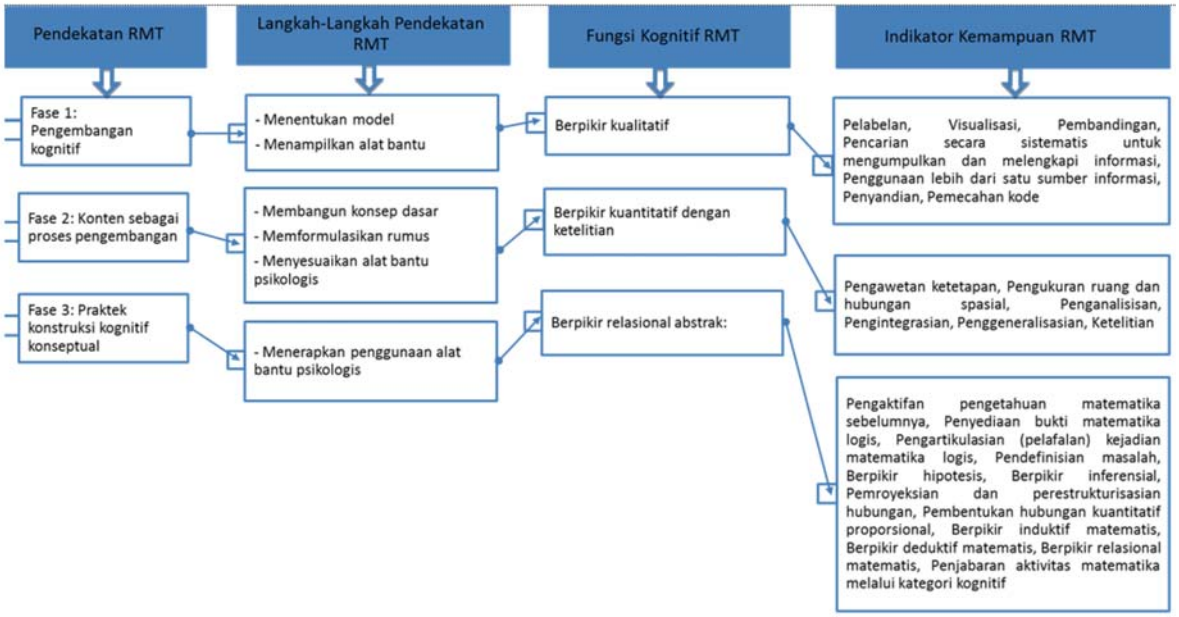
The increase in rigor mathematical thinking (RMT) ability of the subject is closely related to the intelligence level both intellect and emotional. According to Firmasari & Sulaiman (2019) stated that "subjects with low cognitive categories have not been systematic and not thorough in solving mathematical problems." It is known that individual intelligence is largely determined by the work of the brain. This is confirmed by the statement (Evania, 2011) that "brain development is closely related to the development of the prefrontal cortex which requires the longest time than other brain regions". So that it becomes the main responsibility in developing the RMT. Thus, learning activities during lectures must pay attention to brain function and performance. This is again reinforced by a statement (Jensen.TS, 2012) namely "the brain is involved in everything we do in school, so if we ignore it, it means we are not responsible". One of the results of the research explained that "In particular, my position was (and still is) that the cognitive and brain system that have evolved to enable movement in and the representation of three-dimensional space are more highly elaborated in boys and men than in girls and women" (Geary, 1998). Geary revealed that three-dimensional spatial abilities of men are better or faster than women. Furthermore, this study shows that women learn differently from men because of their abilities and different ways of thinking. According to Firmasari et al, (2019) the confidence of male students in mathematical abilities is higher than that of women.

Nurhayati (2016) states that differences in intellectual abilities between women and men include three things, namely: (1) verbal ability, (2) visual-spatial ability, and (3) mathematical ability. Women have oral ability better than boys, boys excel in visual-spatial and mathematical abilities. Alifah (2012) summarized the differences in abilities between men and women based on expert opinion in the form of the table below.

Research Resources	Talent and Interest	
	Male	Female
University of Cambridge	mechanical motion, *good gross motoric*, not easy to express fear, and more emotional.	a reliable imilator, superior hand ability, tends to be timid, and not easily emotional.
Michael Gurian	has a brain that tends to develop and has a more complex spatial, verbal ability that is 7,000 words per day, does not contain serotonin and aksitosin in the brain, brain size is smaller than women.	have less spatial ability, high verbal ability which is about 20,000 words per day, contains serotonin and aksitosin in the brain which makes him calm and understand other people, and has a larger brain size.
Macooby dan Jacklin	the verbal abilities period is low, but will be about the same age of 11 years, spatial visual abilities are superior in teenagers.	the verbal ability period is high, and low spatial visual abilities in teenagers.
Ward	like the field of physics.	underachieving in mathematics and preferring biology.
Dweck	experimenting	refuse to take risks in experimenting.
Cameron	master the shadow of more complex shapes.	women lack mastery in the shadow of more complex forms.

Table 1. Differences in Cognitive Ability between Men and Women in the Opinion of Experts

Based on the background of the problems stated above, it is necessary to develop a assessment prototype with a RMT approach based on gender that is able to represent each thinking style of the two different sexes. The ability development of the RMT is very necessary so that the subject understands the concepts learned and to exercise sharpness, critical power and can develop and improve the subject's high-level thinking skills (Yunita dkk, 2018). It is very important to know the RMT's capabilities because it requires a valid and reliable assessment instrument. Rigorous Mathematical Thinking (RMT) according to Kinard, (2007) "The RMT invention defines mathematical rigor as that quality of thought that reveals itself when learners are engaged through a state of vigilance – driven by a strong, persistent, and inflexible desire to know and deeply understand." The real analysis course is a very suitable course for applying the RMT because it contains compatible indicators with the RMT. To be clearer, the following is a chart of the relationship between the RMT approach and the RMT ability.



Picture 1. Chart of the relationship between the RMT approach and the RMT ability (Kinard, 2015)

From the picture above, it can be seen that the RMT approach can be closely related to the RMT ability indicator. This can be seen from the thinking process of the subject which begins with the RMT approach and ends with an indicator of the ability of the RMT. From this indicator, a Real Analysis course assessment instrument is prepared which is adjusted to the subject's cognitive thinking style according to gender. Thus the objectives of this study are (1) to make an assessment prototype for the Real Analysis course, (2) to design the Real Analysis course assessment instrument, (3) validate the results of the assessment instruments by expert validators, and (4) test the effectiveness and practicality of assessment instruments for the Real Analysis course that have been compiled. Therefore, the product produced from

this study is a valid, practical and effective course assessment instrument sheet for Real Analysis.

II. METHOD

Research methods can be interpreted as scientific procedures to obtain data with specific purposes and uses (Sugiyono, 2009). This study uses a mix method simultaneously to obtain a comprehensive analysis of research problems as stated by Creswell, (2013) or can be known as the concurrentmix method. This study uses research and development design, also known as R&D research. The results of this study are in the form of a Real Analysis course assessment instrument through the Rigorous Mathematical Thinking (RMT) approach based on gender. The development model in this study will follow the steps of Borg and Gall (2003) which are more detailed and operational. The development model of Borg and Gall (2003) that should have been taken in development research has ten steps, but this research only reached the eighth step. The eight steps are: (1) preliminary study, (2) planning, (3) hypothetical model development, (4) hypothetical model review, (5) revision, (6) limited trial, (7) revision of trial results, (8) wider trial. This research only reached the eighth stage because this product was not to be tested en masse. Data collection techniques used are the method of written tests, documentation, observation, interviews, and questionnaires. Data analysis in the instrument development process, that is, the initial product is validated by the expert board to obtain valid instrument contents. Furthermore, this instrument was tested on a limited basis to the subject, namely FKIP UGJ students of mathematics education study program. The results of trial assessment instruments using the RMT approach based on gender are measured empirical validity using the product moment formula. While the reliability test uses alpha formula. The difficulty level of the question and the distinguishing force are also measured. In the instrument for evaluating democratic characters, the validity and reliability are measured using SPSS version 22 software.

III. RESULTS AND DISCUSSION

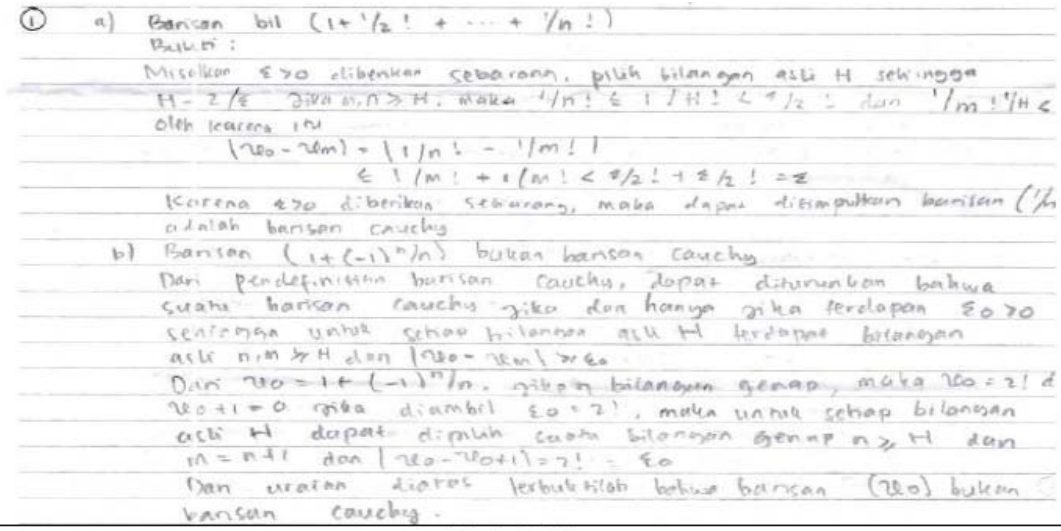
Results

The results of the research related to the instruments used by researchers in measuring the ability of the RMT are carried out by written tests on material sequences and real functions. The technique used by researchers in assessing aspects of mathematical thinking style is based on gender by making observations from the results of answers and lecture activities in the classroom and interview. The following is a question of RMT ability tests and then analyzed subject thinking styles based on gender.

No.	RMT Ability Test Questions for Sequence Materials and Real Functions
1.	Show that the sequence (1+1/2!+1/3!+...+1/n!) is a Cauchy sequence and show that $(n+(-1)^n) / n$ is not a Cauchy sequence.
2.	Show if each sequence (x_n) and (y_n) is Cauchy, then (x_n+y_n) and $(x_n.y_n)$ are also *Cauchy*.
3.	Show that the monotonically up and limited line is the Cauchy line.
4.	Suppose that (x_n) is a Cauchy sequence so that (x_n) (xn) is a sequence of integers for each natural number n. Show that the sequence (x_n) is finally constant.
5.	Suppose that y_1, y_2 is real number and $y_1 < y_2$. Define $y_n = 1/3y_{n-1} +2/3y_{n-2}$ for $n > 2$. Show the sequence (y_n) convergent and specify the limit.

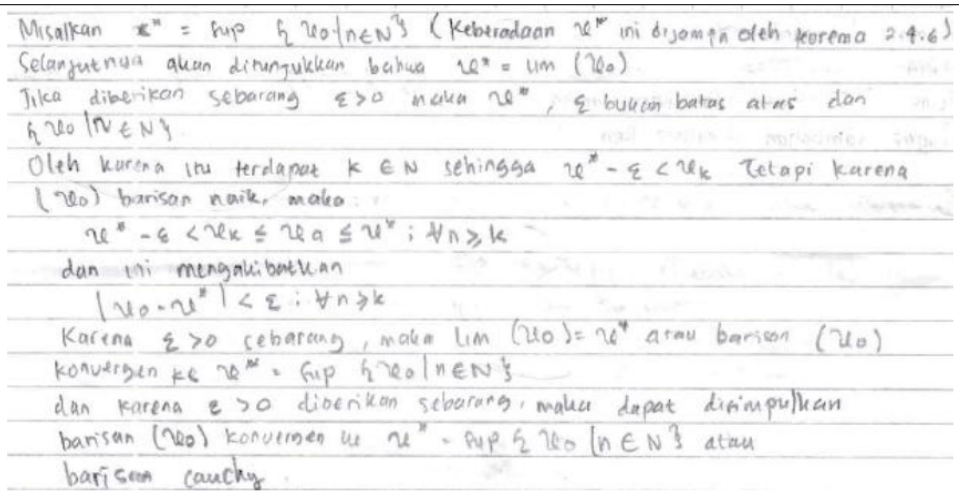
From the test questions above, the following is one of answers from classified subjects according to gender, namely men and women with random sampling techniques.

Question No.1

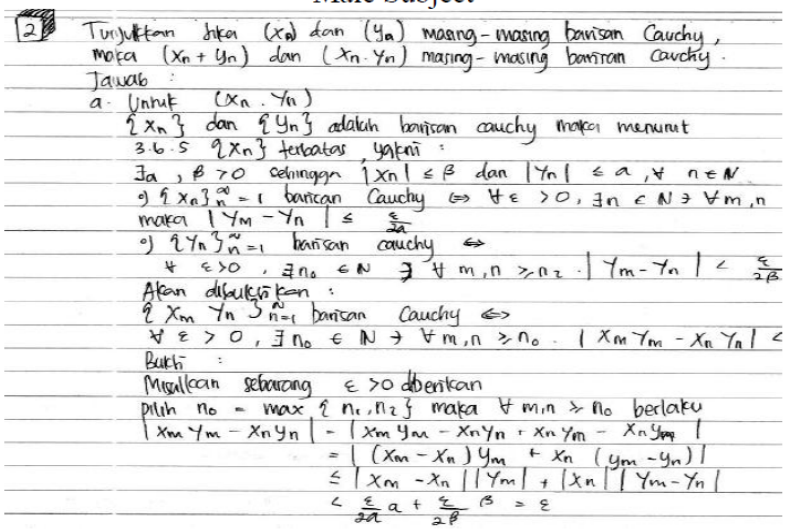

① a) Barisan bil $(1+1/2! + \cdots + 1/n!)$
Bukti :
Misalkan $\varepsilon > 0$ diberikan sebarang, pilih bilangan asli H sehingga $H = 2/\varepsilon$ jika $m, n \geq H$, maka $1/n! \leq 1/H! < \varepsilon/2!$ dan $1/m! \, 1/H <$
oleh karena itu
$|x_0 - x_m| = |1/n! - 1/m!|$
$\leq 1/m! + 1/m! < \varepsilon/2! + \varepsilon/2! = \varepsilon$
Karena $\varepsilon > 0$ diberikan sebarang, maka dapat disimpulkan barisan (1/n
adalah barisan cauchy
b) Barisan $(1+(-1)^n/n)$ bukan barisan cauchy
Dari pendefinisian barisan cauchy, dapat diturunkan bahwa suatu barisan cauchy jika dan hanya jika terdapat $\varepsilon_0 > 0$ sehingga untuk setiap bilangan asli H terdapat bilangan asli $n, m \geq H$ dan $|x_0 - x_m| \geq \varepsilon_0$
Dari $x_0 = 1 + (-1)^n/n$, jika n bilangan genap, maka $x_0 = 2!$ d
$x_0 + 1 = 0$ jika diambil $\varepsilon_0 = 2!$, maka untuk setiap bilangan asli H dapat dipilih suatu bilangan genap $n \geq H$ dan $m = n+1$ dan $|x_0 - x_0 + 1| = 2! = \varepsilon_0$
Dan uraian diatas terbuktilah bahwa barisan (x_0) bukan barisan cauchy.

Male Subject

Question No.2



Male Subject



Female Subject

From the picture above, it can be seen that differences in thinking styles with the RMT approach will later be adjusted to gender. From the results of the answers, at first glance, there seems to be no difference in thinking style, but after being examined more deeply by interviewing each subject, there is a difference from the thinking style that is in accordance with his gender. The following are the results of the test for the ability of the RMT of line material and real functions with the product moment correlation that are made into table forms.

No.	NK	IV	TS	Validity	DR	TK	DP
1	0.640	High	$\alpha = 5\ \%$	Valid	High	Medium	2.905
2	0.425	Medium	$n = 15$	Valid	High	Medium	3.973
3	0.619	High	$r_{Tabel} = 0.304$	Valid	High	Medium	5.970
4	0.545	Medium	$r_{xy} > r_{Tabel}$	Valid	High	High	2.433
5	0.689	High		Valid	High	High	5.523

Keterangan :

NK : Validity Correlation Score
IV : Questions Validity Index
TS : Questions Significance Level
DR : Questions Reliability Degree
TK : Questions Difficulty Level
DP : Questions Differential Force

Table 2. Results of the RMT Ability Test for Sequence Materials and Real Functions

From the table above, it can be seen the results to prove the validity criteria, the degree of reliability of the question is calculated by alpha formula and the results obtained with high criteria and for the level of suitability of the problem depends on the medium and difficult region. After the validity test for ability test with RMT, below is a Real Analysis course assessment instrument with RMT adjusted for cognitive thinking style based on gender table.

Level	Cognitive Function	RMT Indicator	Cognitive thinking styles focused on sex		Scale			
			Male	Female	1	2	3	4
I	Qualitative Thinking	Labeling	√	√				
		Visualization	Spatial	Verbal				
		Comparison	Spatial	Verbal				
		Searching systematically to gather and complete information	√	√				
		Use of more than one source of information	√	√				
		Encoding	Spatial	Verbal				
		Code solving	Spatial	Verbal				
II	Quantitative Thinking with Precision	Preservation of provisions	Logic, reason and spatial	Logic, reason and verbal				
		Spatial measurement and relations	√	Not required				
		Analyzing	Logic, reason and spatial	Logika, nalar, precision and verbal				
		Integration	Spatial	Verbal				
		Generalization	Logic, reason and spatial	Logic, reason, precision and verbal				
III	Abstract Relational Thinking	Previous mathematical knowledge activation	Spatial strategy	Verbal strategy				
		Logical mathematical evidence provision	√	√ (added verbal)				
		Articulating (pronunciation) logical mathematical events	√	√ (added verbal)				
		Defining the problem	Logic, reason and spatial	Logic, reason, precision and verbal				
		Generalization	Logic, reason and spatial	Logic, reason, precision and verbal				
		Hypothesis Thinking	Spatial	Verbal				
		Inferential Thinking	Spatial	Verbal				
		Relationship projecting and restructuring	Spatial strategy	Verbal strategy				
		Formation of proportional quantitative relations	Spatial strategy	Verbal strategy				
		Mathematical inductive thinking	√	√				
		Mathematical deductive thinking	√	√				
		Mathematical relational thinking	√	√				
		Descripting mathematical activities through cognitive categories	√	√				

Notes :
√ = subjects are required to do so
1 = Unable to do at all
2 = Not able to do well
3 = Enough to do well
4 = Able to do very well

Table 3. Assignment Assessment Instruments and Course Test Results of Real Analysis Based on Sex with the RMT Approach

From the table above, it can be seen that the assessment instrument for the Real Analysis course with the RMT approach adapted to the cognitive thinking style according to gender can represent the ability to think personally. So that this assessment instrument is expected to be able to raise the subject's learning achievements, especially the Real Analysis course. Because this instrument is so the basis for lecturers to provide lecture material by paying attention to aspects of cognitive thinking style according to gender that future expectations are subject learning achievement can increase optimally. This can be proven by the final value which shows the results with satisfying criteria. The following is a table of the results of the validity of the task assessment instrument and the results of the subject exam Real Analysis based on gender with the RMT approach.

BP	Indikator RMT	NV	IV	NR	IR
1	Labeling	0.728	High		
2	Visualization	0.831	High	R_{11} =	High
3	Comparison	0.670	High	0.755	
4	Searching systematically to gather and complete information	0.827	High	Sehingga	
5	Use of more than one source of information	0.561	Medium	didapat :	
6	Encoding	0.680	High		
7	Code solving	0.773	High	$0.60 < R_{11}$	
8	Preservation of provisions	0.811	High	<0.80	
9	Spatial measurement and relations	0.731	High		

10	Analyzing	0.570	Medium
11	Integration	0.628	High
12	Generalization	0.640	High
13	Previous mathematical knowledge activation	0.510	Medium
14	Logical mathematical evidence provision	0.487	Medium
15	Articulating (pronunciation) logical mathematical events	0.428	Medium
16	Defining the problem	0.528	Medium
17	Generalization	0.613	High
18	Hypothesis Thinking	0.788	High
19	Inferential Thinking	0.630	High
20	Relationship projecting and restructuring	0.597	Medium
21	Formation of proportional quantitative relations	0.778	High
22	Mathematical inductive thinking	0.690	High
23	Mathematical deductive thinking	0.528	Medium
24	Mathematical relational thinking	0.647	High
25	Descripting mathematical activities through cognitive categories	0.638	High

Keterangan :
BP : Butir Pengamatan (Observation Item)
NV : Nilai Validitas (Validity Score)
IV : Indeks Validitas (Validity Index)
NR : Nilai Reliabilitas (Reliability Value)
IR : Indeks Reliabilitas (Reliability Index)

Table 4. Validity Test Results of Assignment Assessment Instruments and Course Test Results of Real Analysis Based on Gender with the RMT Approach

From the table above, it can be seen that the results of validity tests for task assessment instruments and course test results of Real Analysis based on gender with the RMT approach is valid with a medium to high validity index. Sedangkan, indeks reliabilitas menunjukkan kriteria tinggi. The validity and reliability test of this instrument is conducted by an expert validator (rater) of two people who had doctoral degrees in mathematics education. Thus, the final conclusions from the validity and reliability test for this assessment instrument have a decent result or can be used properly.

Discussion

Development of a course assessment prototype Real Analysis through a gender-based RMT approach is carried out with a preliminary study phase in order to establish and define the provisions when lecturing in class, as well as literature studies related to the problems studied to formulate a research framework. Activities carried out in this study include curriculum analysis, analysis of subject situations, lecture material analysis of Real Analysis, independent task analysis, and instructional objectives formulation. Furthermore, questions about the ability of the RMT are made to measure the subject cognitive abilities and test the validity, reliability and index of the difficulties first. After that, a Real Analysis course assessment instrument is created, which is focused on gender-thinking cognitive styles. The practicality of the developed prototype assessment of the Real Analysis course can be determined by the following indicators: 1) the use of lecture devices; 2) the observations results of the lecturers ability in managing lectures using assessment instruments in very good categories; 3) subject response to positive lecture ratings, indicated by a percentage more than 80% (Amidi 2012: 106). The results of the developed course assessment prototype usage of Real Analysis can be seen from the total average value of all meetings. The average total use of the developed prototype assessment of the Real Analysis course is 3.98, so it is concluded that the use of prototypes is in the category of "good". The results of the researchers' responses in using lecture assessment instruments of Real Analysis are obtained a total average of two raters, namely 85. This means that the use of the developed prototype is classified as "very good". While the subject response showed positive results, the course assessment prototype of Real Analysis with the RMT approach based on gender is said to be practical. The test results of the course assessment prototype effectiveness of Real Analysis with the RMT approach based on gender can be seen if the assessment instrument meets the criteria of valid, reliable, objective, systematic, economical, and practical (Sudiyatno 2010: 239). In general, the rater assesses that the prototype assessment course of Real Analysis with a gender-based RMT approach has a very good value of objectivity, economics and systematic. It is illustrated by the average for each aspect, namely Objectivity 3.56 (very good), 3.45 (very good) and Systematic 3.56 (very good), while the validity, reliability and practicality have also been

tested. Overall, it can be concluded that the effectiveness criteria have been fulfilled.

IV. CONCLUSION

Based on the results of research and discussion, it can be concluded as follows: (1) The lecturer has not so fully used the Real Analysis course assessment prototype with a gender-based RMT approach that it is expected that in the future it can use and assess the subject's cognitive abilities more fairly and measurably, (2) development of a course assessment prototype of Real analysis with a gender-based RMT approach produces valid, reliable, practical and effective assessment instruments, (3) the results of the trial of prototype assessment course of Real Analysis with the RMT approach based on gender are measured empirical validity using the product moment formula which produces 5 items declared valid. For reliability test, the researcher uses alpha formula with results of the assessment prototype having a high degree of reliability. The difficulty level is balanced, where there are difficult and moderate questions. As for the differentiating force, the results of the test questions can distinguish between high, medium and low ability subjects. Positive responses from interested lecturers in using a course assessment prototype of Real analysis with a gender-based RMT approach provide excellent comments on the assessment instruments that have been prepared. Based on the results of observations of lecture management capabilities, the researcher obtains scores from a maximum score of 36. The subject also give a positive response, as indicated by the results of a questionnaire that shows interest in joining the next lecture which is equal to 95.00%. The developed course assessment prototype of Real analysis with a gender-based RMT approach was is effective. It is indicated by the fulfillment of valid, reliable, objective, systematic, economical, practical and effective criteria with an average score obtained at 3.54 which means the product effectiveness is very high.

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