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Self-regulated Learning Questionnaire: Differential Item Functioning (DIF) and Calibration using Rasch Model Analysis

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ABSTRACT

Questionnaires are commonly utilized on educational research. However, studies on Differential Item Functioning (DIF) and calibration using Rasch Models are still limited. Therefore, a Self-regulated learning questionnaire was developed which aims to determine the ability of students to regulate themselves to achieve learning goals. The instrument consists of twelve items. The involved participants were 300 students who enrolled in first-year to fourth-year. Data were analyzed using Racsh Model Analysis with Winsteps 4.5.2 software. As a result, there are four items that were not fit, so that, therefore should be eliminated or revised. The DIF analysis found that gender bias was unidentified, but long-study bias was detected for items number one and six. The reliability value of the item is categorized as very good (0.99), which indicates that the instrument has sufficient consistency/reliability. While, the function curve showed that the items on the self-regulated learning questionnaire produce optimal information in individuals with moderate (θ) ability. Overall, self-regulated learning questionnaires have to be revised then tested on different sample groups. In addition, longitudinal and cross-sectional research is necessary to determine the level of self-regulated learning of students more comprehensively.

Keywords: *Self-regulated learning; bias; DIF; rasch model; item response theory*

INTRODUCTION

Questionnaires are broadly employed in educational assessment. Questionnaire is one of common instruments to support the researchers collecting relevant data (Taherdoost, 2022). Various examples of educational research using questionnaires include burnout, motivation, and (de-) motivating teaching style (Hellebaut et al., 2023); predicts cyberloafing during online

learning (Zhang et al., 2022b); affective engagement (Zhang et al., 2023); online assignment motivation (Xu, 2022); self-regulated learning on online learning (Zhang et al., 2022a); and many other research topics. These studies use questionnaires as the main and supporting data collection tool.

The most often questionaire used in educational research, especially to measure attitude, is the Likert scale type developed by Rensis Likert in 1932. This type is commonly used by respondents to give affirmative or disagreeing responses to the statements given. Self-regulated learning (SRL) is one of the educational research topics that covers aspects of cognitive, metacognitive, behavioral, motivational, and emotional/affective learning (Panadero, 2017). Therefore, SRL is a crucial aspect of a large number of variables that affect student learning success. As self-regulated skill is one of metacognitive (part of high order thinking skill, HOTS), an evaluation example on a developed questionaire related to this HOTs is necessary.

Students should have the ability to regulate themselves to achieve learning goals. According to Piaget's cognitive theory, students enter the formal operational stage (early adulthood) who already have the ability to overcome problems (Santrock, 2008). At this stage, students have the ability to think about future possibilities and strategize to achieve goals (Pressley & Harris,2009).

Self-regulated learning is part of the learning strategy component. Another component of a learning strategy is skill and willpower. Most of these studies used questionnaires (Gambo & Shakir, 2021). Most of the research methods literature related to the use of questionnaires focuses on issues related to reliability and validity. Estimates of latent traits of measured questionnaires are based on the characteristics of people and items, and people's abilities and item difficulties are measured on the same scale (logits) (Van Zile-Tamsen, 2017). It is important at this time to correct the compiled category instruments and evaluate participants by the average of their responses to the item. Similarity assessments are needed to support reliability and validity, including bias detection.

In addition to maintaining the quality of the instrument such as validity and reliability, the instrument should be avoided from bias (Sumintono & Widhiarso, 2015). Bias means that the instrument does not benefit a particular group of respondents, is inconsistent, contaminated with other factors outside the aspect to be measured, and misuses of tests (Retnawati, 2017). Subsequently the term item bias, to avoid negative connotations, was replaced with Differential Item Functioning (DIF). Although no single IRT method can be used to detect DIF, all IRT

procedures compare item characteristic curves (ICCs) that are assumed to remain invariant among groups after being scaled (Yeşim & Baştuğ, 2016). The general framework includes: (a) matching examiners, (b) selecting appropriate IRT models, (c) estimating item and test participant parameters for each group, (d) transforming estimates to a common scale, and (e) finding DIF areas by reducing reference groups' ICCs and focusing on each other.

Items can be identified which have different functions for certain group respondents, hopefully. This kind of bias was found in research (Mumpuni et al., 2022) reagrding parental understanding to support children's science activities at home. Three questions are biased towards the difference between mothers' jobs as housewives and teachers, where these questions are more beneficial for mothers who also work as teachers. This study assesses the importance of having the latest information in analyzing instruments with the principle of fairness or detecting item bias. For this purpose, DIF testing was used in this study. In rasch modeling, DIF testing directly reveals differences in scores between groups of respondents by presenting values to test for bias and validating the questionnaire's Self-regulated learning instruments in more detail.

METHOD

This study used a SRL questionnaire. The questionnaire used consisted of 12 closed questions consisting of 4 anchor Likerts (4-Point Likert Scale), namely strongly agree, agree, disagree, and strongly disagree. This instrument measures how students have appropriate learning strategies, the ability to monitor emotions / affective actively, and the ability to manage and regulate themselves in the learning process. The SLR questionnaire consists of three aspects, namely self-strategy (symbolized by STR-5 items), self-emotional (symbolized by EMO-3 items), and self-management (symbolized by MAN-4 items).

The respondents in this study were 300 students consisted of first-year to fourth-year students, so they already have experience of adult learning illustrated in self-regulated learning. There are also two gender groups, namely men and women. The self-regulated learning questionnaire is conducted online through gform, which contains questions and biodata needed by researchers. Respondents also filled in willingness to fill out questionnaires.

Data were analyzed using Racsh Model Analysis with Winsteps 4.5.2 software (Linacre, 2020). Rasch modeling tests the respondents (persons) and question items simultaneously. In quantitative research, error calculation standards and calibration requirements (measurement

scales, respondents, and items) can be met (Sumintono & Widhiarso, 2014). The self-regulated learning questionnaire was analyzed for calibration and bias detection. Table 1 lists the questions and question codes used in the analysis.

Table 1. List of question items and codes

Aspects	Questions	Code
Strategy	It is important for me to have a record of every lecture activity.	I1
	It's not my type to figure out which points are important to each lesson, letting the learning material flow is better.	I2
	I can find at least one important point during a friend's presentation or discussion activity.	I3
	I just follow every lecture in the hope that later I will understand myself.	I4
	When facing exams, I often try to predict the questions that will come out.	I5
Emotional	I always feel ready to face the exam.	I6
	I am always enthusiastic about all courses.	I7
	I'm the kind of person who always focuses on what I'm doing.	I8
Behaviour	If I don't understand a certain material, I will ask a friend to explain again.	I9
	Setting a schedule is the most important way I do tasks.	I10
	I often reflect back on whether or not I understand today's lecture material.	I11
	I always encourage myself that I can.	I12

RESULTS & DISCUSSION

Result

Uni-dimensionality

The unidimensionality of an instrument is defined as the ability of an instrument to measure various attributes. This analysis uses Output Table 23 of winstep. With this in mind, the results of data analysis showed that the raw variance described by measurements amounted to 37.1% was in the appropriate category. Meanwhile, the unexplained variants in residual contrast from the first to fifth order were 14.5%, 7%, 6.5%, and 5.5%, respectively. An argument for unidimensional measurement can be made if raw variance can be explained by a measurement of ≥ 20% (M. Linacre, 2012), (The interpretation criteria are as follows: it is sufficient if it is between 20% and 40%, it is good if it is between 40% and 60%, and it is very good if it is above 60%) and a variation of about 15% for contrast of residuals is unexplained first through fourth. Therefore, this instrument measures one single variable, namely self-regulated learning. Therefore the items satisfy the initial assumptions for the Rasch Model to analyze.

Wright Map

In Rasch's analysis, the distribution of student ability and item difficulty is shown in Figure 1. Figure 1 shows the distribution of student respondents (persons) in the left column and questions (items) in the right column. The most difficult item to approve is the I8 and the easiest is the I12. The more above position I, the higher the approved difficulty level compared to Q below it. The item reaches all intervals in the item map. This means that the difficulty level of the item varies from easy to difficult. Wright map cannot be displayed all persons and items because there is too much data, so it is abbreviated with the symbol # which represents 4 persons and "." which represents 1 to 3 persons.

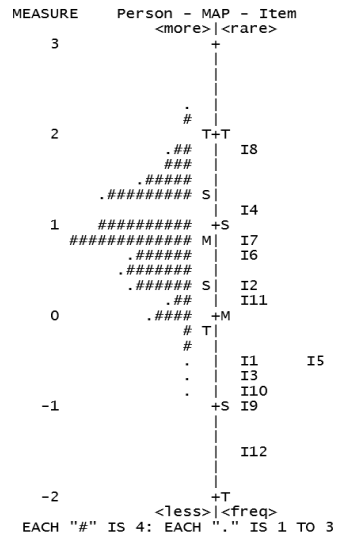

Figure 1. Map of item difficulty distribution (degree of ease of giving consent) and respondents' ability to answer questions depicted in Wright map

Item Measurement

The quality of the question items used in this study can be seen from the measurement items. The results of the analysis are shown in Table 2.

Table 2. Statistical conformity of items on the instrument to rasch analysis

Item Code*	Logit	SE	Outfit MNSQ	Outfit ZSTD	PtMeasure Corr
I8	1.82	0.08	1.12	1.70	-0.04
I4	1.24	0.08	1.05	0.73	0.43
I7	0.89	0.08	1.13	1.75	0.01
I6	0.68	0.08	1.14	1.87	-0.04
I2	0.40	0.08	0.94	-0.69	0.56
I11	0.19	0.08	0.82	-2.44	0.51
I5	-0.53	0.09	0.89	-1.77	0.40
I1	-0.53	0.09	1.00	0.18	0.46
I3	-0.74	0.09	0.81	-2.86	0.43

I10	-0.90	0.09	1.14	1.23	0.46
Item Code*	**Logit**	**SE**	**Outfit MNSQ**	**Outfit ZSTD**	**PtMeasure Corr**
I9	-1.02	0.09	0.83	-2.47	0.48
I12	-1.51	0.10	1.21	2.45	0.44

Mean Suaqre (MNSQ); Z-Standsrd (ZSTD); SE (Standard error); PtMea (Point Measurement Correlation)

*This item code is sorted by item difficulty from highest (I8) to lowest (I12) indicated in the logit measure value

Based on Table 2, all items function normally to measure respondents' self-regulated learning . The benchmarks used are the value of Outfit MNSQ (0.5<MNSQ<1.5), Outfit ZSTD (-2.0<ZSTD<2.0), and Pt. Measure Corr (0.4<Pt. Mea Corr<0.85). Of the three criteria, some values of Outfit ZSTD and Pt. Measurement Corr do not match. However, according to Sumintono & Widhiarso (2015), this is still tolerable because the other two criteria are already qualified.

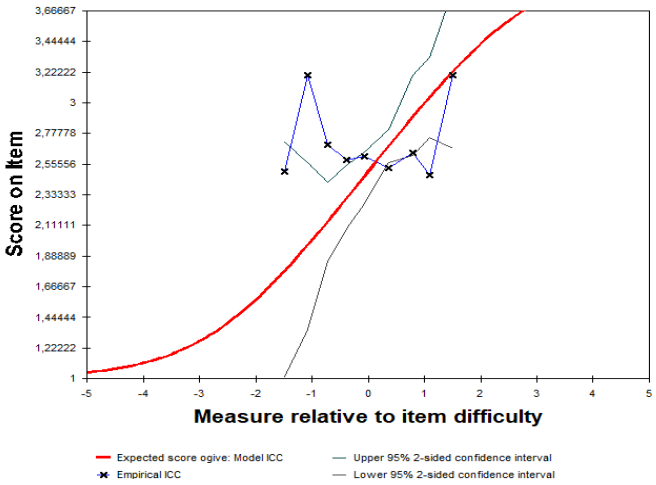

Figure 2. ICC Expected score of I6 in graph form.

The red line indicates the expected line of the Rasch model. Meanwhile, the green line is the tolerance limit, the upper green line is the inflit data trust limit, and the lower black line is the outfit data trust limit. The (x) sign indicates the number of data groupings.

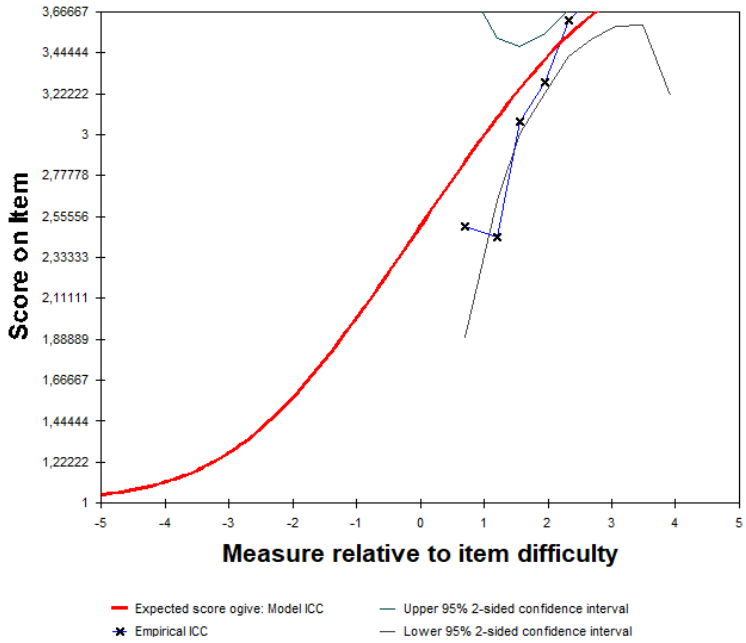

Figure 3. ICC Expected score from I12

Figure 2 indicates that if (x) is above the red line it means that the question item was answered correctly, and vice versa. The blue line is the research data. The hope is that the blue line follows the red line pattern. However, the blue line in Figure 1 does not follow that pattern and is outside the tolerance limit within the green line zone. Therefore, it is better to eliminate the I6 question items or revision first with a retest, these include I8, I7, and I6. Figure 3 indicates that most (x) in I12 is within the tolerance limit within the green line zone, there is only one x. Therefore, such items can be used but are better revised first, including I9, I3, and I13.

Bias Item

Self-regulated learning questionnaires, in addition to being valid and reliable as described earlier, the instrument must be free from bias (Retnawati, 2017). The bias in question is that the instrument does not take sides or provide benefits to certain groups of respondents. This is shown in Table 3.

Table 3. Analysis of gender bias of the questions in the questionnaire

Item Code	Probability	Item Code	Probability
I1	0.1950	I7	0.6088
I2	0.2212	I8	0.1436
I3	0.2129	I9	0.4969
I4	0.3200	I10	0.1990
I5	0.7800	I11	0.5014
I6	0.6427	I12	0.0615

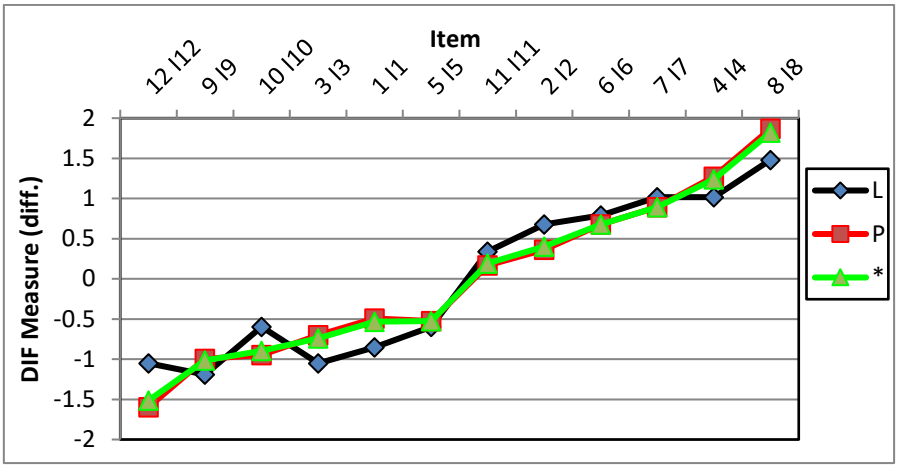

Figure 4. Results of Differential Item Functioning (DIF) analysis. L (male) and P (female). * Expected model line.

Two groups of respondents with male and female gender, there were no biased items because all probability items were more than 5%. This means that self-regulated learning questionnaires are suitable for measuring self-regulated learning in both men and women. Furthermore, it was analyzed about the grouping of student study periods which were divided into 4, namely first, second, third, and fourth year students. The following is the analysis of study period bias in Table 4.

Table 4. Analysis of study period bias towards questions in questionnaires

Item Code	Probability	Item Code	Probability
I1	0.0029	I7	0.1816
I2	0.4299	I8	0.6642
I3	0.9097	I9	0.0953
I4	0.7991	I10	0.1233
I5	0.1219	I11	0.7642
I6	0.0039	I12	0.2253

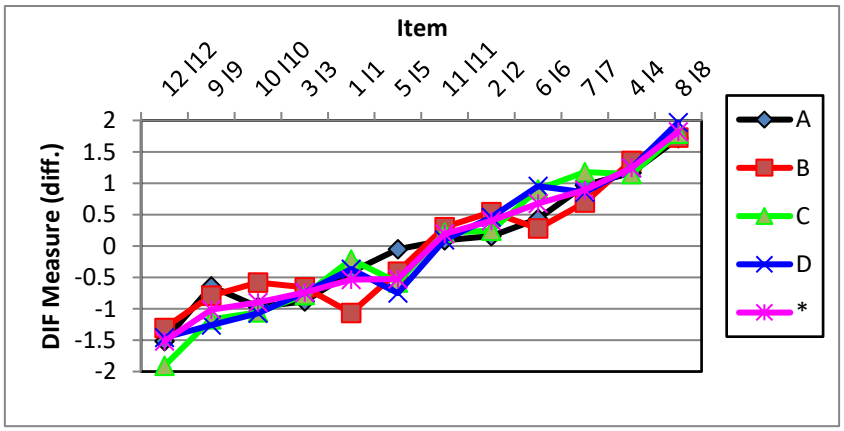

Figure 5. Results of personal Differential Item Functioning (DIF) analysis. First year (A), second year (B), third year (C), and fourth year (D). * Expected model line.

Based on Table 4, there are two questions that contain bias, namely I1 and I6. This bias occurs because the probability is less than 5%. Based on Figure 5, question I1 contains bias which means that the problem is more difficult for the second-year student group to agree on than other batches of students. As for I6, groups C and D are easier to agree with than groups A and B.

Summary Item Statistic

Summary statistics (Table 5) provide comprehensive information about the quality of student response patterns, the quality of instruments used, and interactions between person and item. The item reliability value is 0.99, meaning that the quality of the items in the instrument has very good consistency / reliability. Furthermore, for infit and outfit Mnsq respectively of 1.01 and 1.00, with the ideal value is 1. ZSTD infit and outfit of 0.01 and -0.03 respectively, the ideal value is 0.00 (the closer to 0 the better). So it was concluded that the items on the self-regulated learning questionnaire were fit or appropriate to measure self-regulated learning.

The separation value is 10.78, rounded to 11. This means that the results of working on self-regulated learning questionnaires by 300 students can be grouped into 11 groups of items ranging from difficult to easy levels of difficulty. This corresponds to the distribution of items in Figure 1, where I1 and I5 are on the same difficulty.

	TOTAL SCORE	COUNT	MEASURE	MODEL S.E.	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD
MEAN	868.7	300.0	.00	.09	1.01	.01	1.00	-.03
SEM	40.9	.0	.30	.00	.04	.55	.04	.56
P.SD	135.6	.0	.98	.01	.14	1.82	.14	1.86
S.SD	141.7	.0	1.02	.01	.14	1.90	.15	1.94
MAX.	1060.0	300.0	1.82	.10	1.21	2.44	1.21	2.45
MIN.	609.0	300.0	-1.51	.08	.81	-2.75	.80	-2.86
REAL RMSE	.09	TRUE SD	.98	SEPARATION	10.78	Item	RELIABILITY	.99
MODEL RMSE	.09	TRUE SD	.98	SEPARATION	11.14	Item	RELIABILITY	.99
S.E. OF Item MEAN = .30								

Figure 6. Summary of 12 Measured Item

Test Information Function

The curve graph of the measurement information function shows that the self-regulated learning questionnaire that students do, is good to be used to measure self-regulated learning. Figure 6 shows that at the medium ability level (measure or logit value = 0), the information obtained from the measurement is very high. Unlike if the measure value is high or low, then

the information value is also low. This suggests that items on self-regulated learning questionnaires produce optimal information in individuals with moderate (θ) ability.

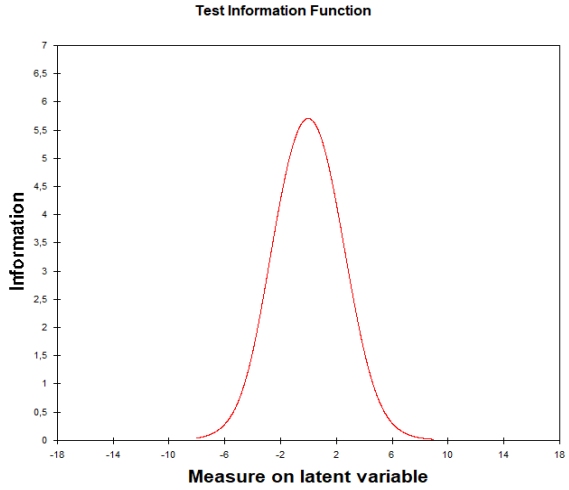

Figure 7. Test Information Function

Discussion

Unidimensionality as a prerequisite for rasch model analysis is fulfilled so that the analysis continues. On the Wright map, the hardest item to approve is the I8 (I'm the type of person who always focuses on what I'm working on) and the easiest to approve is the I12 (I'm always encouraging myself that I can). The items on this questionnaire reach all intervals, items vary from easy to difficult.

Item Measurement shows which items are not yet fit and need to be eliminated or revised. Due to item limitations, these items were revised and retested. Furthermore, item bias (DIF) is not found in gender, but in the study period. In line with the bias that occurs in research (Muslihin et al., 2022) that students may be influenced by academic and cultural capacity factors. On I6 (I always felt ready for the exam) it was easily approved by older Batch students (third and fourth year) because they had longer college experience.

The item reliability value is 0.99 which means that the instrument has very good consistency / reliability. Furthermore, for infit and outfit, Mnsq and Zstd are also fit to meet the standards. So that, it was concluded that the items on the self-regulated learning questionnaire were fit or appropriate to measure self-regulated learning. This questionnaire is also able to distinguish students in certain groups according to student responses to the questionnaire.

The capability range (θ) can be adapted to the development objectives of the instrument. Instrument development by Istiyono & Suyoso (2019) aims to measure and detect weaknesses

of higher-order thinking skills in Physics, hence it has a range of $-1.6 \leq \theta < 3.0$. Self-regulated learning questionnaires are expected to be used to measure students' self-regulated learning with a wider θ range.

Most self-regulated learning models combine the cognitive, metacognitive, behavioral, motivational, and affective dimensions of learning, and include a large number of variables, for example, self-efficacy, self-efficiency, metacognitive and cognitive strategies, motivational and emotional factors, and learner beliefs (Panadero, 2017). These things have been integrated into the questionnaire compiled. The research of Panadero (2017) can also be a reference for revising questionnaires.

The developed self-regulated learning questionnaires can be tested on different sample groups. Longitudinal and cross-sectional research is needed to determine students' level of self-regulated learning more comprehensively (Öz & Şen, 2018). Additional advice is to control the culture and look for appropriate techniques for online research data collection to minimize outliers (Natanael et al., 2022).

CONCLUSION

Gender bias was unidentified, but long-term study bias was detected for items number one and six. The reliability value of the item was very good (0.99), which indicates that the instrument has very good consistency/reliability. Function curve indicated that items on the self-regulated learning questionnaire produce optimal information in individuals with moderate (θ) ability. Self-regulated learning questionnaires can be revised and then tested on different sample groups. Longitudinal and cross-sectional research is needed to determine the level of self-regulated learning of students more comprehensively.

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APPENDIX A: Research Instruments for Student Self-Regulation Survey

Student Self-Regulation Survey

Learning, both online and offline, is a regular activity for students. Whether we realize it or not, a person will regulate himself when learning. This self-regulation questionnaire serves to find out how students understand the skills, abilities, and willingness to regulate themselves in achieving learning goals. Your response, as a student, will help us in understanding how to design appropriate learning activities from the point of view of the learning subject. The results of this questionnaire will have no effect on your study score. Your personal data will be kept confidential. Your participation is voluntary and truly portraying yourself will help us tremendously. If you agree to complete this questionnaire, please select (√) Yes in the field below. Next, you can fill out your biodata and questionnaire.

☐ ☐ **Do you agree to take this survey?** Yes No

Biodata
Name : _____
Students Number : _____
Year : _____

Instructions
Determine your self-regulation by choosing the appropriate option to describe yourself in the column provided!
1= strongly disagree with the statement
2= disagree with the statement
3= agree with the statement
4= strongly agree with the statement

Questions

No	It is important for me to have a record of every lecture activity.					
1	Strongly disagree	1 ○	2 ○	3 ○	4 ○	strongly agree
2	It's not my type to figure out which points are important to each lesson, letting the learning material flow is better.					

	Strongly disagree	1 ◯	2 ◯	3 ◯	4 ◯	strongly agree
3	I can find at least one important point during a friend's presentation or discussion activity.					
	Strongly disagree	1 ◯	2 ◯	3 ◯	4 ◯	strongly agree
4	I just follow every lecture in the hope that later I will understand myself.					
	Strongly disagree	1 ◯	2 ◯	3 ◯	4 ◯	strongly agree
5	When facing exams, I often try to predict the questions that will come out.					
	Strongly disagree	1 ◯	2 ◯	3 ◯	4 ◯	strongly agree
6	I always feel ready to face the exam.					
	Strongly disagree	1 ◯	2 ◯	3 ◯	4 ◯	strongly agree
7	I am always enthusiastic about all courses.					
	Strongly disagree	1 ◯	2 ◯	3 ◯	4 ◯	strongly agree

8	I am the kind of person who always focuses on what I'm doing.					
	Strongly disagree	1 ○	2 ○	3 ○	4 ○	strongly agree
9	If I don't understand a certain material, I will ask a friend to explain again.					
	Strongly disagree	1 ○	2 ○	3 ○	4 ○	strongly agree
10	Setting a schedule is the most important way I do tasks.					
	Strongly disagree	1 ○	2 ○	3 ○	4 ○	strongly agree
11	I often reflect back on whether or not I understand today's lecture material.					
	Strongly disagree	1 ○	2 ○	3 ○	4 ○	strongly agree
12	I always encourage myself that I can.					
	Strongly disagree	1 ○	2 ○	3 ○	4 ○	strongly agree