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Profile of Genetic Concepts Understanding for 9th Junior High School

Bhian Ananda Javanica Rubiyanto[1*], Puguh Karyanto[1], Bowo Sugiharto[1]

[1]Department of Biology Education, Faculty of Teacher Training and Education, Sebelas Maret University, Indonesia.

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Corresponding Author:
Bhian Ananda Javanica Rubiyanto
bhian.anandajr@student.uns.ac.id

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Abstract: This research aims to analyze the understanding of students' concepts in 9th grade junior high school on genetic material. Mastery of concepts is one of the important aims in the process of learning biology. In this research, it is used case study method with the research design pretest only one group design. The number of samples is 50 9th grade students consisting of 35 female students and 15 male students. The average of sample is 14--15 years old. The research instruments consist of 15 multiple choice questions on genetic material. The results show that the understanding of the concept of most of the students is about -0.19 logit. There are differences in mastering the concept of understanding between male and female students at certain concepts. It is used the Rasch model that can explain well the profile of students' conceptual understanding using output table 3.1 summary statistics: reliability person and separation person. Response patterns are known from person fit and scalogram table, as well as output table 30. Item: dif, between/within is applied to detect question bias both genders. The results of profile in understanding the concept of biology learning on genetic concepts require further researches to be able to improve the learning process so as to elevate the understanding of genetic concepts for 9th grade junior high school students.

Keywords: Understanding genetics; Misconceptions; Rasch model analysis

Introduction

Education in the 21st century is the main focus in ensuring the quality of students having skills and abilities. Based on the 26-nations-consortium results in 2013, it formulates a product that can change the paradigm of science standards known as the Next Generation Science Standard (NGSS). The NGSS Lead States states that to increase the success of *Science, Technology, Engineering, and Mathematics* (STEM) by students, it is needed a clear standard description or a minimum framework must be achieved by students in studying the science (Inc., 2013).

Biology is part of science, then what applies in science, it applies in biology. Coley et al. (2012) define biology learning as a branch of science whose object of study contains scientific conceptions derived from phenomenal trends regarding the life of living things and the interactions. One of the learning objectives in biology is that students are able to understand interrelated biological concepts. An important foundation in studying biology is that when students have understood the concepts and can formulate applied principles (Çimer, 2012; Reinke et al., 2019). In the development of the biology learning paradigm, learning is seen as a process of forming and understanding the concepts. If the learning process aims or expects forming and understanding of concepts to students, learning must be designed well, namely learning emphasizing the thinking process (Haskel-Ittah et al., 2018). The thinking process is used as a tool to understand concepts and solve problems. The concept understanding is a reflection of the thinking process, so that understanding the concept and the thought process is a unified whole that cannot be separated.

Students who have a complete and intact understanding of basic concepts can develop and understand more complex concepts. Influencing the learning success of students later (Ghazali et al., 2014). Students' understanding of concepts can be used to solve problems related to the concepts being studied or as a basis for studying other interrelated concepts.

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Understanding the concepts possessed by students can be implied to solve problems about the studied concepts, as well as a base to study other interrelated concepts. Meanwhile, the lack of concepts understanding for students can lead to misconceptions or failure to construct concepts, even misunderstanding the concepts. This condition causes students' learning outcomes to not develop optimally (Özarslan et al., 2018). The recent educational research examines the problem of misconceptions that often occurs in biology learning and become a major problem for students today (Galvin et al., 2015; Sugawara et al., 2014).

The concepts of genetics as one of the materials in biology learning should be presented entirely and the relationships of concepts is presented clearly. In fact, genetic material is explained as abstract so it is difficult to understand (Cesarini et al., 2017). The results of research about understanding genetic concepts by students after learning according to Altunoğlu et al. (2015), includes: after learning genetic concepts is not immediately understood correctly; genetic knowledge in class failed to be understood critically by students. According to Kiliç et al. (2014), students tend to learn genetics by rote and may not realise the interrelationships in daily life and do not reconstruct their thought after learning genetics.

The genetic learning process should be designed intentionally and programmed to empower students' thinking abilities. Students who are able to deconstruct and reconstruct their knowledge using critical thinking and logical reasoning will experience less misconceptions about concepts. Through critical thinking and logical reasoning, concepts mastery can be improved even if high quality instruction is given. Mioković et al. (2012) stated that the forming of the concept of knowledge at the beginning of previous learning is a big key of processing new information in learning new concepts. Based on Mioković et al. (2012), students' initial knowledge becomes recipients of new genetic information/concepts, but their initial knowledge cannot be separated from misconceptions. It is considered as scientific concept, then it is what is referred to as the perceptual factor causing misunderstanding.

Misconceptions can be obtained from the previous learning process and continue until receive or understand new information (Duman, 2018). According to Etobro et al. (2017), if students have the correct prior knowledge or they are free from misconceptions, students can accept new information or knowledge.

The finding results of the Focus Group Discussion (FGD) with science teachers in Surakarta is the teachers have difficulty when teaching difficult concepts such as genetic material. It happens because of several factors: teachers seldom evaluate the genetic learning every year; the learning resources are limited to textbooks provided by the government; and there are misconceptions about questions or assignments given by teachers.

Based on the explanation above, the research is conducted to reveal the profile of the initial concepts understanding of genetics occurred for students. The student profiles are based on the characteristics between male and female students. The research findings can be used as a source of knowledge for teachers regarding the importance of digging important information up about students' prior knowledge before having learning. The profile of the genetic concept understanding of 9th grade students can also be the base for determining what genetic concepts are the focus of attention so that there are no misconceptions in the learning of genetic concepts.

Method

This research uses descriptive approach. It uses a test to measure the genetic concepts understanding at the junior high school level in science subjects in grade 9. The data obtained are in the form of students' answer scores for each item. The research subjects are 50 students randomly consisting of 37 female students and 13 male students. The average sample is 14--15 years old. The research subjects have received genetic material taught by the Science teacher.

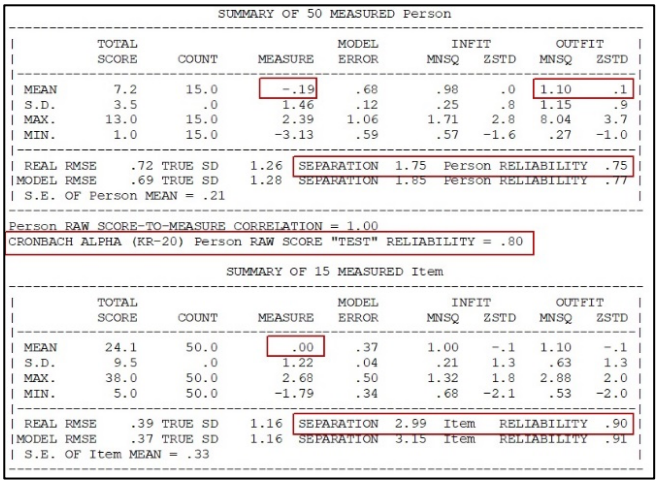
The instrument is in the form of 15 questions on genetic material for 9th grade junior high school by adopting competency standards from the K-13 curriculum with one of the international curriculum, Cambridge O-level. The materials competencies given are: 1) DNA structure; 2) inheritance of the nature of living things based on Mendel's law; and 3) heredity patterns in living things and humans. The data obtained will be analyzed using the Rasch model.

The using of the Rasch model is to help in analyzing more deeply about the profile of the ability to understand genetic concepts by looking at the output table 3.1 summary statistics: reliability person and separation person. The student's ability profile is measured based on several indicators, they are the student's ability analysis by looking at *the person measure* appropriate with the Rasch model and the response pattern with the *scalogram*. The quality of each item is further identified based on the gender differences using the output features of the rasch model application winsteps.

Result and Discussion

Figure 1 shows that the logit score of the person measure is -0.19 and the logit score of the item measure is 0.0. It means that the person measure score is smaller than the item measure. It can be stated that the ability of

students tends to be lower than the level of difficulty of the questions. In other words, it is possible that some items are difficult to be answered correctly. Therefore, students who have the highest ability are less likely to be able to answer the most difficult questions correctly. Meanwhile, Person's Reliability is 0.75 and Cronbach's Alpha is 0.80. The reliability score can be affected by the number of samples used quite a lot (N = 50). Based the score, the level of consistency of answers from the students is quite high and the quality of the items on the test instrument has very good reliability of 0.90. Based on the score from Cronbach's Alpha, it shows the interaction between person and item overall is good at 0.80.



SUMMARY OF 50 MEASURED Person

	TOTAL SCORE	COUNT	MEASURE	MODEL ERROR	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD
MEAN	7.2	15.0	-.19	.68	.98	.0	1.10	.1
S.D.	3.5	.0	1.46	.12	.25	.8	1.15	.9
MAX.	13.0	15.0	2.39	1.06	1.71	2.8	8.04	3.7
MIN.	1.0	15.0	-3.13	.59	.57	-1.6	.27	-1.0

REAL RMSE .72	TRUE SD 1.26	SEPARATION 1.75	Person RELIABILITY .75		
MODEL RMSE .69	TRUE SD 1.28	SEPARATION 1.85	Person RELIABILITY .77		
S.E. OF Person MEAN = .21					

Person RAW SCORE-TO-MEASURE CORRELATION = 1.00

CRONBACH ALPHA (KR-20) Person RAW SCORE "TEST" RELIABILITY = .80

SUMMARY OF 15 MEASURED Item

	TOTAL SCORE	COUNT	MEASURE	MODEL ERROR	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD
MEAN	24.1	50.0	.00	.37	1.00	-.1	1.10	-.1
S.D.	9.5	.0	1.22	.04	.21	1.3	.63	1.3
MAX.	38.0	50.0	2.68	.50	1.32	1.8	2.88	2.0
MIN.	5.0	50.0	-1.79	.34	.68	-2.1	.53	-2.0

REAL RMSE .39	TRUE SD 1.16	SEPARATION 2.99	Item RELIABILITY .90		
MODEL RMSE .37	TRUE SD 1.16	SEPARATION 3.15	Item RELIABILITY .91		
S.E. OF Item MEAN = .33					

Figure 1. Summary statistics

Table1. The Result of Summary Statistics

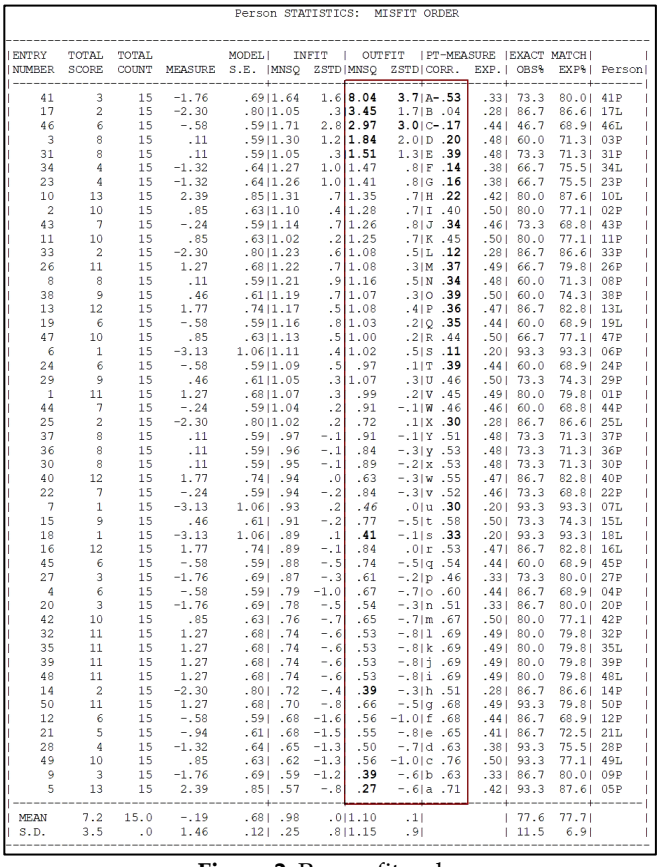
	Information	Score
Logit Measure	Person	-0.19
	Item	0.00
Reliability	Person	0.75 (enough)
	Item	0.90 (very good)
	Alpha Cronbach	0.80 (good)
Outfit MNSQ	Person	1.10
	Item	1.10
Outfit ZNSTD	Person	0.10
	Item	-0.10

Another quantity shown in table 1 is the Outfit Mean Squared (OutfitMNSQ) score of 1.10 both the person and item columns. The logit score of 1.10 is included in the fit criteria, between 0.5 < MNSQ < 1.50, meaning that the ability of students and the instrument used is in accordance with the model applied to measure the ability to understand the genetics of 9th grade junior high school students. Moreover, the standardized Z outfit score (ZSTD) is 0.10 logit on the person and -0.10 logit on the item. Both logit scores are between -2.0<ZSTD<2.0, meaning that the data have possible rational score.

The score of separation person shows that the response distribution is good. This is conveyed by (Sumintono et al., 2016) that the greater the separation score, the quality of the instrument in terms of overall respondents and items is better, because it can identify groups of respondents and items clearly. Here is the formula for calculating the Separation value, as equation 1.

$$H= [(4xSEPARATION) +1]/3 \quad (1)$$

The score of Separation person is 1.75, then the score of H = [(4x1.75)+1]/3=2.67. If it is rounded up to 3 which means there are three groups of students who can be identified as groups representing high, medium, and low so the data is quite heterogeneous. Mapping students' abilities can detect different or inappropriate response patterns. The purpose of the different response patterns is the discrepancy of the answers given based on their abilities compared to the ideal model. Figure 2 shows the output table 6. Person Fit Order is to determine the incompatibility level with the model.



Person STATISTICS: MISFIT ORDER

ENTRY NUMBER	TOTAL SCORE	TOTAL COUNT	MEASURE	MODEL S.E.	INFIT MNSQ	INFIT ZSTD	OUTFIT MNSQ	OUTFIT ZSTD	PT-MEASURE CORR.	PT-MEASURE EXP.	EXACT MATCH OBS%	EXACT MATCH EXP%	Person
41	3	15	-1.76	.69	1.64	1.6	**8.04**	**3.7**	A -.53	.33	73.3	80.0	41P
17	2	15	-2.30	.80	1.05	.3	**3.45**	1.7	B .04	.28	86.7	86.6	17L
46	6	15	-.58	.59	1.71	2.8	**2.97**	**3.0**	C -.17	.44	46.7	68.9	46L
3	8	15	.11	.59	1.30	1.2	**1.84**	2.0	D .20	.48	60.0	71.3	03P
31	8	15	.11	.59	1.05	.3	**1.51**	1.3	E .39	.48	73.3	71.3	31P
34	4	15	-1.32	.64	1.27	1.0	1.47	.8	F .14	.38	66.7	75.5	34L
23	4	15	-1.32	.64	1.26	1.0	1.41	.8	G .16	.38	66.7	75.5	23P
10	13	15	2.39	.85	1.31	.7	1.35	.7	H .22	.42	80.0	87.6	10L
2	10	15	.85	.63	1.10	.4	1.28	.7	I .40	.50	80.0	77.1	02P
43	7	15	-.24	.59	1.14	.7	1.26	.8	J .34	.46	73.3	68.8	43P
11	10	15	.85	.63	1.02	.2	1.25	.7	K .45	.50	80.0	77.1	11P
33	2	15	-2.30	.80	1.23	.6	1.08	.5	L .12	.28	86.7	86.6	33P
26	11	15	1.27	.68	1.22	.7	1.08	.3	M .37	.49	66.7	79.8	26P
8	8	15	.11	.59	1.21	.9	1.16	.5	N .34	.48	60.0	71.3	08P
38	9	15	.46	.61	1.19	.7	1.07	.3	O .39	.50	60.0	74.3	38P
13	12	15	1.77	.74	1.17	.5	1.08	.4	P .36	.47	86.7	82.8	13L
19	6	15	-.58	.59	1.16	.8	1.03	.2	Q .35	.44	60.0	68.9	19L
47	10	15	.85	.63	1.13	.5	1.00	.2	R .44	.50	66.7	77.1	47P
6	1	15	-3.13	1.06	1.11	.4	1.02	.5	S .11	.20	93.3	93.3	06P
24	6	15	-.58	.59	1.09	.5	.97	.1	T .39	.44	60.0	68.9	24P
29	9	15	.46	.61	1.05	.3	1.07	.3	U .46	.50	73.3	74.3	29P
1	11	15	1.27	.68	1.07	.3	.99	.2	V .45	.49	80.0	79.8	01P
44	7	15	-.24	.59	1.04	.2	.91	-.1	W .46	.46	60.0	68.8	44P
25	2	15	-2.30	.80	1.02	.2	.72	.1	X .30	.28	86.7	86.6	25L
37	8	15	.11	.59	.97	-.1	.91	-.1	Y .51	.48	73.3	71.3	37P
36	8	15	.11	.59	.96	-.1	.84	-.3	y .53	.48	73.3	71.3	36P
30	8	15	.11	.59	.95	-.1	.89	-.2	x .53	.48	73.3	71.3	30P
40	12	15	1.77	.74	.94	.0	.63	-.3	w .55	.47	86.7	82.8	40P
22	7	15	-.24	.59	.94	-.2	.84	-.3	v .52	.46	73.3	68.8	22P
7	1	15	-3.13	1.06	.93	.2	.46	.0	u .30	.20	93.3	93.3	07L
15	9	15	.46	.61	.91	-.2	.77	-.5	t .58	.50	73.3	74.3	15L
18	1	15	-3.13	1.06	.89	.1	.41	-.1	s .33	.20	93.3	93.3	18L
16	12	15	1.77	.74	.89	-.1	.84	.0	r .53	.47	86.7	82.8	16L
45	6	15	-.58	.59	.88	-.5	.74	-.5	q .54	.44	60.0	68.9	45P
27	3	15	-1.76	.69	.87	-.3	.61	-.2	p .46	.33	73.3	80.0	27P
4	6	15	-.58	.59	.79	-1.0	.67	-.7	o .60	.44	86.7	68.9	04P
20	3	15	-1.76	.69	.78	-.5	.54	-.3	n .51	.33	86.7	80.0	20P
42	10	15	.85	.63	.76	-.7	.65	-.7	m .67	.50	80.0	77.1	42P
32	11	15	1.27	.68	.74	-.6	.53	-.8	l .69	.49	80.0	79.8	32P
35	11	15	1.27	.68	.74	-.6	.53	-.8	k .69	.49	80.0	79.8	35L
39	11	15	1.27	.68	.74	-.6	.53	-.8	j .69	.49	80.0	79.8	39P
48	11	15	1.27	.68	.74	-.6	.53	-.8	i .69	.49	80.0	79.8	48L
14	2	15	-2.30	.80	.72	-.4	**.39**	-.3	h .51	.28	86.7	86.6	14P
50	11	15	1.27	.68	.70	-.8	.66	-.5	g .68	.49	93.3	79.8	50P
12	6	15	-.58	.59	.68	-1.6	.56	-1.0	f .68	.44	86.7	68.9	12P
21	5	15	-.94	.61	.68	-1.5	.55	-.8	e .65	.41	86.7	72.5	21L
28	4	15	-1.32	.64	.65	-1.3	.50	-.7	d .63	.38	93.3	75.5	28P
49	10	15	.85	.63	.62	-1.3	.56	-1.0	c .76	.50	93.3	77.1	49L
9	3	15	-1.76	.69	.59	-1.2	**.39**	-.6	b .63	.33	86.7	80.0	09P
5	13	15	2.39	.85	.57	-.8	**.27**	-.6	a .71	.42	93.3	87.6	05P
MEAN	7.2	15.0	-.19	.68	.98	.0	1.10	.1			77.6	77.7	
S.D.	3.5	.0	1.46	.12	.25	.8	1.15	.9			11.5	6.9	

Figure 2. Person fit order

Explanation of Figure 2 is the assessment criteria for the suitability of individual outliers or fit (ideal fit). Based on Figure 2, there are five students whose response patterns considered unfit, they are 41P, 17L, 46L, 03P, and 31P. The five students are outside the

accepted limits. Information on this unbiased response pattern can be seen at Figure 3.

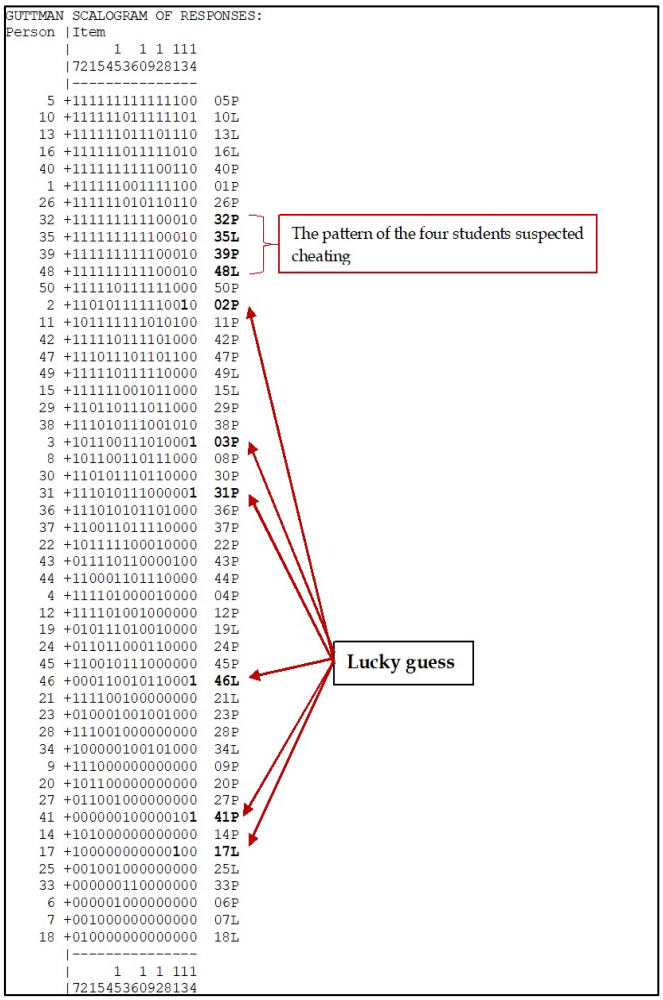


Figure 3. Scalogram responses

The five students (41P, 17L, 46L, 03P, and 31P) are detected by the lucky guess type, the participants can work on difficult questions beyond their abilities. Next, it is also found that 43P students are not careful, which question number 7 cannot be done correctly but he is able to do on question number 10. The same pattern is shown by students of 32P, 35L, 39P, and 48L. The pattern of the four students suspected cheating on each other saw the initial indication that their person logit score is 1.27.

Based on the graph in Figure 4, the researcher can evaluate the students' achievement on each item of the question. The item on the S1 item is biased between the achievements of male students and female students. S1 items contain the concept understanding of chromosomes in humans. This question is easier for female students to answer. Although these two groups of students are below 0.0 logit or lower than the average level of difficulty of the questions. Question items biased on the ability of female and male students are also found in S4, S5, S6, and S13 questions. Although the difference is not far, the mastery of the concept of female students is better than male students. Items for S4 are at the C2 (Factual) level and S13 are at the C5 (procedural) level, which are about understanding the concept of decreasing Mendelian trait disorders. Problem S5 is at level C2 (conceptual) about the concept of gene cross linked to the x chromosome. Then S6 is at the C2 (conceptual) level about the concept of multiple alleles in human blood groups. Furthermore, for the S3 item at the C1 level (factual), there is a bias from the ability to master genetic concepts in male students is better than female students because it is more than the logit score (0,0).

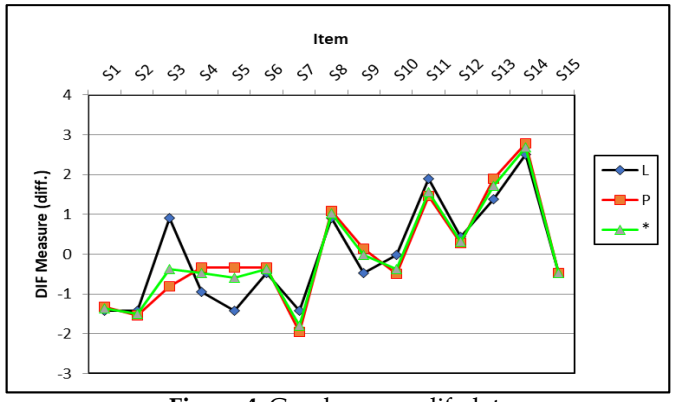


Figure 4. Graph person dif plot

The ability of male students and female students is the same on the S15 question. This one question has no bias for the two gender groups. The achievement of male and female students on the S15 question is –0.48 logit or is an easy question. Problem S15 is at level C5 (conceptual) about pariental gametes formed from dihybrid crosses containing the concept of gamete formation from dihybrid crosses. Meanwhile, the S14 question ability of the two groups of students is at logit above +2. Question S14 is at level C5 (procedural) about determining the decrease in color blindness linked to the X chromosome with the blood types combination. Differences in the ability of male and female students also happen in other questions. The ability of male students is higher than that of female students in S2, S10, S11, S12, and S14 questions.

S3, S8, S9, S11, S12, S13, and S14 questions are quite understood by students that the abilities of all students are above the average standard of difficulty. Meanwhile, S1, S4, S5, S6, S7, S10, and S15 questions are classified as difficult for students to understand that the abilities of all students are below the average standard of difficulty. Thus, gender factors need to be considered to provide treatment in the form of models/strategies/learning media in the learning process. A summary of the achievement of mastery of the concepts of female students and male students can be seen in the table 2.

Table 2. Mastery of Student Concept Understanding by Gender

Question Item Number	Result
S1	L<P
S2	L>P
S3	L>P
S4	L<P
S5	L<P
S6	L<P
S7	L>P
S8	L<P
S9	L<P
S10	L>P
S11	L>P
S12	L>P
S13	L<P
S14	L>P
S15	L=P

Based on Table 2, the achievement of mastery of understanding the concept of male students is higher than female students (L>P) totaling seven items: S2, S3, S7, S10, S11, S12, and S14. The achievement of mastery of understanding the concept of male students is as same as female students (L = P) totaling 1 question item, S15. The achievement of mastery of understanding the concept of male students is lower than female students (L<P) totaling 7 items: S1, S4, S5, S6, S8, S9, and S13.

From S14 ability male students is higher than female student (L>P), S14 discusses determining the genotype of the inheritance pattern of a case. The ability to work on evaluation questions is more mastered by male students, according to Baran, (2016) male students have the same attitude better than female students in terms of observing, processing data and concluding.

Based on the findings, the researcher recommends to add collaborative learning activities that are student oriented (student oriented). Students can be grouped heterogeneously (male and female) that female students can be assisted by male students who tend to be easier to understand and master certain parts of the concept. On the other hand, some parts of the concept are easier for female students to understand. Critical and logical reasoning in students' mastery of concepts can be improved even if they are given higher stage instructions (Safarati et al., 2022).

Yamtinah et al. (2017) explained that men's abilities can exceed women's abilities in terms of observation, control variables and determine conclusions, while the ability women exceed the ability of men in terms of conceptual knowledge and interpret the data. In terms of thinking styles and creativity, men's abilities exceed abilities women, this is because most women only use it memorization method to achieve academic success (Meric, 2014). Rodzalan et al. (2015) previously stated that men have better thinking skills than woman. But the results of this study are in line with the research of Celik (2014) which shows that thinking skills are male gender and female gender alike. Thinking skills are absolutely required by each person.

Their interest in learning will also experience changes that are influenced by developments and changes in the type of work they choose. Collins et al. (2010), Sudibjo et al. (2019), and Himmetoglu et al. (2021) explains that science and technology today have trends that move towards customization, interaction, and control from the users themselves. They added that technology will depend heavily on the speed of access to enable students to quickly obtain goals to provide learning space according to the type of learning they want.

One of the learning models which can optimize learning collaborative is a challenge-based learning model. The Challenge Based Learning (CBL) model is a collaborative learning based on learning experiences which students and teachers work together to learn from interesting and real problems, propose the solutions, and take the action. This approach asks for the students to reflect on what they have learned and publish their solutions to citizens of the world (Willis et al., 2017). CBL learning is effective to make students actively involved in the learning process and helping students understand concepts or learning materials (Nawawi, 2016). Challenge Based Learning is a learning that combines problem-based learning, learning project-based, and contextual learning. When faced with a challenge someone and the group will be successful in leveraging experience, leveraging internal and external resources, develop a plan and push to find the best solution (Fairazatunnisa et al., 2021).

According to El-Emadi et al. (2019) teacher support also increases the positive effect of student involvement. Given that women, generally speaking and especially in advanced classes, feel less competent than boys in science, the teacher's role is very important the learning and engagement of influential female students. Thus, the CBL learning model can be an alternative solution to elevate students' conceptual understanding.

Conclusion

The results of data analysis from the developed instrument can be used as empirical support to convey that the instrument for measuring the genetic concepts understanding of 9th grade junior high school students has good validity and reliability. It can be seen in the reliability score of Cronbach's alpha (KR-20) reaching 0.80 with person reliability in the sufficient category (0.75 logit). The result of the preliminary study is that the understanding of the genetic concept of junior high school students grade 9 is still low because the mean logit person is at -0.19 logit. So that further research is needed to improve understanding of the concept of genetic material for 9th grade junior high school

students. Mastery of students' concepts on genetic material as a whole based on the gender of male and female students, there are differences in understanding several concepts. The limited understanding of genetic concepts experienced by 9th grade junior high school students needs to be improved in the learning process. One of the models facilitating learner-centered learning by looking at the understanding profiles of male and female students to be brought into challenge based collaborative learning is CBL.

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