Concept Learning of Regulation of Genetic Expression in Eukaryotes Using *Drosophila Melanogaster*

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Abstract: *Drosophila melanogaster* is one of the organisms that had been widely used as genetic model organism, including in Genetics lecture in Biology Department, Universitas Negeri Malang. Meanwhile, Genetics lecture in other universities in Malang were still not using *D. melanogaster* or any other model organism. Therefore, the learning processes were still lack of practical activities. Utilization of *D. melanogaster* in learning process is useful to increase student's activity and also to enhance their concept understanding. Eukaryotes Genetics Expression Regulation is one of the concepts studied in Genetics lecture. Expressed traits of *D. melanogaster* are also influenced by environmental conditions such as high temperature. The development of Genetics lecture module that includes the study of environmental effects on *D. melanogaster* trait expression can be done to enhance concept understanding on that topic. The module development had been done by *Four-D* model, and through the validation and small scale trial it was known to be valid with very good qualification. By the development of such module, learning process obstacles especially those that related to practical work because of learning resource unavailability in other universities can be solved.

Keywords: genetics lecture, regulation of genetic expression, *drosophila melanogaster*

Genetics Course is one of the subjects that must be taken by undergraduate students in Biology major. Various colleges programmed Genetics course in different semesters, with credits and hours per semester is also different according to the curriculum and policy of department at the college, as well as based on the graduate profile to generate. The profile of undergraduate program graduates on each college has been synchronized according to the Indonesian National Qualifications Framework (KKNI) arranged on PP No. 08 Year 2012. Based on KKNI levels, undergraduate students are at level 6. At that level, some of the criteria that have to be mastered are able to apply their expertise and take advantage of science and technology, mastering the concept of the field of knowledge in general. Specifically, they should be able to master theoretical concepts deeply and resolve procedural issues. Based on these criteria, it is clear that undergraduate students who have graduated from a course including genetics course, must master the theoretical aspects (the cognitive) and the application of these theories (skills or psychomotor).

The ideal learning allows students to be actively involved, both mentally and physically. Not only are the cognitive aspects developed, but also the skills of learners. Genetics lectures should be implemented by reviewing the material that refers to relevant learning resources, accompanied by appropriate practical activities to help students find and learn their own concepts. Through discovery learning, students will master the theories better because the concept could become stronger. Kolb (1984) also suggests that learning processes are based on experience (*experiential* learning). According to this theory, the experience (which may include certain skills) is the source of one's learning and development. In addition, the study is

emphasizing on the process undertaken in learning activities, not only assessed on the basis of learning outcomes.

Based on observations at several universities in Malang, Genetics lab activities that utilize the *D. melanogaster* have not been done. Practical works that utilize *D. melanogaster* to study new genetic concepts had been implemented in the Department of Biology, Universitas Negeri Malang (UM). In Biology Department of UM, Genetics practical works is divided into the classical style and 16 kinds of practical projects. Practical projects are done by involving small groups consisting of two students. The project takes one semester and carried out independently by the student along with some consultations with the lecturer / assistant ranging from the preparation of the procedure, research methods, data collection, preparation of reports, until the classical seminar of research reports. Nevertheless, it seems that the practical projects using *D. melanogaster* still not been carried out in other universities in Malang because of some limitations. These limitations exist with regard to the absence of practical activities in the curriculum and in the absence of learning resources that support the practical implementation.

The absence of practical activities utilizes the *D. melanogaster* in the lecture Genetics certainly very unfortunate. As a genetic model organism, *D.melanogaster* had enormous potency to examine the concepts of genetics. *D. melanogaster* has been widely investigated so that information regarding to its genetic profile, development, behavior, physiology or ecology is very easy to obtain (Markow and Grady, 2006). D. melanogaster has an assortment of mutant strains other than the wild-type, for example, mutant white (white eye color) and ebony (black body color) which are easily identified (Chyb and Gompel, 2012). D. melanogaster is also quick to breed, easily maintained in a simple culture media, and abel to produce many offspring so it is suitable to be reproducing organism for genetic studies (Demerec and Kaufman, 1996). The results or findings of experimental research that utilizes the *D. melanogaster* are therefore useful for ensuring a source of learning theories related.

As well as other living things, the expression of *D. melanogaster* characteristics is determined by genotype and environmental factors (Vieira et al., 1999; Mackay and Anholt, 2007). Related to environmental factors that influence the expression of *D. melanogaster* characteristics, high temperatures have been associated with the expression of fecundity and development time of *D. melanogaster*. Fecundity is a female individual's ability to produce eggs that survive to adult phase (Lazzaro et al., 2008). The decline in fecundity has been reported in *D. melanogaster* that was cultured at extreme temperatures (Krebs and Loeschcke, 1994; Huey et al., 1995; Dillon et al., 2007).

D. melanogaster has a life cycle consisting of egg, larva, pupa, until the imago phases (Demerec and Kaufman, 1996). The time required to complete the life cycle is defined as development time. Chyb and Gompel (2012) states that *D.melanogaster* development time can vary up to a few days because of the influence of environmental temperature. Time development of *D. melanogaster* has been reported to occur more rapidly in high temperature environment (Dillon et al., 2007). Exposure to high temperatures in the *D. melanogaster* can be given for several generations to determine the effect more clearly and also to know the tendency of thermal adaptation (Huang et al., 2007; Gilchrist et al., 1996; Dillon et al., 2007).

The findings of the study revealed the influence of environmental factors such as high temperature on the expression of *D. melanogaster* characteristics can be associated with one of the Genetics subject material, namely Regulation of Genetic Expression in Eukaryotes. Referring to the syllabus and lecture plan of Genetics II, Biology Department UM, Regulation of Genetic Expression in Eukaryotes studied to achieve the basic competency 7.1 i.e. understanding the events of regulation of gene expression in eukaryotes. Indicators of that basic competency are students are able to explain the role of environmental factors in the regulation of gene expression in eukaryotes. The results also associated with basic competency in the area

of skills, namely basic competency 13.1: understanding some of the genetic theory through practical application / research project. The effects of high temperatures on the expression of fecundity and development time on *D. melanogaster* can thus be used as a basis for the preparation of learning resources that support the development of cognitive and skills among students.

Learning resource is anything that can be used for learning. Learning resources are not limited to books, but include all the information contained in the various forms of media. Learning resources can also be people, objects, messages, materials, techniques, and background (Liandiani, 2008). According to Wisdom and Gibbs (1994), learning resources are divided into four kinds, including learning resources that teach the lesson content, learning resources that are build another source, learning resources that support learning activities, and learning resources that support learning. One of those learning resources is module. Module is a unit of a planned learning program, which is designed to help students achieve the learning objectives. Learning packages contained in the module is self-contained and self-instruction, so that they can act as self-learning material (Hernawan et al., 2012).

Thus, the experimental research that utilizes *the D. melanogaster*, especially on the topic of the influence of environmental temperature on the expression *D. melanogaster* characteristics can be used as the basis for learning resources Genetics lectures at universities. With the learning resources based on the results of research, universities that still require teaching materials incorporating Genetics lab activity guide will also be helped.

RESEARCH METHOD

The learning module had been developed based on the result of experimental research on the effects of high temperature on fecundity, developmental time, and sex ratio of *D. melanogaster* for several generations (Sukmawati et.al. 2016). Module development was done by *Four D* model from Thiagarrajan (1974). Due to the limitation of research, it was done at three steps including *Define*, *Design*, and *Develop*.

Define

Define stage was carried out to define the needs of Genetics lecture based on the necessity analysis conducted in Universities in Malang. The necessity analysis includes the front-end analysis, learner analysis, task analysis, concept analysis, and specifying instructional objectives.

Design

This stage was carried out by designing the module based on the basic competence stated in the syllabus. Preparation of the module is based on the appropriate format. In this development model, the format used was mastery-learning format, in this case the module format.

Develop

This stage was carried out by developing the module, testing the validity by experts and small scale trial. The experts who validate the module were two lecturers as Genetics experts, and a lecturer as learning resource development expert. The small scale trial involve 10 students of Biology Department, UM who have had studied Genetics course.

The validation by experts and students are conducted using validation instrument consisting some indicators. The comments of those validations were analyzed descriptively. The validation results were scores calculated by the following equation:

$$P = \frac{\sum x}{\sum xi} \times 100\%$$

Where:

P = Validity percentage

$\sum_x$ = Total sum of whole answer score per *item*

$\sum_x$ = Total sum of maximum score per *item*

Furthermore, the meaning and decision making of the modules quality were done according to Table 1 as follows.

Table 1: Criteria of Module Development Achievement

Level of Achievement	Qualifications	Decision
>80%	Very good	No revision
70% – 80%	Good	No Revision
60% – 69%	Adequate	Revision
50% – 59%	Inadequate	Revision
<50%	Very Inadequate	Revision

(Source: Akbar, 2013)

RESEARCH RESULTS AND DISCUSSION

The result of Define stage was information acquired from front-end analysis, learner analysis, task analysis, concept analysis, and specifying instructional objectives.

1. ***Front end analysis*** showed that one of the Basic Competence in Genetics Lecture is to understand the concept of Regulation of Genetic Expression in Eukaryotes, and to understand the theory through practical work. But in other Universities in Malang, there were no practical work and *D. melanogaster* were not used due to limitation of facilities and the absence of practical work guidelines**.**
2. Learners analysis showed that the students were able to do independent learning activities, but were still needed some guidance in practical activities.
3. Task analysis reveals the learning outcomes stated in the Semester Lecture Plan.
4. Concept analysis showed that the concept related to the Regulation of Genetic Expression in Eukaryotes. The result of experimental result could enhance the concept of *"Biological and Environmental Factors Role on the Regulation of Genetic Expression in Eukaryotes".*
5. Specifying instructional objectives reveal that the objective of the module was to make the students understand the concept of Regulation of Genetic Expression in Eukaryotes and its application in practical work.

The design of the module was as follows:

1. Front Cover
2. Content List
3. Introduction
4. Module General Guide
5. Map of Basic Competence, Indicator, Learning Experience, and Concepts
6. Learning activities 1-4 (research result integrated in learning activity 2, practical work guidelines available on learning activity 4)
7. References
8. Appendix

The development of the module contains expert appraisals and small scale trial. Quantitative descriptive analysis was conducted to determine the validity percentage of module developed according to expert of learning resource development. The analysis is based on expert or validator assessment of the 18 aspects. Scores from each of these aspects are summarized in Table 2.

Table 2: Assessment of Module by Learning Resource Development Expert

No	Aspek Penilaian	Maximum Score	Module Score
1	Title	16	15
2	Preface	12	12
3	Content List	8	7
4	Introduction	20	20
5	Module Guide	8	8
6	Material	8	8
7	Basic Competence	8	8
8	Indicator	8	8
9	Learning Objectives	12	12
10	Main Concepts	28	26
11	Practical Activity	16	16
12	Summary	8	8
13	Formative Tests	12	11
14	Feedbacks and Follow Ups	12	12
15	Practical Guidelines	24	24
16	Answer Keys	12	12
17	Reference	8	8
18	Module Graphics	40	33
	Total Score	**260**	**248**

From the result, validity percentage could be calculated as follows.

$$P = \frac{\sum score\ of\ all\ answers\ per\ item}{total\ of\ maximum\ score\ per\ item} \text{ x } 100\%$$

$$= \frac{248}{260} \text{ x } 100\% = 95,38\%$$

Through these calculations, it is known that the results of the module development have reached the validity percentage of 95.38%. The percentage has been higher than 80%, so that according to Akbar (2013), the module had met the criteria of very good qualification and do not need revision.

The validation by Genetics experts was done according to 9 aspects. The score of those aspects could be seen in Table 3

Table 3: Assessment of Module by Genetics Expert

No	Scoring Aspects	Maximum Score	Scoring by Validators		Total of Module Score
			Expert I	Expert II	
1	Material Scope	16	15	16	31
2	Material Accuracy	16	14	15	29
3	Material Novelty	12	12	12	24
4	Module Format According to Material	8	5	8	13
5	Material Presentation	16	15	14	29
6	Summary	8	8	8	16
7	Formative Tests	8	8	8	16

8	Formative Tests Answer Keys	8	7	8	15
9	References	8	8	8	16
	Total Score	100	92	97	189
	Total of Maximum Score (x2)	200			

From the result, validity percentage could be calculated as follows.

$$P = \frac{\sum score\ of\ all\ answers\ per\ item}{total\ of\ maximum\ score\ per\ item} \times 100\%$$
$$= \frac{189}{200} \times 100\% = 94{,}5\%$$

Through these calculations, it is known that the results of the module development have reached the validity percentage of 94.5%. The percentage has been higher than 80%, so that according to Akbar (2013), the module had met the criteria of very good qualification and do not need revision.

From the small scale trial, 10 students were giving their comments on the module. Most of them were giving comments about the cover layout, font type, and contrasts of the pictures. Module scoring was based on the criteria: ease of use, clearance and helpfulness of material and practical guide, language, and the attractiveness of module layouts. In detain, the assessment of those aspects can be seen in Table 4.

Table 4: Module Assessment by Students

No	Assessment Indicators	Respondent's Scores										Total Score	Maximum Score
		1	2	3	4	5	6	7	8	9	10		
1	The material contained in the module is easily understood	4	3	3	3	3	3	4	4	3	3	33	40
2	The learning guide makes you easier to study the module	4	4	4	3	3	3	3	4	4	3	35	40
3	The material help you to understand the concept of genetic expression	4	4	4	3	4	3	4	3	3	4	36	40
4	The practical work empower you to be actively involved in learning process	4	4	3	4	3	3	4	4	4	4	37	40
5	The material is suitable for undergraduate program students	4	4	4	4	4	3	4	4	4	3	38	40
6	The illustrations is appropriate to the material	4	3	4	4	4	4	4	3	4	4	38	40
7	The sentences are operational and ease the concept understanding	3	3	4	3	4	4	3	3	4	4	35	40
8	Usage of terms are consistent	4	4	3	3	3	3	4	3	4	3	34	40
9	The language is communicative and easy to read	4	4	3	3	3	4	3	4	3	3	34	40
10	The references are relevant and valid	4	4	3	4	4	4	3	4	4	4	38	40
11	Module lay out is attractive	3	3	3	3	4	4	4	3	3	2	32	40
12	The assignments are related to the topic	4	4	4	3	3	4	4	4	4	3	37	40
13	The module could enhance the knowledge on Genetics course, especially in Genetic Expression	4	4	4	3	4	4	4	4	4	3	38	40
14	The module could be used as independent learning resource.	4	4	4	4	3	4	4	4	4	3	38	40

Total Score	**503**	**560**

From those aspects, the validity percentage of module calculation is as follows.

$$P = \frac{\sum score\ of\ all\ answers\ per\ item}{total\ of\ maximum\ score\ per\ item} \times 100\%$$

$$P = \frac{503}{560} \times 100\% = 89{,}82\%$$

Through these calculations, it is known that the results of the module development has reached the validity percentage of 89, 82%. The percentage has been higher than 80%, so that according to Akbar (2013), the module had met the criteria of very good qualification and do not need revision.

The printed module developed was on the topic Regulation of Genetic Expression in Eukaryotes. The scope of these materials include molecular control of the levels of gene expression in eukaryotes, namely transcription, post-transcription, and translation; the role of biological and environmental factors in influencing the regulation of gene expression; and the relationship between gene expression and chromatin organization. Research result on the influence of environmental temperature on fecundity and the development time *D. melanogaster* can support these concepts, especially with regard to the role of environmental factors in the regulation of gene expression. Through the support of these findings, it was expected that the topic Regulation of Genetic Expression in Eukaryotes can be more contextual.

Information regarding to the procedural research techniques is also useful in the development of the module. The procedure that had been done in revealing the influence of environmental temperature on *D. melanogaster* characteristics can be used to draw up a roadmap on practical works in learning modules. With the feature of such practical instructions on the module, module development is also useful to facilitate students who take a Genetics course in the Biology Department of other universities that have not implemented such a pattern lectures at the UM.

CONCLUSION

From the research result, it could be concluded that:

1. Genetics Module on the topic "Regulation of Genetic Expression in Eukaryotes" could facilitate students to learn the topic and implement it on practical work.
2. By the validation and small scale trial, the module was known to be valid with very good qualification.
3. It is recommended to other researchers that have interest in Genetics teaching and learning to implement the module on real Genetics learning activities and analyze its effectiveness.

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