



Drosophila melanogaster utilization in genetics lectures: Innovations that need to be optimized

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Abstract

Drosophila melanogaster is a popular model organism that plays a role in the development of Genetics research and learning. The purpose of this study was to map Genetics lecture activities in Indonesia based on the utilization of *Drosophila melanogaster* during practicum activities. The data was collected using Google Form-based questionnaire analyzed using descriptive statistical analysis. A total of 113 alumni from 39 universities in Indonesia were involved as participants. The results informed that 77% of institutions had conducted Genetic Practicums and more than half had used *Drosophila melanogaster*. However, optimizing the use of these organisms in learning needs to be improved because the use of *Drosophila melanogaster* is still limited to morphological, chromosome, life cycle, and inheritance pattern observations.



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1. INTRODUCTION

Genetics provides a set of concepts related to all aspects of biology. Genetic understanding is also considered essential in solving various public problems, especially those related to health (Gittelman, 2016) and conservation (Byrne, 2018). Various malignant diseases, such as heart disease (Khera & Kathiresan, 2017), cancer (Wong & Xie, 2017), to AIDS (Boyce et al., 2019; Lambert, 2019) can be more easily explored through the application of molecular genetic techniques. The implementation of the concept and Genetic approach has also been used as a basis for overcoming problems in agriculture (Nadeem et al., 2018) and animal husbandry (Camargo & Miguel, 2019).

Interestingly, genetics is known to be the most difficult biological concept to learn and teach (Morris, 2018). The abstractness of various Genetic concepts is considered to be one of the main reasons why Genetics is difficult to understand by students (Fauzi & Fariantika, 2018). The problem is, many educational institutions in Indonesia teach Genetics just based on theoretical explanations. Lectures that

are only based on expository method will further complicate students' understanding of abstract concepts. Conversely, practicum-based learning is still found in a few institutions (Fauzi & Ramadani, 2017).

In connection with practicum activities, living organisms can be used as educational tools in the learning process, one of which is *Drosophila melanogaster*. *Drosophila melanogaster* is one of the most popular model organisms used by genealogy researchers (Lyu & Tonoki, 2019). This organism, commonly known as fruit fly, is an insect whose phase has a pair of wings and three pairs of legs (Tolwinski, 2017). Cheap culture costs, do not require much space, small chromosome number, fast generation time, and the number of strain variants strengthen the involvement of *Drosophila melanogaster* in basic research and education in various countries (Adedeji & Vicente-Crespo, 2017; Tolwinski, 2017). Therefore, the use of *Drosophila melanogaster* as a model organism in studying genetics is recommended to be implemented in higher education in Indonesia.

Actually, various studies aimed at improving the quality of genetic learning in Indonesia have been carried out. Several studies have tried to develop modules or learning resources that can improve the effectiveness of Genetic learning, such as the module based on the blue eyes phenomenon in Sulawesi (Slamet et al., 2019) until the use of electronic modules at Tribhuwana Tunggal University (Fidiastuti et al., 2021). In fact, there are also studies that have developed a module using *Drosophila melanogaster* to study the topic of regulation of genetic expression (Ramadani, 2018). Other studies have even studied the application of research-based learning that also uses *Drosophila melanogaster* in Genetics lectures (Fauzi & Ramadani, 2017). However, based on this information, no research has been found that attempts to map the existence of practicum activities, especially those involving *Drosophila melanogaster*. Therefore, the purpose of this research was to identify the existence of practicum activities in Genetics lectures in the biology department from various universities in Indonesia. Furthermore, information was also collected about the institutions that have utilized *Drosophila melanogaster* in their genetics practicum.

2. METHOD

This research was a survey research with quantitative approach. The participants of this study were alumni of Biology students from various universities in Indonesia. The instrument used was an online questionnaire through *Google Form*. The questionnaire consists of two parts: 1) the part that asks participants 'identities; and 2) the part that asks participants' learning experiences during take genetics course. Several aspects were asked in the questionnaire, namely (1) the subjects that were considered the most difficult during the undergraduate level; (2) the existence of Genetic Practicum; (3) the use of *Drosophila melanogaster* in the Genetic course; and (4) types of activities that utilize *Drosophila melanogaster* during practicum.



Figure 1. Distribution of the location of participant institutions (blue dots) involved in the study

There were 113 participants who responded to the questionnaire distributed. The overall participants were 39 Institution alumni from 29 cities in Indonesia. The distribution of participants'

institutional locations is presented in Figure 1. After the data was collected, data analysis was carried out. Descriptive statistics using percentage calculations were used as data analysis techniques in this study.

3. RESULTS AND DISCUSSION

Genetics is one of the compulsory courses taken by all biology students in many higher education institutions in Indonesia. Unfortunately, the results of this study inform that Genetics ranked first as the most difficult subject in the biology major (35%), followed by Statistics (22%), and Cell Biology (16%) (Figure 2). This finding confirms some previous reports in several other countries (Çimer, 2012; Morris, 2018). Several studies in Indonesia also reported that Genetics is a branch of biology that is difficult to learn by students, both school students (Mardin, 2017) and undergraduate students (Fauzi et al., 2021).

Several conditions can be positioned as the cause of why genetics is difficult to study. Several classical reasons have been identified by several researchers, such as the complexity of the concepts being studied (Fauzi et al., 2021) or the less optimal teaching competence possessed by the teachers (Grace, 2021). In addition to these classic reasons, several studies have also identified that the lack of appropriate learning aids is also the cause of the difficulty in understanding genetics (Grace, 2021; Haambokoma, 2007). The lack of such learning facilities actually needs to be followed up by implementing learning that can help students imagine genetic concepts or phenomena, such as practicum-based learning.

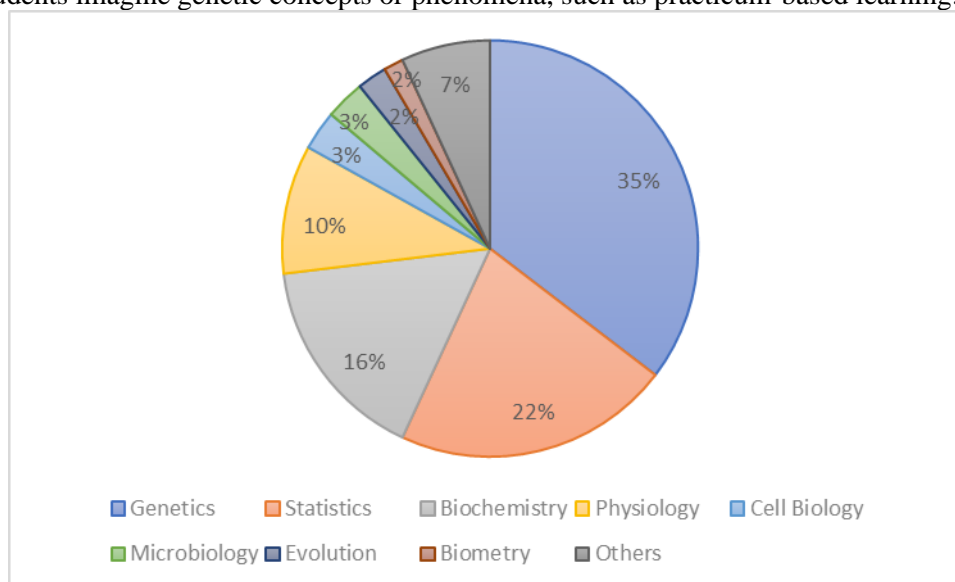


Figure 2. The most difficult subjects chosen by alumni of undergraduate Biology students (n = 113 students)

Based on the finding of this present study, from 39 institutions, there were 30 institutions that reportedly conducted practicum in their genetic lectures (Table 1). The existence of practicum activities is a crucial component in learning various biological concepts. Practicum activities will help students to concretize concepts that were originally abstract. Abstract concepts are one of the main factors causing a concept to be difficult to understand and learn (Çimer, 2012). Not surprisingly, the existence of practicum activities in learning can improve students' biology learning outcomes (Ramadhan & Suyanto, 2020).

Table 1. Existence of Genetic Practicum activities in 39 institutions

No	Practicum activity	Institution number	Percentage (%)
1	Practicum activity	30	
	a. Utilizing <i>Drosophila</i>	16	77
	b. Did not utilize <i>Drosophila</i>	14	
2	Did not held practicum activity	9	23
	Total	39	100

Of the 30 institutions that carry out genetic practices, 16 institutions have utilized *Drosophila*. Although it has not yet been used massively in all institutions, this information includes positive findings.

These findings indicate that various institutions have realized the importance of introducing *Drosophila* as an essential model organism in Genetics to their students. This attempt is important considering that *Drosophila* is one of the main model organisms that has contributed to the development of Genetics to date (Allocca et al., 2018; Lyu & Tonoki, 2019).

Furthermore, based on Figure 3, *Drosophila melanogaster* is often used as a model organism in studying patterns of inheritance. Learning the pattern of inheritance is the first use of *Drosophila melanogaster* in the history of genetic development (Fauzi & Corebima, 2016). Thomas Hunt Morgan was the first geneticist who used *Drosophila melanogaster* to uncover various inheritance phenomena (Tolwinski, 2017). The crossing patterns used by Morgan in his research were later adopted as basic procedures in practicum activities in several educational institutions (Fauzi & Ramadani, 2017).

Drosophila melanogaster is appropriate to study the inheritance pattern contextually because this insect has a fast generation time (Tolwinski, 2017; Yamaguchi & Yoshida, 2018). With fast generation times, students do not have to wait up to a semester to analyze the inheritance patterns of the traits they learn. The use of *Drosophila melanogaster* in this topic can empower students' higher-order thinking skills and improve their understanding of the molecular basis of inheritance patterns. (Marshall, 2008). Another publication states that by ensuring that the flies crossed are still virgins, students can not only learn patterns of inheritance but can also improve their research skills (Venema, 2006). By positioning *Drosophila melanogaster* as a research subject in studying genetics, students' attitudes toward science are also reported to have increased (Intra & Pasini, 2016).

Beside inheritance pattern observation, some institutions only direct students to observe the morphological structure and life cycle of *Drosophila melanogaster*. Both of these activities are only intended to introduce this organism to students. Regarding to the fast generation time (Tolwinski, 2017; Yamaguchi & Yoshida, 2018) and the presence of many strain variants (Chyb & Gompel, 2013; Wangler et al., 2017) of this organism, the utilization of *Drosophila melanogaster* in genetics course should be more optimized.

Actually, the study of molecular aspects of *Drosophila melanogaster* also has great potential to be applied in Genetics course in Indonesia. Indeed, a small number of institutions have used *Drosophila melanogaster* to teach students the concept of molecular genetics. However, practicum activities aimed at learning the concept of molecular genetics are still limited to observing giant chromosomes (Figure 3). Giant chromosomes are large chromosomes due to the high rate of DNA replication in the salivary glands of third instar *Drosophila melanogaster* larvae (Lewin, 2008; Snustad & Simmons, 2012). If lecturers can explore more the potential of *Drosophila melanogaster*, various practicum activities that utilize this organism will be created, including molecular-based practicum.

Finally, the use of *Drosophila melanogaster* as a model organism involved in biology courses is expected to be increased. The reason is, *Drosophila melanogaster* has been considered as the optimal medium in teaching science (Pasini et al., 2010). The use of *Drosophila melanogaster* is also reported to encourage students' research skills (Delventhal & Steinhauer, 2020). Not only that, the presence of *Drosophila melanogaster* in class can also facilitate students in learning various concepts in Biology (Banerjee et al., 2020; Heil et al., 2013; Rothhaas et al., 2020). Therefore, students can learn various biological phenomena directly, making it easier for them to master various abstract concepts in biology.

4. CONCLUSION

This research informed that Genetics is one of the subjects considered to be the most difficult by Biology undergraduate alumni in Indonesia. Even though it is one of the most difficult subjects, 23% of universities have never held practical activities in the Genetics course. Some institutions have used *Drosophila melanogaster* in Genetic practicum activities, although it is still limited to inheritance, giant chromosome, morphological, and life cycles observations. Therefore, the use of *Drosophila melanogaster* to study various molecular aspects is recommended to be developed in the Genetics course.

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