# Gender-based and grade-level mapping of student genetic literacy in the midst of the covid-19 pandemic

Alvin Dewa Yanuar, Sri Wahyuni, Diani Fatmawati, Husamah, Lud Waluyo, Ahmad Fauzi

Biology Education, Faculty of Teacher Training and Education, Universitas Muhammadiyah Malang, Indonesia

*Corresponding author: ahmad_fauzi@umm.ac.id

| ARTICLE INFO | ABSTRACT |
|---|---|
| | The Covid-19 pandemic has resulted in the face-to-face teaching and learning process being shifted to distance learning which has the potential to affect student literacy levels. This quantitative study aims to determine the effect of gender and grade level on the genetic literacy of high school students in Malang. This survey research used a statement instrument as many as 17 items involving 97 students. Data collection was carried out from November to December 2021. The sampling technique used was cluster random sampling. The research data was tested using a Two-Way ANOVA analysis. The results showed that gender did not have a significant effect on genetic literacy, while class level has significant effect. Furthermore, gender and class level did not have a significant interaction. Further research that examines the effect of other variables on genetic literacy needs to be done. |

## INTRODUCTION

In today's modern era, genetic literacy is an important competency that should not be underestimated. Almost all aspects of life have been influenced by the development of genetics (Bernardo, 2020; Castiblanco & Anaya, 2015; Dumache & Enache, 2016). Responding to these conditions, genetics learning in schools must provide learning that makes students understand the concept of genetics well (Hidayat, 2020). However, there are many problems when genetics is taught in schools. Some of these problems, among others students, have difficulty synthesizing knowledge into a deeper understanding (Machová & Ehler, 2021), many of them are afraid of genetics (Paul, 2018), high misconceptions about genetics (Vlckova et al., 2016), and the the low quality of teachers (Grace, 2021).

Another problem faced by students when studying genetics is the implementation of distance learning that is currently being carried out. Until now distance learning had to be carried out due to the COVID-19 pandemic (Dhawan, 2020; Verma et al., 2020). Some of these problems, among others, students are burdened by many tasks while the quality of teaching teachers decreases (Gonzalez et al., 2020), the emergence of economic and pedagogical barriers (Lassoued et al., 2020), incompatibility with learning styles and increased stress on students (Agaton & Cueto, 2021), as well as the difficulty of conditioning collaborative learning (Rannastu-Avalos & Siiman, 2020). However, apart from these various problems, the empowerment of students' genetic literacy should be carried out optimally.

Genetic literacy is related to one's ability to use scientific thinking related to genetics (Chapman et al., 2017). This literacy is part of scientific literacy (Boerwinkel et al., 2017) that can direct someone to make the right decisions regarding the discussion of applications and genetic technology (Cebesoy & Oztekin, 2018). Measurement of genetic literacy needs to be done regularly considering the importance of this competency in the current era. In addition, an analysis of the factors that affect this literacy needs to be done because the information is still limited (Fauzi et al., 2021).

The demographic factors that need to be analyzed for their influence on genetic literacy are gender and grade level. Gender includes an identity, role, personality, and behavior of a person that affects an individual's interaction with other individuals, decision-making, and response given to a particular condition. (Oertelt-Prigione, 2020). Gender causes brain biological differences between men and women (Dilla et al., 2018). Furthermore, in general, women are better at speaking and writing, women also have a mindset that is focused on things that are emotional, concrete, personal, and practical. Men generally have better numeracy skills and have an intellectual, rational and, objective mindset. On the other hand, the grade level is related to the level of development of students and the level of complexity of the material provided by educators to students (Yoenanto & Jati, 2013). At the high-grade level in high school, the material obtained by students will be more complex, so differences in grade levels have the potential to affect student literacy (Delić, 2020).

Based on previous research conducted by Gericke et al. (2017) and Fitzgerald-butt et al. (2017), age can affect genetic literacy. Age affects genetic literacy because as age increases, factual and conceptual knowledge about genetic literacy will increase. The increase is obtained from the experience of a person obtained from the level of education that has been taken. In further research conducted by Swandayani et al. (2021), gender, specialization (department) and location of educational institutions affect genetic literacy. From these various studies, no research focuses on examining the effect of gender and class level on genetic literacy. In addition, the discussion of genetic literacy is still very rarely found in publications in the field of science education. Therefore, this study aims to determine the effect of gender and grade level on students' genetic literacy in the pandemic era. This research will provide data on the genetic literacy of students in Malang so that this research can be used as a source of information for future research that wants to explore genetic literacy more. The lack of research

related to genetic literacy causes the high urgency of the existence of these data.

## METHODS
### Research Design
This quantitative research was conducted from November 22 to December 14, 2021, at one of high schools in Malang Regency. This research was conducted through survey activities using statement instruments distributed using the Google Form platform. The sampling technique used in this research was cluster random sampling. The variables in this study consisted of 2 independent variables, i.e. gender and class level, while the dependent variable was genetic literacy.

### Population and Sampel
The population in this study were all students of Mathematics and Natural Sciences at one of the state senior high schools in Malang Regency. The sample in this study involved students from X MIPA 1, XI MIPA 5, and XII MIPA 3 that were chosen by cluster random sampling technique. In total, as many as 97 students were involved as the sample of this study.

### Instrument
The genetic literacy questionnaire was used as a data collection instrument in this study. The instrument was developed based on Bowling et al. (2008) which refers to Hott et al. (2002). This instrument consists of 17 statement items regarding genetics with 4 answer choices. The four options are: (1) this statement is correct; (2) this statement is incorrect; (3) I once knew this, but I forgot; and (4) I don't know it at all. The seventeen items are derived from six indicators, namely literacy on genetic material, transmission of genetic material, processes of genetic expression, genetic regulation, the concept of evolution, and the relationship between genetics and society. The instrument has passed face validity and content validity. The instruments have been evaluated by a content expert, assessment expert, linguist, and educational practitioners. After revising the instrument based on expert input, the instrument was used as a data collection instrument.

### Procedure
The procedure in this study consisted of 2 stages, namely research preparation and research implementation. The research preparation stage consists of (1) determining the school where the research will be conducted, (2) taking care of licensing to the education and school offices, (3) preparing tools in the form of computers, browsers, and google forms, and (4) preparing research instruments in the form of questionnaires. genetic literacy. Meanwhile, at the research implementation stage, it consisted of: (1) asking for students' approval, (2) distributing genetic literacy instrument questionnaires using Google Forms, (3) giving directions to students when students were going to fill out questionnaires, (4) students filling out questionnaires and sending them, and (5) analyze the data that has been obtained.

### Data Analysis Techniques
The data that has been collected from respondents who have filled out the questionnaire will be analyzed using the Two-Way ANOVA test. The Two-Way ANOVA test itself has several tests that must be met first. The test consists of the data normality test using the Shapiro-Wilk test and the data homogeneity test using Levene's Test. After the normality and homogeneity of the data have been met (the p-value from the Shapiro-Wilk test for each sample group was 0.955, 0.128, 0.425, 0.308, 0.575, and 0.559, while the p-value from Levene's test was 0.650), the Two-Way ANOVA test can be performed. If the ANOVA test obtained significant results ($p < 0.05$), the analysis was continued to the Least Significant Difference (LSD) Test.

## RESULTS AND DISCUSSION

The instruments that have been distributed for three weeks have been filled out by 97 students. There are 34 students in class X MIPA 1 consisting of 26 girls (76.47%) and 8 boys (23.52%). There are 34 students in class XI MIPA 5 consisting of 17 girls (50%) and 17 boys (50%). There are 29 students in class XII MIPA 3 consisting of 18 girls (62%) and 11 boys (37.93%). The results of descriptive statistics on student scores are presented in Table 1.

**Table 1**
Descriptive statistics results of students' genetic literacy data

| Gender | Class | Mean | Standard Deviation | N | Maximal | Minimal |
|--------|-------|------|--------------------|---|---------|---------|
| Male | X MIPA 1 | 5.87 | 2.58 | 8 | 10 | 2 |
| | XI MIPA 5 | 6.76 | 2.92 | 17 | 12 | 0 |
| | XII MIPA 3 | 9.09 | 3.01 | 11 | 15 | 4 |
| | Total | 7.27 | 3.07 | 36 | | |
| Female | X MIPA 1 | 6.65 | 3.01 | 26 | 12 | 0 |
| | XI MIPA 5 | 6.11 | 1.96 | 17 | 9 | 3 |
| | XII MIPA 3 | 8.66 | 3.18 | 18 | 14 | 2 |
| | Total | 7.09 | 2.96 | 61 | | |
| Total | X MIPA 1 | 6.47 | 2.90 | 34 | | |
| | XI MIPA 5 | 6.44 | 2.47 | 34 | | |
| | XII MIPA 3 | 8.82 | 3.07 | 29 | | |
| | Total | 7.16 | 2.99 | 97 | | |

Based on Table 1, the highest mean of genetic literacy was male students in XII MIPA 3 class with a mean value of 9.09. The lowest mean came from male students in the X MIPA 1 class with a mean value of 5.87. The maximum score obtained by male students in XII MIPA 3 class is 15 correct answers from 17 statement questions. The minimum score is obtained by male students in XI MIPA class 5 and female students in X MIPA 1 class with correct answers 0 out of 17 statement questions.

After the descriptive statistical analysis was carried out, the normality and homogeneity of the data were analyzed. Based on the results of the Shapiro-Wilk test, the data of male students in X MIPA 1 class [$W(8) = 0.978$, $p = 0.955$], female students in X MIPA 1 class [$W(26) = 0.939$, p = 0.128], male students in XI MIPA 5 class [$W(17) = 0.948$, $p = 0.425$], female students in XI MIPA 5 class [$W(17) = 0.939$, p = 0.308], male students in XII MIPA 3 class [$W(11) = 0.45$, $p = 0.575$], and female students in XII MIPA 3 class [$W(18) = 0.958$, $p = 0.559$] were normally distributed. Furthermore, Levene's test results inform that the variance of genetic literacy data is homogeneous [$F(5,91) = 0.666$, $p = 0.650$. Thus, the Two-Way ANOVA test can be performed (Table 2).

**Table 2**
Summary of two-way ANOVA test results

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. | Partial Eta Squared |
|--------|-------------------------|-----|-------------|-------|-------|---------------------|
| Gender | 0.200 | 1 | 0.200 | 0.025 | 0.875 | .000 |
| Class level | 117.872 | 2 | 58.936 | 7.282 | 0.001 | .138 |
| Interaction | 7.884 | 2 | 3.942 | 0.487 | 0.616 | .011 |
| Error | 736.492 | 91 | 8.093 | | | |
| Total | 5839.000 | 97 | | | | |
| Corrected Total | 859.361 | 96 | | | | |

Based on Table 2, gender did not have a significant effect on genetic literacy [$F(1,91) = 0,025$, $p > 0,875$, $np^2 = 0,001$]. The difference in class level has a significant effect on genetic literacy [$F(2,91) = 7.282$, $p < 0.001$, $np^2 = 0.138$]. Furthermore, the two factors did not show a significant interaction [$F(2,91) = 0.487$, $p > 0.616$, $np^2 = 0,011$].

Based on the results of ANOVA, gender did not have a significant effect on students' genetic

literacy. This finding is in line with Hermawan et al., (2018) who reported that male and female students did not have a significant difference in making decisions about biological problems in life, especially genetics. Other research conducted by Sulistiyawati, (2017) found that gender did not have a significant difference in critical thinking skills and student learning outcomes in biology subjects. However, the findings of this study are not in line with the results of research conducted by Yanti et al., (2019) who reported that the ability to think, draw conclusions, and reason in biology lessons on blood circulation material had significant differences between male and female students.

Gender is a person's identity that distinguishes between men and women (Oertelt-Prigione, 2020). The ability to think, personality, and decision-making between men and women is influenced by the environment, experience, and education so that in general men and women have a difference (Vleuten et al., 2016). Based on Zaidi (2010), Women generally have a larger hippocampus than men, potentially leading to better long-term memory storage. Therefore, women have a superior ability in the process of remembering. However, in decision-making skills, there is no difference between men and women.

Another factor that causes no significant difference between gender and genetic literacy is the COVID-19 pandemic. Based on Yunitasari, (2020) the Covid-19 pandemic has reduced student interest in learning because online learning is considered less effective because students are bored. These conditions affect students' understanding and learning outcomes. One way to improve student understanding is to use the right online learning platform (Rodiah & Sopandi, 2021). The selection of fun and educational learning platforms will increase students' interest in learning. In addition, another way that can improve students' understanding is the appropriate learning method used by the teacher. Teachers and learning methods play an important role in online or distance learning because the teacher is someone who can recognize the characteristics of students (Lowes et al., 2016). Based on teacher knowledge about student characteristics, teachers can provide learning with the right method, so that it will improve student understanding and learning outcomes.

Based on the results of the ANOVA test (Table 2), grade level has a significant effect on genetic literacy. The results obtained are in line with research conducted by O'Reilly, (2007) who reported that higher grade level affects the level of science knowledge and literacy ability of students. Another report also found that grade level influenced on students' understanding (Lukitasari et al., 2020).

In this study, the grade level has a significant effect, so it is necessary to carry out the BNT test (Table 3). Based on Table 3, the genetic literacy's mean of class X students was the lowest but is not significantly different from class XI students. The genetic literacy of class XII students was the highest but not significantly different from students of class XI as well. However, the mean of class XII students was significantly higher than that of class X students.

**Table 3**
Summary of LSD test results

| Class level | Mean | Standard Deviation | LSD notation |
|:---:|:---:|:---:|:---:|
| X | 6.26 | 2.90 | a |
| XI | 6.44 | 2.47 | ab |
| XII | 8.87 | 3.07 | b |

The class level is related to a person's age, the older a person is, the more knowledge he has in achieving better learning outcomes. In addition, the ability to reason and understand a problem is different between students of high and low class (Delić, 2020). The high class has a high curiosity and social way, which affects the way students think and study. The low class has low curiosity and often makes social adaptations that affect students' mindsets. In addition, the material and assignments between the high and low class have differences, high class is

generally given assignments and more complex materials while the low class is not. This affects students' knowledge.

Another factor that causes differences in genetic literacy in high and low classes is the learning carried out during the COVID-19 pandemic. The COVID-19 pandemic has caused all learning activities that were initially carried out face-to-face to be transferred to online learning. Online learning has the advantage that students can find wider information by utilizing the internet (Hamid et al., 2020). The students in high and low classes students have different abilities in analyzing information obtained from the internet (Hart et al., 2019). High-class students have better abilities due to greater curiosity than low-classes students. In addition, the ability of students to understand the material provided by the teacher with certain online learning methods differs between high and low class. In addition, high-class students have a higher ability to absorb material than low-class students (Almendingen et al., 2021).

Furthermore, the results of the ANOVA test also reported that gender and class level differences did not interact significantly. This finding is in line with research conducted by Aguillon et al. (2020) who reported that the interaction of gender and grade level had no effect, because each student's cognitive abilities, learning styles and learning experiences were different.. Research conducted by Yu, (2021) also in line with the findings obtained. The research conducted found that gender and grade level did not have a significant effect on students' knowledge if the learning method applied did not have a difference between gender and grade level.

Gender and class level is a differences between students in a school. Gender shows the difference between the sexes, while the class level shows the difference in grade level. A person's knowledge is not determined by gender, the factors that cause differences in one's knowledge are the learning process carried out by an individual, the environment, social interactions, and experiences that support one's knowledge (Bryant & Hoon, 2006). However, grade level influences on one's knowledge. Class levels at the education level can be categorized into several levels, namely high, medium, and low. The material given at each level is different, the material given in the high class is more complex than in the middle- and low-class levels. The learning experience that students go through at each grade level is different, the high class has received learning experience from the middle and low-level classes so that the knowledge of students in the high class is much different from that of the middle and low classes. (Kurthen, 2014). Therefore, there is no interaction between gender and grade level because the knowledge possessed by male and female students is influenced by the learning process experienced by each individual.

Despite the interesting findings obtained in this study, several limitations need to be informed. First, this study involved only one school. If the researcher wants to get a broader picture of the population, then sampling involving various schools needs to be designed for further research. Second, the survey was conducted with the help of online questionnaire. The use of online instrument has actually become the best recommendation in conducting surveys during the pandemic. However, further research is expected to use printed questionnaires and be carried out after the pandemic is over. Third, this research only focuses on two demographic variables. Therefore, further research that also analyzes the influence of other demographic variables needs to be designed and carried out.

## CONCLUSION

The results of this study concluded that gender had no significant effect on students' genetic literacy. On the other hand, grade level has a significant influence on other literacy. Furthermore, the two variables did not show a significant interaction. Research related to genetic literacy is still rarely done, especially in Indonesia. Therefore, further studies that also analyze genetic literacy are highly recommended. It is hoped that researchers will be able to

analyze various other demographic variables as well as reveal other factors that can affect students' genetic literacy.

## REFERENCES

Agaton, C. B., & Cueto, L. J. (2021). Learning at home: Parents' lived experiences on distance learning during COVID-19 pandemic in the Philippines. *International Journal of Evaluation and Research in Education (IJERE)*, *10*(3), 901–911. https://doi.org/10.11591/ijere.v10i3.21136

Aguillon, S. M., Siegmund, G. F., Petipas, R. H., Drake, A. G., Cotner, S., & Ballen, C. J. (2020). Gender differences in student participation in an active-learning classroom. *CBE Life Sciences Education*, *19*(2), 1–10. https://doi.org/10.1187/cbe.19-03-0048

Almendingen, K., Morseth, M. S., Gjølstad, E., Brevik, A., & Tørris, C. (2021). Student's experiences with online teaching following COVID-19 lockdown: A mixed methods explorative study. *PloS One*, *16*(8), e0250378. https://doi.org/10.1371/journal.pone.0250378

Bernardo, R. (2020). Reinventing quantitative genetics for plant breeding: something old, something new, something borrowed, something BLUE. *Heredity*, *125*(6), 375–385. https://doi.org/10.1038/s41437-020-0312-1

Boerwinkel, D. J., Yarden, A., & Waarlo, A. J. (2017). Reaching a consensus on the definition of genetic literacy that is required from a Twenty-First-Century citizen. *Science & Education*, *26*(10), 1087–1114. https://doi.org/10.1007/s11191-017-9934-y

Bowling, B. V., Acra, E. E., Wang, L., Myers, M. F., Dean, G. E., Markle, G. C., Moskalik, C. L., & Huether, C. A. (2008). Development and evaluation of a genetics literacy assessment instrument for undergraduates. *Genetics*, *178*(1), 15–22. https://doi.org/10.1534/genetics.107.079533

Bryant, L., & Hoon, E. (2006). How can the intersections between gender, class, and sexuality be translated to an empirical agenda? *International Journal of Qualitative Methods*, *5*(1), 67–79. https://doi.org/10.1177/160940690600500106

Castiblanco, J., & Anaya, J.-M. (2015). Genetics and vaccines in the era of personalized medicine. *Current Genomics*, *16*(1), 47–59. https://doi.org/10.2174/1389202916666141223220551

Cebesoy, U. B., & Oztekin, C. (2018). Genetics literacy: Insights from science teachers' knowledge, attitude, and teaching perceptions. *International Journal of Science and Mathematics Education*, *16*(7), 1247–1268. https://doi.org/10.1007/s10763-017-9840-4

Chapman, R. (2017). Genetic Literacy And Attitudes Survey (IGLAS): International population-Wide assessment instrument. *The European Proceedings of Social & Behavioural Sciences*, 45–66. https://doi.org/10.15405/epsbs.2017.12.6

Chapman, R., Likhanov, M., Selita, F., Zakharov, I., Smith-Woolley, E., & Ko- vas, Y. (2017). Genetic Literacy and Attitudes Survey (iGLAS): International population-wide assessment instrument. *The European Proceedings of Social & Behavioural Sciences EpSBS*, *33*(6), 45–66. https://doi.org/10.15405/epsbs.2017.12.6

Delić, H. (2020). The analysis of learning styles among high school students. *Journal of Education and Humanities*, *3*(1), 17–28. https://doi.org/10.14706/JEH2019222

Dhawan, S. (2020). Online learning: A panacea in the time of COVID-19 crisis. *Journal of*

*Educational Technology Systems*, *49*(1), 5–22. https://doi.org/10.1177/0047239520934018

Dilla, S. C., Hidayat, W., & Rohaeti, E. E. (2018). Faktor gender dan resiliensi dalam pencapaian kemampuan berpikir Kreatif matematis Siswa SMA. *Journal of Medives : Journal of Mathematics Education IKIP Veteran Semarang*, *2*(1), 129. https://doi.org/10.31331/medives.v2i1.553

Dumache, R., & Enache, A. (2016). Molecular Genetics and its Applications in Forensic Sciences. In *Forensic Analysis - From Death to Justice.* InTech. https://doi.org/10.5772/63530

Fauzi, A., Saefi, M., Kristiana, E., Adi, W. C., & Lestariani, N. (2021). Factor and Rasch analysis on COVID-19 genetics literacy assessment instrument. *Eurasia Journal of Mathematics, Science and Technology Education*, *17*(11), em2032. https://doi.org/10.29333/ejmste/11264

Fitzgerald-Butt, S. M., Bodine, A., Fry, K. M., Ash, J., Zaidi, A. N., Garg, V., Gerhardt, C. A., & McBride, K. L. (2016). Measuring genetic knowledge: a brief survey instrument for adolescents and adults. *Clinical Genetics*, *89*(2), 235–243. https://doi.org/10.1111/cge.12618

Gericke, N., Carver, R., Castéra, J., Evangelista, N. A. M., Marre, C. C., & El-Hani, C. N. (2017). Exploring Relationships Among Belief in Genetic Determinism, Genetics Knowledge, and Social Factors. *Science and Education*, *26*(10), 1223–1259. https://doi.org/10.1007/s11191-017-9950-y

Gonzalez, T., De la Rubia, M. A., Hincz, K. P., Comas-Lopez, M., Subirats, L., Fort, S., & Sacha, G. M. (2020). Influence of COVID-19 confinement on students' performance in higher education. *PLoS ONE*, *15*(10 October), 1–23. https://doi.org/10.1371/journal.pone.0239490

Grace, E. N. (2021). The problems of teaching and learning genetics in secondary schools in Enugu South Local Government Area of Enugu State. *British International Journal of Education And Social Sciences*, *8*(4), 13–19. https://www.cirdjournal.com/index.php/bijess/article/download/230/224

Hamid, R., Sentryo, I., & Hasan, S. (2020). Online learning and its problems in the Covid-19 emergency period. *Jurnal Prima Edukasia*, *8*(1), 86–95. https://doi.org/10.21831/jpe.v8i1.32165

Hart, C. M. D., Berger, D., Jacob, B., Loeb, S., & Hill, M. (2019). Online Learning, Offline Outcomes: Online Course Taking and High School Student Performance. *AERA Open*, *5*(1), 233285841983285. https://doi.org/10.1177/2332858419832852

Hermawan, W., Abidin, Z., & Junaedi, E. (2018). Peran gender dan kesadaran metakognitif siswa SMA di Kabupaten Kuningan terhadap hasil belajar biologi. *Quagga*, *10*(2), 11–18. https://doi.org/10.25134/quagga.v10i2.904

Hidayat, T., & Kasmiruddin. (2020). Miskonsepsi materi genetika tentang ekspresi gen. *BIOEDUSAINS: Jurnal Pendidikan Biologi Dan Sains Volume*, *3*(1), 59–65. https://doi.org/10.31539/bioedusains.v3i1.1262

Hott, A. M., Huether, C. A., McInerney, J. D., Christianson, C., Fowler, R., Bender, H., Jenkins, J., Wysocki, A., Markle, G., & Karp, R. (2002). Genetics content in introductory biology courses for non-science majors: Theory and practice. *BioScience*, *52*(11), 1024–1035. https://doi.org/10.1641/0006-3568(2002)052[1024:GCIIBC]2.0.CO;2

Kurthen, H. (2014). What influences college classroom interaction? *International Journal of Assessment and Evaluation*, *20*(4), 13–34. https://doi.org/10.18848/2327-7920/CGP/v20i04/58943

Lassoued, Z., Alhendawi, M., & Bashitialshaaer, R. (2020). An exploratory study of the Obstacles for achieving quality in distance learning during the COVID-19 pandemic. *Education Sciences*, *10*(9), 232. https://doi.org/10.3390/educsci10090232

Lowes, S., Lin, P., & Kinghorn, B. R. C. (2016). Gender differences in online high school courses. *Online Learning Journal*, *20*(4), 100–117. https://doi.org/10.24059/olj.v20i4.1049

Lukitasari, F., Nurlaela, L., Ismawati, R., & Rijanto, T. (2020). Comparison of learning outcomes between discovery learning with inquiry learning reviewed of student learning independence at vocational high school. *International Journal for Educational and Vocational Studies*, *2*(10), 837–842. https://doi.org/10.29103/ijevs.v2i10.3305

Machová, M., & Ehler, E. (2021). Secondary school students' misconceptions in genetics: origins and solutions. *Journal of Biological Education*, 1–14. https://doi.org/10.1080/00219266.2021.1933136

O'Reilly, T., & McNamara, D. S. (2007). The impact of science knowledge, reading skill, and reading strategy knowledge on more traditional "high-stakes" measures of high school students' science achievement. *American Educational Research Journal*, *44*(1), 161–196. https://doi.org/10.3102/0002831206298171

Oertelt-Prigione, S., & Mariman, E. (2020). The impact of sex differences on genomic research. *The International Journal of Biochemistry & Cell Biology*, *124*(May), 105774. https://doi.org/10.1016/j.biocel.2020.105774

Paul, A. O. (2018). Dealing with biology students' fear of genetics: computer assisted instruction (CAI) to the rescue. *Educational Research*, *9*(4), 105–117. https://doi.org/10.14303/er.2018.224

Rannastu-Avalos, M., & Siiman, L. A. (2020). Challenges for distance learning and online collaboration in the time of COVID-19: Interviews with science teachers. In A. Nolte, C. Alvarez, R. Hishiyama, I. A. Chounta, M. Rodríguez-Triana, & T. Inoue (Eds.), *Collaboration Technologies and Social Computing* (pp. 128–142). Springer. https://doi.org/10.1007/978-3-030-58157-2_9

Rodiah, S., & Sopandi, W. (2021). The effect of online learning on learning interest and digital literacy of students in terms of gender (gender-based comparative causal study of students' learning interest and digital literacy in distance learning due to the covid-19 primary school pande. *International Conference on Elementary Education*, *3*(1), 233–237. http://proceedings.upi.edu/index.php/icee/article/view/1468

Sulistiyawati, S., & Andriani, C. (2017). Kemampuan berpikir kritis dan hasil belajar biologi berdasarkan perbedaan gender siswa. *Wacana Akademika*, *1*(2), 127–142. https://jurnal.ustjogja.ac.id/index.php/wacanaakademika/article/view/1289

Swandayani, Y. M., Cayami, F. K., Winarni, T. I., & Utari, A. (2021). Familiarity and genetic literacy among medical students in Indonesia. *BMC Medical Education*, *21*(1), 524. https://doi.org/10.1186/s12909-021-02946-8

Verma, G., Campbell, T., Melville, W., & Park, B. Y. (2020). Science teacher education in the times of the COVID-19 pandemic. *Journal of Science Teacher Education*, *31*(5), 483–490. https://doi.org/10.1080/1046560X.2020.1771514

Vlckova, J., Kubiatko, M., & Usak, M. (2016). Czech high school students' misconceptions about basic genetic concepts: Preliminary results. *Journal of Baltic Science Education*, *15*(6), 738–745. http://oaji.net/articles/2016/987-1482503099.pdf

Vleuten, M. van der, Jaspers, E., Maas, I., & Lippe, T. van der. (2016). Boys' and girls' educational

choices in secondary education. The role of gender ideology. *Educational Studies*, *42*(2), 181–200. https://doi.org/10.1080/03055698.2016.1160821

Yanti, E. D., Wigati, I., & Habisukan, U. H. (2019). Perbedaan kemampuan berpikir kritis laki-laki dan perempuan pada materi sistem peredaran darah mata pelajaran biologi kelas XI MIPA MAN Banyuasin III. *Bioilmi: Jurnal Pendidikan*, *5*(1), 66–71. https://doi.org/10.19109/bioilmi.v5i1.3541

Yoenanto, N. H., & Jati, G. W. (2013). Kecerdasan emosional siswa sekolah menengah pertama ditinjau dari faktor demografi. *Jurnal Psikologi Pendidikan Dan Perkembangan*, *2*(02), 113. http://journal.unair.ac.id/JPPP@kecerdasan-emosional-siswa-sekolah-menengah-pertama-ditinjau-dari-faktor-demografi-article-7071-media-53-category-10.html

Yu, Z. (2021). The effects of gender, educational level, and personality on online learning outcomes during the COVID-19 pandemic. *International Journal of Educational Technology in Higher Education*, *18*(1), 14. https://doi.org/10.1186/s41239-021-00252-3

Yunitasari, R., & Hanifah, U. (2020). Pengaruh pembelajaran daring terhadap minat belajar siswa pada masa COVID 19. *EDUKATIF : JURNAL ILMU PENDIDIKAN*, *2*(3), 232–243. https://doi.org/10.31004/edukatif.v2i3.142

Zaidi, Z. F. (2010). Gender differences in human brain: A review. *The Open Anatomy Journal*, *2*, 37–55. https://doi.org/10.2174/1877609401002010037