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Dilemmas in Society

Preservice Biology Teachers' Perspectives

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Fostering Knowledge and Decision-Making Skills through an Exploration of Genetic Dilemmas in Society: Preservice Biology Teachers' Perspectives

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Abstract: The topic of genetics is an essential concept in the biological sciences, and it is also relevant to people's daily lives. Several community dilemmas trigger a controversial debate on genetics that requires a better understanding of "genetics literacy." This research aimed to investigate biology students' opinions on the current genetic dilemmas in their environment. Data were gathered through interviews and genetic syllabus documents. The results indicated that genetics dilemmas in society are categorized into four topics: sex-influenced genes, sex-linked genes, aneuploidy, and autosomal genes. Public perceptions of genetic dilemmas are based on myths rather than science. Preservice biology teachers linked the concept of genetics with existence in society. Students' decision making about the truth of myths associated with genetic ideas can bridge the gap between community knowledge and science.

Keywords: Preservice Biology Teachers, Genetic Learning, Genetic Dilemmas, Decision-Making Skills

Introduction

The development of knowledge in science and technology conveys various issues in society and has the potential to improve lives. These developments trigger the experience of personal and social dilemmas. They additionally raise moral, ethical, social, and political issues. Dawson and Venville (2010) note that people face personal choices about issues such as mobile phone usage, consuming genetically modified foods, or recycling household waste. They also make decisions addressing the problems of global warming, soil salinity, population control, and water supply and quality. These decisions are not simple and require measuring risks and benefits and evaluating the validity of the information. Recently, making decisions has become a research trend in science education and is considered essential to overcome various issues (Genisa et al. 2020).

One of the dilemmas that spark debates in society is related to genetics. This dilemma is relevant to people's everyday lives and often prompts intense discussion. In the biological sciences, genetics is one of the concepts with which students encounter serious difficulties (Cebesoy and Tekkaya 2012; Duncan and Reiser 2007; Jennings 2004; Lewis and Kattmann 2004).

Science educators introduced the term socioscientific issues (SSI) to denote social dilemmas with conceptual ties to science (Fleming 1986; Kolstø 2001; Sadler, Chambers, and Zeidler 2004; Zeidler and Keefer 2003). Most SSIs are multidisciplinary. Some researchers have recognized the requirement for an understanding of overlapped disciplines in explaining these problems. Rundgren, Eriksson, and Rundgren (2016, 1060) developed a framework, the SEE-SEP model, to highlight the different disciplinary subjects that are integral to SSIs: sociology/culture, environment, economy, science, ethics/morality, and policy (Morris 2014).

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The dilemmas in genetics can be classified as SSI because they encompass different aspects of culture, environment, economy, science, ethics, and policy. Several studies have shown a general lack of comprehension of the concept of genetics (Bates et al. 2005; Bowling et al. 2008a; Christensen et al. 2010; Duncan and Marini 2006; Iredale et al. 2003; Lanie et al. 2004). Moreover, details on informally posed genetic dilemmas are often inaccurate (Bowling et al. 2008b; Lanie et al. 2004). Genetic learning in Indonesia is not common, but the information about genetics is accessible to the public; however, not all have good literacy to understand the concept. This then leads to public misunderstandings about genetic dilemmas. Therefore, genetic literacy is also crucial for students when confronting real-life problems. Genetics literacy has been proposed as a part of scientific literacy to emphasize the issues and challenges related to genetics and biotechnology (Cebesoy and Tekkaya 2012; Jennings 2004). Bowling et al. (2008a) define genetics literacy as sufficient knowledge and appreciation of genetics principles to enable informed decision-making for personal well-being and active participation in social decisions on genetics issues.

Some experts recommend in-class discussion when elaborating on science-related social dilemmas. Yang (2005) suggests that science is a “social” activity. Several studies have recommended that a better way to assess understanding of the nature of the scientific enterprise would be to analyze the evaluative thinking of learners in authentic situations where the complex linkage between science and society could be exposed (Sadler and Zeidler 2004; Sadler 2009; Walker and Zeidler 2003; Yang 2005; Zeidler et al. 2002). Learning that involves social aspects begins by identifying social science dilemmas that emerge in society by linking existing scientific knowledge to the students’ understanding of these issues through perception and information gained through social-learning activities. This research aimed to identify genetic dilemmas in the context of daily life and to explore issues in society by investigating students’ views on the current genetic predicaments in their environment.

Theoretical Framework

Genetic Dilemmas in Society

Social dilemmas refer to a wide range of real-world problems that exist within dyads, small groups, and massive society. They deal with the issues in a large number of knowledge disciplines, such as anthropology, biology, economics, mathematics, psychology, political science, and sociology (Lange et al. 2013). There are social dilemmas involving two people, including people in a country, continent, or even different parts of the world. One example of a social dilemma related to the biological sciences is a genetic disorder in society. This dilemma may arise because of the emergence of information and technology concerning genetics in the community, which plays a significant role in health and public policy (Kolstø 2001) but is not supported by a correct understanding of genetics. Based on several studies (Bates et al. 2005; Iredale et al. 2003; Lanie et al. 2004), public knowledge of genetics is still weak (Bowling et al. 2008b). This lack of understanding renders it difficult for members of the public, who tend to have inappropriate perceptions of genetic dilemmas, to recognize valid information. According to Simon and Farndon (2008), genetic diseases can be due to an alteration in one gene, an adjustment in several genes in combination with environmental factors, or an imbalance in many genes. In the community, genetic disorders are linked to myths that develop in society and often lead to debates about the correction of information.

Genetic Learning

A discussion of genetic dilemmas requires knowledge of genetic literacy. Genetic literacy signifies the lives of people (Kaye and Korf 2013). Genetic literacy reflects the knowledge essential for making such decisions (Abrams et al. 2015). Bowling et al. (2008a) define genetics literacy as

sufficient knowledge and appreciation of genetic principles to make informed judgments for personal well-being and active participation in social arrangements on genetics-based issues. It consists of three dimensions: familiarity, practical skills, and knowledge of principles (Abrams et al. 2015). Surveys indicate that the general public and health-care providers have limited genetics literacy. For example, in a study of individuals with genetic and familial conditions, 64 percent showed they had not gained an understanding of hereditary material (Kaye and Korf 2013).

School is an academic institution that promotes genetics literacy to address hereditary dilemmas through active participation in public discussion about social problems that challenge biological perspectives (Olander and Olander 2013). Exploring social dilemmas can provide an opportunity for students to explore their knowledge and biological viewpoints. The teacher raises a dilemma that occurs in the community, and the students seek answers by exploring the relevant information to arrive at the appropriate decision. Students who have an understanding of the difficulty involved will have better decision-making abilities. The integration of SSI into science classroom learning requires meaningful real-world contexts that enable an analysis of these complex relationships to promote the acquisition of competencies (Aikenhead 2006; Gresch 2011; Pedretti 2003; Sadler 2009).

Knowledge and Decision Making

Decision-making skills are defined as making objective judgments based on data and arguments presented with various considerations (scientific, ethical, economic, political, and social) and support with appropriate as well as relevant scientific facts and knowledge (Lee 2007). Decision making is also described as the ability to systematically evaluate the factual and ethical action on complex situations of the phenomenon and issues and make the final decision (Rizal, Siahaan, and Yuliani 2016). In this vein, decision making commonly involves the following process: identification of an issue, search for alternatives, evaluation of alternatives, and make a decision. The decision-making process requires gathering scientific information, which is related to the implementation of scientific knowledge. Specifically, the cognitive process that involves the decision-making process can be identified and classified using Bloom's taxonomy. Bloom's taxonomy classifies educational goals or objectives into three domains: cognitive, affective, and psychomotor; these three domains are divided into more detailed dimensions based on their hierarchy (Anderson and Krathwohl 2001). The cognitive area is an aspect of ability that is related to issues of knowledge and reasoning. Bloom's taxonomy classifies cognitive levels of learning to define the skill or competency that students have learned; it consists of knowledge, comprehension, application, analysis, synthesis, and evaluation (Crowe, Dirks, and Wenderoth 2017). Bloom's taxonomy divides the dimension of expertise into four categories: factual, conceptual, procedural, and metacognitive (Adams 2015). Factual knowledge is the fundamental element that candidates must know to be acquainted with discipline, while theoretical knowledge is the relationships between components or systems; both were used as a basis in the decision-making process in this study. The cognitive dimension in decision making entails making judgments based on criteria and standards; it requires the ability to evaluate by checking and critiquing (Anderson and Krathwohl 2001).

Method

This study was conducted in Palembang city, South Sumatera Province, Indonesia. The participants were comprised of sixty preservice biology teachers from the Faculty of Teacher Training and Education from the same university (six males, fifty-four females) and 120 members of society (fifty-five males, sixty-five females).

In the identification process, sixty preservice biology teachers took a genetics course in which they had to conduct observations about several cases that exist in society (phase 1) and then choose one of the cases as a topic on which to interview members of society (phase 2). The data collection

was performed using interviews based on 5W1H questions (What, Who, Where, Why, How). Questions were used in the interviews to help identify, explore, and gather information about dilemmas in society to make decisions. The standard form of questions that students used as guidelines in the interview are as follows: (1) what are the causes of abnormality? (2) when did the abnormality begin? (3) who has an abnormality in the family? (4) why does the family have an abnormality? (5) where can the abnormality occur, and (5) how does the relationship of hereditary, environmental, and cultural factors affect the abnormalities in the family?

In the exploration process, the preservice biology teachers conducted an exploration about a case of their choice to collect information and compare it with their perspectives (phase 3). The exploration process by preservice was done through the justification of facts and the concept of genetic dilemma from society’s perceptions. All perceptions of the participants were obtained for data analysis. The data reported here spans the identification and the exploration process, as shown in Figure 1.

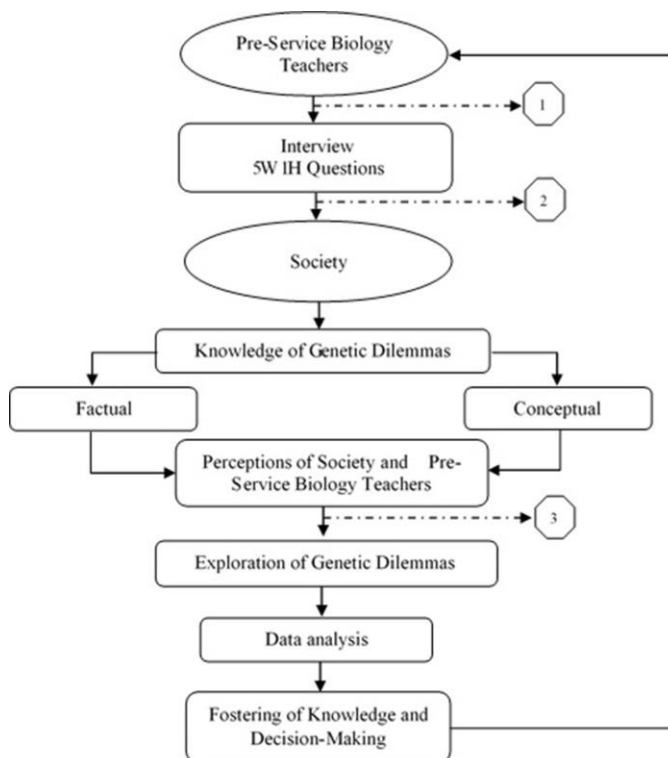


Figure 1: Schematic Representation of The Process for Data Collection
 Source: Genisa et al.

Findings

Popular Topics in Genetics

Based on the results of the interviews conducted by the students in examining the overview of genetics dilemmas in society linked to genetics content and concepts (Figure 2), the most popular topics in genetics revealed four major topics: (1) autosomal genes, (2) aneuploidy, (3) sex-linked genes, and (4) sex-influenced genes (Figure 3).

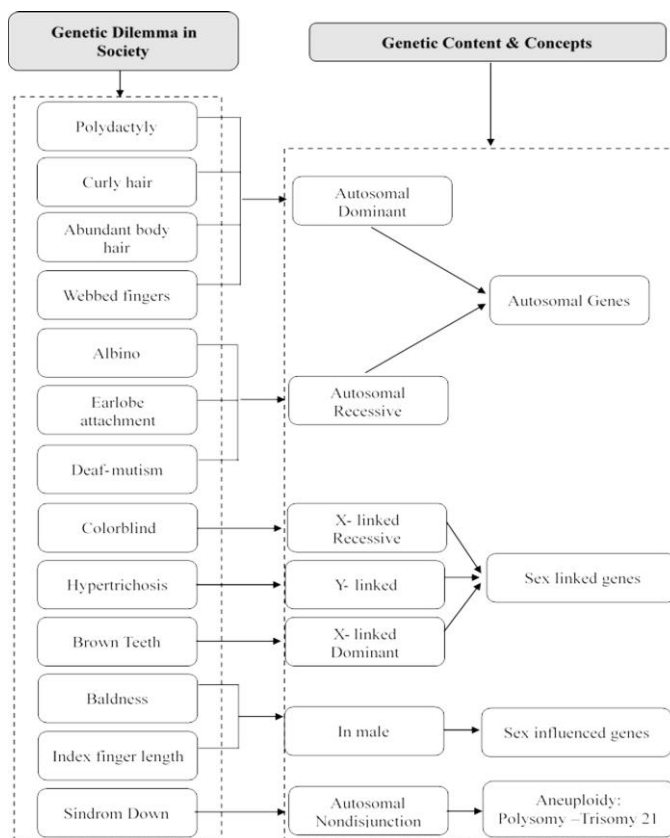


Figure 2: Overview of Genetic Dilemmas in Society Linked to Genetic Content and Concepts
 Source: Genisa et al.

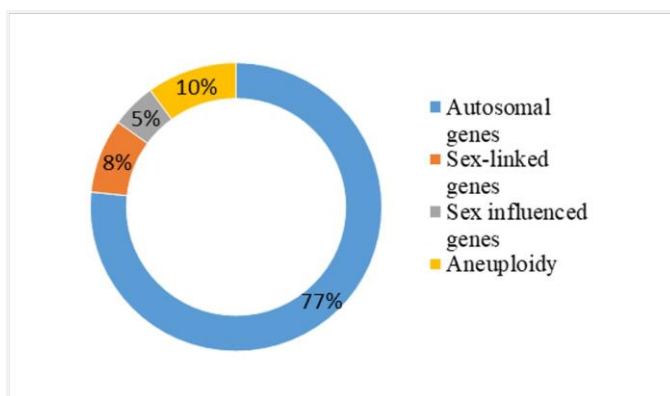


Figure 3: Percentage of Popular Topics in Genetics among Society
 Source: Genisa et al.

Public and Preservice Biology Teacher Perceptions of Genetic Dilemmas

Public perceptions of genetic dilemmas in society were obtained through interviews that were conducted to gauge the extent to which the public understands the dilemmas. The results reveal the public perceives genetic disorders to be caused by taboos (41%), the inheritance of traits

(28%), unknown causes (22%), and poor maternal health (9%). On the other hand, 97 percent of preservice biology teachers responded that genetic disorders are caused by the inheritance of traits, and only 3 percent perceived them as being caused due to poor maternal health. The percentage of public perception and preservice teachers based on the question of why abnormalities might occur in a person's body is presented in Figure 4.

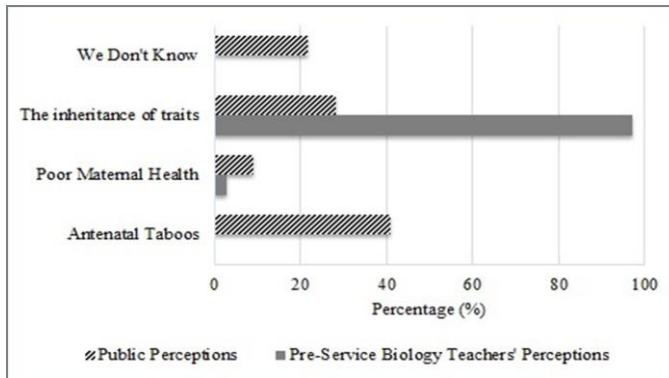


Figure 4: Public and Preservice Teachers Perceptions of Why Genetic Disorders Occur
Source: Genisa et al.

Discussion

Popular Topics in Genetics

The dilemmas, which often appear and become the focus of other studies in SSI, primarily include genetically modified (GM) foods, genetic testing, gene therapy, and cloning (Sadler and Zeidler 2004). Genetic dilemmas that develop in an environment or community are different from one another. Community factors and environmental circumstances play a vital role in the determination of a dilemma. Dilemmas in developed countries are more complex than dilemmas in developing countries because of differences in industrial development, technology, environmental conditions, and social circumstances of the community. Additionally, cultural and ethnic diversity factors play a significant role. Therefore, genetic dilemmas may vary across countries and regions.

In this study, the most popular topic in genetics in a rural area in Palembang City was identified through interviews using questions based on 5W1H. This research is located far from the city of Palembang, and the social conditions are quite varied. Based on these results—although the genetic dilemmas that occur within the community are quite diverse—in general, students raised topics in the interviews related to genetic disorders. Furthermore, each of these topics became the focus of each student's assessment. Based on the results obtained, 77 percent of the students were involved in interviews with the theme of autosomal genes, 10 percent of the students discussed aneuploidy, 8 percent discussed sex-linked genes, and the remaining 5 percent discussed sex-influenced genes. These topics showed relevance to people's lives, mostly because of the direct experience of having encountered a case in their environment.

Public and Preservice Biology Teacher Perceptions of Genetic Dilemmas

The public was asked, why might abnormalities occur in someone's body? Dominantly, the public perception of the genetic dilemma is correlated with antenatal taboos. A taboo is a social prohibition of words, objects, or actions that a group, culture, or society considers unwanted. Taboo is often associated with myths by a society whose truthfulness still needs to be scientifically proven. The society connects to and perceives the dilemmas with myths rather

than scientific knowledge, as the evidence was gained through their own opinions and expressions. Some women reflected a lack of modern scientific knowledge about healthy pregnancy, which is a concern due to the possible counter influence on recommended health behaviors during pregnancy. A lack of scientific understanding of the scientific viewpoint about genetics was found, which can lead to errors in interpreting the dilemmas and finding solutions to the problems that are not maximally exposed. Furthermore, the public perception of the dilemma is cited as one of the factors influencing people in the decision-making process. In a qualitative study among Thai women, the role of fate and natural beliefs influence the decision to engage in a healthy lifestyle during pregnancy (Wulandari and Klinken Whelan 2011).

Cultural rituals and taboos heavily exist regarding pregnancy and childbirth. These cultural traditions define transition, demarcate vulnerability, and structure sociomoral support. A study showed that traditional customs and rituals were subscribed to pregnant women living in Western societies (Lee et al. 2009). Knowledge, culture, and experience determine expectations regarding pregnancy and childbirth outcomes. The process of knowledge creation is influenced by cultural and social context (Handayani et al. 2019). It is also argued that various myths and beliefs in society are influenced by demographics, characteristics, affluence, and sociocultural factors that play a significant role in maternal care practices (Choudhury and Ahmed 2011). The practices that surround childbirth are underpinned and shaped by local beliefs and social context. Women from diverse backgrounds may use different reference frames to make sense of pregnancy events and may behave in ways contrary to Western beliefs (Carolan and Cassar 2010). Based on the research area, it was noticed that the community generally trusted myth more than science. This is due to the genetics dilemma repeatedly occurring in the community with the same activity. This myth grew and developed in society and descended from the previous generation with various practices and rituals that exist to protect and support the new mother and baby. Some myths, especially in Indonesia, continue to be maintained in the community's whole life with a fear of inviting problems if they are violated. Concerning the genetics dilemmas in Palembang, most believe that abnormalities, such as albinism and polydactylism, are caused by the mother breaking taboos and engaging in behaviors in which pregnant women should not engage.

Nevertheless, it is explained that maternal malnutrition during pregnancy has potential for maternal, fetal, and neonatal complications, such as low birth weight (Lassi et al. 2020). Besides that, a lack of knowledge and preparedness about reproductive health in the family, community, and healthcare providers plays an essential role. Studies have found evidence regarding the importance of beliefs and views toward pregnancy in determining whether pregnant women perform recommended health actions, such as consumption of iron supplements, folic acid intake, prenatal testing, attendance at prenatal classes, adherence to other prenatal health guidelines, and health-care utilization (Wulandari and Klinken Whelan 2011). These actions would protect pregnant women from pregnancy problems. Based on the data obtained in this research, genetic disorders, such as albinism and polydactylism, become a dominant dilemma addressed in the student interviews. The majority connected the genetic disorders with antenatal taboos rather than scientific reasons.

The following are the public perceptions that represent the primary topic of genetics dilemmas in this study:

- Polydactylism
 - Mistakes from his mother during pregnancy (50-year-old female)
 - When the mother was pregnant, her father or husband hurt an animal. As a result, her child suffers the impact of what her husband did (45-year-old female)
 - Babies who are deficient in nutrients suffer from abnormalities (40-year-old male)
 - Eating squid during pregnancy (42-year-old female)
 - Grace as a sign of cheap fortune because the child has an excessive number of fingers (45-year-old male)

- Albinism
 - When his mother was pregnant, she had cravings for corn and said terrible things about the corn feathers so that the child was born with pale white skin, hair, and eyebrows (35-year-old female)
 - His ancestors came from the Netherlands (36-year-old male)
 - They are condemned as a result of their parents' actions when they have killed animals (40-year-old male)

Some cases of genetics dilemmas demonstrated that myths in society occur in almost all countries with various beliefs. Many traditional customs are still widely practiced in the studied areas, even though some traditional beliefs are contradictory to present-day scientific knowledge. For instance, in Botswana and rural Nigeria, protein-rich meat is commonly restricted (Ebomoyi 1988). Salt, sweets, bread, corn, and fats are also prohibited among pregnant women in Botswana (Ebomoyi 1988). In traditional Chinese culture, pregnancy is considered a vulnerable period that requires rest and recuperation (Lee et al. 2009). Many antenatal taboos may contrast with international guidelines on exercise during pregnancy. Two relevant taboos intended to preclude spontaneous miscarriage include “not walking too fast” and “not walking too often,” which are reportedly adhered to by the majority of Chinese women (Guelfi et al. 2015). In Zambia, it is believed that future problems during childbirth and in the unborn child can be avoided by avoiding certain foods during pregnancy (Maimbolwa et al. 2003). In Bangladesh, some food, such as ducks, pigeons, beef, and Hilsha fish, are considered “hot” and are restricted during pregnancy (Choudhury and Ahmed 2011), but scientifically, the cultural practice of depriving a pregnant woman of essential food nutrients may contribute to malnutrition, which is common among pregnant women in Zambia and may be responsible for lower birth weights, congenital malformations, and maternal and perinatal mortality (Maimbolwa et al. 2003). Another myth that has become a general belief in Zambia is that a pregnant woman should not make it known in the neighborhood that labor has begun for fear of attracting evil spirits and witches believed to have magical powers, which could cause complications during labor and delivery (Maimbolwa et al. 2003). It is also believed that evil spirits are more active in the evening, at noon, and at night; pregnant women avoid leaving their houses during these times (Maimbolwa et al. 2003). Walking through graveyards is also thought to be harmful to pregnant women; if they do so, they tie up their hair and cover their heads with veils (Choudhury and Ahmed 2011).

Generally, the preservice biology teachers' responses are that abnormalities in a person are caused by the inheritance of traits (97%), and only 3 percent associate these abnormalities with malnourishment during pregnancy. They are able to explain the facts of genetic dilemmas based on genetic concepts acquired in learning. For example, polydactylism and albinism are considered in society as the result of taboo things when the mother was pregnant, such as her father or husband hurting an animal. As a result, her child suffers, but the preservice teacher's perception of both polydactylism and albinism is autosomal hereditary in humans. Polydactylism is determined by the autosomal gene dominant, whereas the autosomal recessive gene determines albinism. Polydactylism is an anomalous limb (hereditary limb anomaly), which is most commonly characterized by additional fingers or toes that are inherited mainly as autosomal dominant entities with variable penetration and caused by defects in the anterior-posterior of leg development (Umair et al. 2018). In contrast, albinism is an autosomal recessive disorder caused by a lack or reduction of melanin biosynthesis in melanocytes (Kamaraj and Purohit 2014).

Decision-Making Skills

The identification of topics in genetics that are relevant in society and the investigation of such in the interviews involve decision-making skills. Preservice biology teachers make decisions through the process of checking and critiquing. The checking aims to find internal

inconsistencies while critiquing to assess external inconsistencies based on the criteria of fact and concept of genetic dilemma. Decision making in cognitive psychology involves two distinct modes of thinking, namely the experiential and the analytic. The former includes automatic, fast, and effortless processes, whereas the latter relies on conscious, slow, and effortful processes. It is widely believed that experiential processing predominates people's thinking (Klaczynski 2001; Papadouris 2012; Stanovich 1999). Therefore, decision making can be heuristic, intuitive, or analytical. According to Jho, Yoon, and Kim (2014), many factors influence students' decision making, including knowledge of scientific concepts, nature of science, previous experiences, cognitive styles, personal values and beliefs, perspectives, context of the issues discussed, culture, and types of discussions conducted.

Searching for information is closely related to decision making and determines the decision-making strategy that a person takes in exploring a dilemma. Current technological developments make it possible to search for information on various topics virtually, but they affect the quality and usefulness of the information accessed. When different aspects of making decisions on the topics in genetics are considered based on the results of the analysis of student opinions as described in the interviews, it is clear that most of the material selection is based on preexisting knowledge and issues familiar to the students. Students' beliefs in the source of information in this society was also clearly observable in the interviews.

The data on students' perceptions of genetics dilemmas were collected through interviews by students using 5WIH questions from field sources, which became one of the considerations of information sources for the students in interpreting their perceptions of the genetics dilemmas. Furthermore, it becomes one of the considerations when included in arguing and decision making. Students can integrate factual and conceptual knowledge when distinguishing genetic dilemmas that occur in society. An example of polydactylism from genetic learning that has a well-known term in the society is "octopus' hand." Based on the result of the characteristics of the hand, the community used the term to characterize polydactylism. In addition, people explained that both girls and boys could be exposed to polydactylism due to their parents' activity during pregnancy. For example, killing animals is believed to cause polydactylism. Based on the result, students conducted a critiquing evaluation that polydactylism is not classified as a sex-linked gene but is classified as an autosomal gene that can occur in men or women. The data obtained revealed that the students are able to link the concept of genetics with real dilemmas in society.

Knowledge of genetics concepts is considered an essential component for understanding issues and reasoning in making decisions about dilemmas. Several previous studies (Rizal et al. 2019; Jho, Yoon, and Kim 2014; Jho, Song, and Levinson 2013) have demonstrated that knowledge of context and content also contribute to informed decision making because before making a decision, students need to understand the dilemma and make the right decisions. The exploration of genetic dilemma effectively broadens the horizon of factual and conceptual preservice biology teachers in decision making. Based on the results of this study, public perceptions of the genetics dilemmas associated with the concept of genetics evaluated through the stages of checking and critiquing will promote the development of students' decision-making abilities.

Conclusion

Based on the analysis conducted in this study, it was found that the prominent themes in genetics that are relevant to the genetics dilemmas in the community are the inheritance of genes on the body chromosomes, sex-influenced genes, and confinement of genes to one sex. Public perceptions of genetics dilemmas are generally based on antenatal taboos. The preservice biology teachers' ability to make decisions in determining the interview topics was mostly based on the problems and knowledge that already exist. Knowledge and decision-making skills of preservice biology teachers can be fostered through the exploration stage that requires factual and conceptual understanding to evaluate the genetic dilemma.

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