Pre-service science teachers’ genetic literacy level and attitudes towards genetics

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Abstract

The aim of this study is to determine pre-service science teachers’ genetic literacy level and their attitude towards genetics. The Genetics Literacy Assessment Instrument (GLAI; Bowling et al., 2008) and the Genetics Attitude Scale (see Acra, 2003) were used to collect relevant data. Pre-service science teachers held quite favorable attitude towards genetics (M=3.75) while they had a relatively low level of genetic literacy (M=15.39). Their knowledge levels with respect to dimensions of the GLAI varied. For example, they were found to be more knowledgeable in the transmission of genes and followed by the nature of genetic material dimensions compared to gene expression, gene regulation and evolution dimensions. Their knowledge level in the genetics and society dimension was relatively low, indicating limited understanding of the interactions between genetics and society.

Keywords: attitudes, genetics literacy, pre-service science teachers, genetics education;

1. Introduction

Technological advances confront the public with new information about genetics and genetics technologies (Bowling et al., 2008; Jennings, 2004). These advances bring about the term biotechnology revolution which involves science and technology related public policy issues, such as the transmission from fossil-based energy systems to new energy sources (Miller, 1998). As the importance of these issues increases, an adequate level of scientific literacy in order to understand and follow up these issues becomes crucial.

The term “genetics literacy” is proposed as a part of scientific literacy to emphasize the issues and challenges that are related with genetics and biotechnology (Jennings, 2004). Genetics literacy is defined by Bowling et al. (2008, p.16) as ‘sufficient knowledge and appreciation of genetics principles to allow informed decision-making for personal well-being and effective participation in social decisions on genetics issues’. Recently, Tsui and Treagust (2010) stressed the importance of having contemporary knowledge on DNA, genes, and their relations to human affairs on making informed decisions about ethically and socially controversial issues. Genetics and the decision making process are also assumed to have an impact on individuals’ scientific literacy level (Freidenreich, Duncan, & Shea, 2011; Tsui & Treagust, 2010). Accordingly, comprehension of genetics is necessary not only to make thoroughly informed decisions about socio-scientific issues such as cloning, genetic screening, gene therapy and genetically modified foods but also their ethical, legal, and social implications (Fowler & Zeidler, 2010;...
Freidenreich et al., 2011). Therefore, it is important for modern societies to raise genetically literate individuals who make informed judgments and decisions about scientific and technological issues by utilizing their genetics knowledge.

Since available studies reported that genetics is among the topics that students struggle with serious conceptual difficulties (Duncan & Reiser, 2007; Jennings, 2004; Lewis & Kattman, 2004), it is crucial to improve students’ genetics knowledge for raising genetically literate individuals. To this end, a comprehensive genetics education framework is needed. This framework should not only comprise the basic knowledge of genetics concepts, but also the understanding and reasoning abilities of ethical, legal and social issues related with genetics, patient rights and collective common understanding of genetics-technology related issues (Jennings, 2004; Miller, 1998). For the development of this framework, it is imperative to determine both teachers’ and students’ genetics literacy level. Since pre-service science teachers are an indispensable part of this process, it is also necessary to uncover their genetics literacy level. Accordingly, the purpose of this study is to identify pre-service science teachers’ genetics literacy level and their attitudes towards genetics.

2. Method

2.1. Sample

A total 183 sophomore and senior pre-service science teachers (38 male, 139 female and 6 failed to report) who were selected from various universities participated in this study. Participants’ age ranged from 20 to 27 with a mean age 21.77 (SD= 1.59). All participants were enrolled the ‘Genetics and Biotechnology’ course in their 6th semester. Therefore, they were expected to have a certain level of genetics knowledge. While 4.6% of the participants perceived themselves as uninterested in genetics, 67.5% of them perceived themselves as little interested in genetics. Only 0.6% of participants thought that they were quite knowledgeable in genetics and majority of students (66.5%) thought that they were less knowledgeable in genetics. While 76.3% of participants believed that teaching genetics subjects is important as much as other science subjects, 89.6% of them believed that teaching genetics subjects does worth time and effort.

2.2. Instruments

2.2.1. Genetics Literacy Assessment Inventory

Pre-service science teachers’ genetics literacy level was determined through The Genetics Literacy Assessment Instrument developed by Bowling et al. (2008). The GLAI, originally includes 31 multiple choice items which assesses core concepts of genetics literacy such as gene regulation (4 items), nature of genetic material (8 items), gene expression (6 items), transmission (4 items), evolution (10 items), and genetics & society (7 items).

The test items were translated and adapted into Turkish and items which were not suitable for Turkish culture were replaced with the appropriate ones. Some additional items especially reflecting legal regulations according to Human Rights and Biomedical legislation were also added to the original inventory. Accordingly, the modified GLAI contains 39 multiple-choice items. After being examined by a group of experts, the GLAI was pilot tested. The internal consistency reliability (Kuder-Richardson-KR) was found as 0.72.

2.2.2. Genetics Attitude Scale

The Genetics Attitude Scale (see Acra, 2003) was used to gather information about participants’ attitudes towards genetics. The scale was translated and adapted into Turkish by the authors of the present study and pilot tested. The adapted scale included 8 items with a 5-point Likert format. Cronbach’s alpha reliability coefficient was found as 0.70.
3. Results

3.1. Descriptive Statistics

3.1.1. Pre-Service Science Teachers’ Genetics Literacy Level

Of a possible 39 correct responses on the test, a relatively low mean score of 15.39 was attained by the participants. This shows that, the participants responded correctly to less than 50% of the questions, indicating a very low level of genetics literacy.

<table>
<thead>
<tr>
<th>Dimension</th>
<th>% of participants with correct answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nature of the Genetic Material</td>
<td>51.57</td>
</tr>
<tr>
<td>Transmission of Genes</td>
<td>55.74</td>
</tr>
<tr>
<td>Gene Expression</td>
<td>31.51</td>
</tr>
<tr>
<td>Gene Regulation</td>
<td>37.43</td>
</tr>
<tr>
<td>Evolution</td>
<td>36.23</td>
</tr>
<tr>
<td>Genetics &amp; Society</td>
<td>28.96</td>
</tr>
</tbody>
</table>

As seen from the table, pre-service science teachers seemed to be slightly more knowledgeable about “the transmission of genes”. 55.74% of the participants correctly answered the questions in this dimension which implies that they are fairly knowledgeable about the concepts related to Mendelian patterns of inheritance and meiosis. Almost half of the participants (51.57%) were found to be moderately knowledgeable about the properties of DNA, DNA-gene and chromosomes interaction, gene activity and genetic variation which were reflected in “nature of genetic material” dimension. Similar percentages of participants correctly answered the questions regarding “gene regulation” (37.43%) and “evolution” (36.23%), implying that participants have relatively limited understanding of genetic variation-disease relationship, gene regulation and genetic variation-natural selection relationship. Furthermore, percentages of participants with correct answers in the “gene expression” and “genetics & society” dimensions were the lowest among all dimensions, indicating that they had quite low understanding of multiple genes, disorders with related multiple genes, gene-protein relationship and its interaction with the environment and current and future applications of genetics, science-ethnic-genetics concerns.

3.1.2. Pre-Service Science Teachers’ Attitudes towards Genetics

According to descriptive results, pre-service science teachers had quite favourable attitudes towards genetics ($M = 3.75$, $SD = 4.74$). For instance, less than half of the participants (46.5%) agreed on the importance of genetic engineering. While more than half of the participants (54.1%) believed that the role of public media in genetics is important, 20.6% of the participants remained undecided. While 31% of the participants agreed on the impact of genetic discoveries on their health, 26.2% indicated their disagreements on this issue. Moreover, 37.4% of the participants thought that “it was ethical to conduct medical research on embryonic stem cells”. However, approximately 35.1% of participants chose the “undecided” option for this item. These results revealed that although majority of pre-service science teachers had quite favourable attitudes towards genetics, some of them perceived the applications of genetics as suspicious.

3.1.3. Pearson correlations

3.1.3.1. Pearson correlations among dimensions of GLAI

The correlations among the six dimensions of the GLAI are presented in Table 2. An investigation of significance showed some relationships among the GLAI dimensions.
According to Table 2, the nature of genetic material positively correlated with transmission (r = .31; p < .01), gene expression (r = .24; p < .01), gene regulation (r = .40; p < .01), evolution (r = .35; p < .01) and genetics & society (r = .29; p < .01). These findings suggested that pre-service science teachers who understood the basic principles of genetics were more likely to understand the biological basis of Mendelian patterns of inheritance, gene-protein-environment relationships, multiple genes, genetic variation-disease relationship, turn on and off genes as well as the role of genetics as basis for evolution and its role in shaping current and future technologies. Statistically significant positive relationships were also found between gene expression and gene regulation (r = .26, p < .01), evolution (r = .33, p < .01) and genetics & society (r = .22, p < .01) indicating that high level of knowledge in gene expression is associated with a high level of knowledge in gene regulation, evolution and genetics & society. Furthermore, finding a statistically significant positive correlation between gene regulation and evolution (r = .36, p < .01) and genetics & society (r = .27, p < .01) indicated that pre-service science teachers with high levels of knowledge in gene regulation tended to have high level of knowledge in evolution as well as in genetics & society. Lastly, knowledge in evolution positively correlated with genetics & society (r = .27), implying that pre-service science teachers who possess high levels of knowledge in evolution were more likely to be knowledgeable in genetics & society (p < .01). Calculated correlations, in this study, ranged from small to moderate (Cohen, 1977; pp. 79-80). However, knowledge in transmission of genes was not significantly correlated with gene expression, gene regulation, evolution and genetics & society dimensions (p > .01) which indicated that participants’ knowledge in transmission did not necessary lead to an increase in their knowledge of gene expression, gene regulation, evolution and genetics & society.

3.1.3.2. The relationship between pre-service science teachers’ genetics literacy level and attitudes towards genetics

The Pearson correlation was conducted to examine the possible relationship between pre-service science teachers’ overall genetics literacy level and their attitude towards genetics. The results did not reveal a significant relationship between pre-service science teachers’ genetics literacy scores and their attitude scores towards genetics (r (161) = .08, p > .05). The results of this study provided no support for the relationship between genetics literacy level and attitude towards genetics.

4. Discussion and Conclusion

The present study investigated Turkish pre-service science teachers’ genetics literacy level, their attitudes towards genetics as well as the relationship between their genetics literacy level and attitudes towards genetics. Results revealed that pre-service science teachers had low levels of genetics literacy. Their knowledge levels with respect to dimensions of the GLAI were varied. This finding is consistent with previous studies (Acra, 2006, Bowling, 2007; Bowling et al., 2008; Moskalik, 2007) that reported relatively low levels of genetics literacy indicating limited understanding of basic genetics concepts at undergraduate level. In spite of their low genetics literacy level, pre-service science teachers tend to hold quite favorable attitudes towards genetics. The present study failed to report a significant statistical relationship between pre-service science teachers’ genetics literacy level and attitudes towards genetics which means that high levels of genetics literacy may not necessarily lead to a positive attitude or vice versa. This result is consistent with previous studies (Acra, 2006; Lanie et al., 2006) which reported an increase in knowledge was not associated with an increase in attitude scores towards genetics.

As Jennings (2004) highlighted, genetics literacy is necessary for conscious societies that understand and take the responsibilities of their own decisions in issues related to genetics. According to Acra, (2006), universities are the best places for evaluating, assessing as well as improving genetics literacy. Within this context, teacher education
departments play a critical role for training genetically literate teachers who are responsible for raising genetically literate individuals. To be brief, if they wish to prepare their students genetically literate, they themselves must be genetically literate. Therefore, teacher education programs needs to find ways to enhance their students’ literacy level regarding genetics. This research, however, has several limitations to consider. Thus, further research is needed to clarify the findings of the current study.

References