Full Length Research Paper

Integrating Argumentation in Bioethics Education: A Case Study on Genetically Modified Organisms and Genetic Screening

Melike Özer Keskin[1]*, Nilay Keskin Samanci[1], Hale Yaman[2]

[1]Faculty of Education, Biology Education Department, Gazi University, Turkey. *Corresponding author. E-mail: mozerkeskin@gmail.com.
[2]Mutlu Yasam College, Turkey.

Nowadays, there is a need in science education to consider scientific research and its applications alongside ethical consensus. Even though classroom debates of value issues have been demonstrated to significantly contribute to the raising of social consciousness and awareness, research shows that neither academics in higher education nor teachers in primary and secondary education deal with these issues sufficiently in their classes. In this study, the "*Framework for Teaching Bioethics*" was used in tackling the ethical issues about 'Genetic Screening Tests' (GST) and 'Genetically Modified Organisms' (GMOs). The present study examined the effect of "*Framework for Teaching Bioethics*" on students' argumentation quality and on students' ethical values which students consider while they are deciding about the ethical dilemmas. Also the contribution of individuals' content knowledge on the argumentation quality was examined. In this study a quasi-experimental pre-post test design was used. The participants of the study were biology teacher candidates (n=38). *Achievement Test (AT)* and *Bioethical Values Instrument (BVI)* were used as data collection tools. Also interviews were conducted with 12 of participants, who were selected according to their AT scores. During interviews, participants advanced their positions about ethical dilemmas, which were about *genetically modified organisms* and *genetic screening tests*. Participants' arguments assessed in terms of justifications and their scientific grounds based on a four point rubric *(Argumentation Quality Rubric)*. Results indicate that "*Framework for Teaching Bioethics*" significantly affected students' argumentation quality and content knowledge was not significant factor for prediction of argumentation quality.

Key words: Bioethics education, socioscientific issues, argumentation, genetically modified organisms (GMOs), genetic screening.

INTRODUCTION

The rapid advances currently witnessed in biological sciences have triggered a process in which individuals question the consequences and possible future impact of these developments, as in the last few decades the deve-lopments observed in biology and related sciences (medicine, genetics, biotechnology, and molecular biology in particular) have had a direct or indirect impact on individuals, societies, and their surroundings (Kormondy, 1990). With their roots dating back much earlier than the 1950's, these advances speeded up research in gene technology in the 20th century. Today, with health and agriculture at the top, many fields such as the environ-ment and industry make use of plants, animals, and microorganisms as biological systems. It is a fact that all

this work offers present and future benefits in the solution of the problems faced by societies. Their expected future benefits notwithstanding, these advances are still viewed with skepticism due to the ethical debates that both social and scientific circles engage in. This has raised the importance of 'science literacy' in science education, since analyzing the complex relationship between science and society and related skills are significant components of science literacy (Pella et al., 1966; Bybee and DeBoer, 1994; Sadler, 2004). From this standpoint, it is crucial that individuals, who will assume the social roles in the future, should be given the chance to raise their awareness and knowledge, and gain interpretation skills. In order to improve these skills, modern educational approaches look to alternative learning processes and strategies, the most noteworthy of these being bioethics education which aims to equip individuals with the skills necessary to interpret controversial issues from legal, cultural, religious, and social perspectives. Ethical contro-versies arising from biological sciences are debated in alternative processes in science classes, informing students of the risks, advantages, and disadvantages of a given issue, and enabling them to improve their judgment and reasoning skills. Although this may seem like a short-term academic target, it is crucial in that in the long run it improves individuals' abilities to tackle controversial issues from all aspects, realize their own values, and reach informed decisions (Willmott and Willis, 2008). Studies suggest that content knowledge must be complemented with social, cultural, religious, moral, and legal considerations in preparing individuals for their future social roles. Knowledge alone is not sufficient in improving informal reasoning and decision-making skills (Harding and Hare, 2000). For this reason, science classes have in the last few years been supported by a process of argumentative bioethics education where developments in biological sciences and ethical controversies arising from them are considered in order to raise social information, consciousness, and awareness.

Argumentation is considered to be one of the basic processes of explaining scientific concepts, asserting claims, producing and debating evidence that supports or refutes these claims, and interpreting the results obtained (Toulmin, 1969). This process can be described as a student-centered one in which the teacher as a facilitator avoids judgments and direct answers, encouraging students instead to share their knowledge by researching, thinking, and debating, thereby improving the values that they hold. Based on these dynamics of the process, it can be claimed that argumentation is quite an important component of science education. It is, however, rarely observed in schools (Chowning et al., 2012; Bell, 2004). One way to help students develop argumentation skills is to have them engage in argumentation, because they need experience and practice justifying their claims, recognizing and addressing counter-arguments, and learning about elements that contribute to a strong justification (Sadler, 2004; Herrenkohl and Guerra, 1998). In the argumentation process, the data, claims, and warrants are concerned with scientific data and scientific process. But such practices as evaluating evidence, assessing alternatives, establishing the validity of claims, and addressing counter positions are both important and necessary for ill-structured problems in socio-scientific issues (SSI) because socio-scientific argumentation involves the negotiation of ill-structured problems, regarding informal reasoning (Sadler and Donnely, 2006).

Bioethics education through an argumentative process focuses on students' negotiation skills with their peers regarding ethical issues, rather than their reaching the 'right' decision. A learning environment of questioning and explaining based on Socratic methodology, where students can realize their own values and apply them to situations concerning biological sciences, is central to bioethics education (Kormondy, 1990). The primary objective here is to let individuals discover their priorities and values. To achieve this, the individual studies the available options and possible consequences, discovers and explains their own values in the mean while, and shares them with others (Doğanay, 2006). This process therefore requires argument-forming and ethical decision-making skills from a critical perspective, for in the ethical decision-making process it is essential that the individual discovers their own values and makes rational, logical, and systematic analyses also taking into account other points of view (Güngör, 1993; Akbaş, 2004). From this viewpoint, *moral development* and individuals reaching *ethical maturity* are among the prioritized outputs of bioethics education (Macer, 2008).

In the process of bioethics education, it is essential that the individual should realize their own values and con-sciously explain them. To this end, the individual first studies the value problem, collecting information and evidence about it. They assess the truth and suitability of the information and evidence for possible solutions. In the mean time they discover and explain their own values, reach a decision, and share this decision with other individuals. Reaching a decision about a value problem in this process therefore requires scientific research and informal reasoning skills. For this reason, it is of crucial importance that these skills should be improved in an argumentative process.

In addition to basic content knowledge, argumentation based bioethics education involving informal reasoning and decision making skills is on the science education agenda. Controversial subjects with no clear cut answers do not fit easily within the traditional teacher centered models of instruction since these kinds of subjects require alternative learning settings where students can freely discuss and express their beliefs and values. Moving on from here, a process of argumentation-based bioethics education was laid out in collaboration with prospective teachers. In light of the data obtained, the impact of bioethics education on prospective teachers'
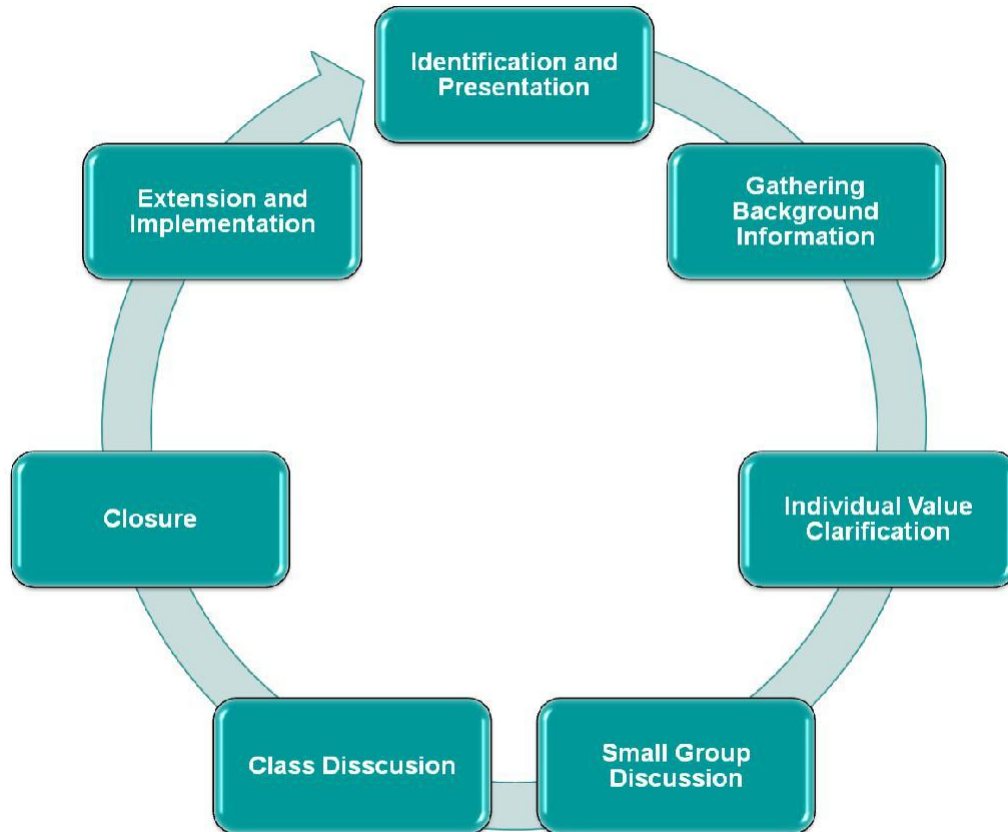
Figure 1. Framework for teaching bioethics (Smith, 1992).

argumentation skills was studied along with the impact of content knowledge on the quality of argumentation. The following research questions were then put forward:

(1) Is there a significant effect of "*Framework for Teaching Bioethics*" on students' argumentation quality?,
(2) How individuals' content knowledge contribute their argumentation quality?,
(3) Is there a significant effect of "*Framework for Teaching Bioethics*" on students' ethical values which students consider while they are deciding about the ethical dilemmas?

METHODOLOGY

Research design

In order to answer these research questions, a quasi experimental research method was used for this study. No control group was included in the design of the study. In the experimental group, the framework for teaching bioethics by Smith (1992) was used in tackling the ethical issues about 'Genetic Screening Tests' (GST) and 'Genetically Modified Organisms' (GMOs).

According to Smith (1992)'s framework, bioethics education is structured around seven sequential steps shown in Figure 1. Regarding these seven steps of the framework, the targets of each

step are summarized in Table 1 from the perspectives of the teachers and students.

In the context of the model summarized above, 'Genetic Screening Tests (GST)' and 'Genetically Modified Organisms (GMO)' were covered in the practices. Each topic took two hours a week for three weeks, with the practices thus taking six weeks in total. The stages of the model illustrated above are as follows.

Identification and presentation of the dilemma

The researcher made a presentation on definitions of ethics in this first stage which aimed to have the prospective teachers identify the ethical problem and explain the situation that causes the ethical controversy. Scenarios involving ethical dilemmas on genetic screening tests and genetically modified organisms were then read out to the prospective teachers, who in turn were asked to write argumentative essays answering such questions as 'What is the basic problem in the dilemma?', 'Who are the stakeholders?', 'What values must be considered in the decision-making process?'.

Gathering background information

Sample articles selected from science and technology journals and national peer reviewed journals were presented to the prospective teachers in this stage which aimed to increase their knowledge of GSTs and GMOs and made them realize the link between scientific knowledge and ethical dilemmas. The prospective teachers were asked to read and summarize these articles.

Table 1. Gradual definition of the framework for teaching bioethics by Smith (1992)

Teacher activities		Student activities
To monitor and check student's perception of dilemma/develop dilemma through questioning	IDENTIFICATION AND DEVELOPMENT (Is there a dilemma?)	To identify, understand, refine, revise dilemma/to understand meanings of words
Assign readings, articles, activities/provide the facts	BACKGROUND INFORMATION (What are the facts?)	To complete all assigned activities: articles, films, newspapers, etc.; start dilemma based on information
Guide through value clarification	INDIVIDUAL VALUE CLARIFICATION (Who am I?)	Examine individual perspectives
Stimulate discussion with "construct" questions/create disequilibrium	SMALL GROUP DISCUSSION (Understanding)	Declare personal values, positions, and solutions to group
Co-ordinate discussion and thinking with "construct" questions/ create disequilibrium or support	CLASS DISCUSSION (Agreement)	Group reports, discussion of issues, implications, consequences, solutions
Summarization and review of process	CLOSURE (Summary)	Review main ideas and points of agreement/ metacognition
Determine relevant activities/action	EXTENSION OR IMPLEMENTATION (Optional)	Further research, case studies or promote action

Individual value clarification

This stage involved an activity with the prospective teachers who, having identified and analyzed the ethical dilemma and done the relevant reading, were intended to achieve value clarification and a realization of their own opinions. They were given 10 minutes in which to write their decisions on the ethical dilemma and the justifications for their decisions.

Small group discussion

Having stated their opinions on the ethical dilemma, the prospective teachers were divided into small groups by the researcher. They were intended to debate the scenario on the ethical dilemma during the discussion period. Each group was monitored during the discussions and follow-up questions were asked to enhance the debate where necessary. The trigger question and the follow-up questions were meant to point out all parties involved and the different perspectives that come into play in the decision-making process. At the end of the discussions, the prospective teachers' opinions and their justifications were written up in a report.

It was important for the prospective teachers, who had shared their individual opinions on the ethical dilemma with the researcher, to hear their peers' opinions in these small group discussions, to realize the existence of different points of view, and to gain the skills to review and question their own stand when necessary.

Class discussion

The prospective teachers divided into small groups share their opinions and their justifications with the whole class in this stage. The groups threw questions at one another, which brought about a large group discussion. In this way, all opinions were heard out and questioned.

The primary goal in this stage was not to reach a common decision; it was rather to enable the prospective teachers to realize different perspectives and to review their own decisions.

Closure and summary

In this stage the researcher summarized the topic in its outlines. The values and the ethical principles considered in the decision making process were outlined and all parties and factors involved were taken into consideration again in the context of the scenario.

The next stage in the selected research model is *extension and implementation* but this was optional. The students may do further research, deepen their knowledge, and share their findings with the researcher if they wish to.

Research Group

The research group of the study was composed of the prospective teachers studying at the School of Education of a university in Ankara. 38 prospective teachers in their third year took part in the study. Participants were chosen according to a purposive sampling scheme.

Data collection and data analysis

Both quantitative and qualitative data collection techniques were used in the study. The quantitative data involved a pre-test of an 'Achievement Test' and a 'Bioethical Values Inventory' given out to the prospective teachers before the implementation of the

Table 2. Argumentation quality rubric revised from Sadler and Fowler (2006)

Score	Reference	Sample answer
0	No claim or justification	I don't know / I have no knowledge of this
1	Claim with no or scientifically wrong justification	Yes, it should be done / No, it shouldn't Because the genes may mix with the soil
2	Claim with a simple justification	Yes, it should be done if it's beneficial / No, it would be unjust
3	Claim with one or more detailed justifications or counter-arguments	No, because this might tip the balance of nature in favor of one gender, which could in turn cause social divisions and fractions. However, the right of gender determination could be reserved in cases of hereditary diseases so that these will not be passed on to future generations.

argumentation-based process of bioethics education. After the implementation, the same tests were administered as a post-test. The qualitative data, on the other hand, involved a series of semi-structured interviews with the prospective teachers conducted prior to and following the implementation. These interviews were intended to reveal the prospective teachers' individual values and justifications in their decision-making processes. They were further intended to reveal the quality of the prospective teachers' argumentation skills.

Achievement Test (AT)

A multiple-choice 'Achievement Test' of 20 items was prepared to be administered as a pre-test and a post-test. The test covered nucleic acids, basic genetic principles, and protein synthesis. In the pilot implementation, the test was administered to 156 prospective teachers studying biology education. An item analysis was carried out in light of the data obtained from the pilot study. Those items with a total correlation lower than .20 were taken out of the test. The Kuder-Richardson-20 (KR-20) factor was also calculated for the internal consistency of the test scores and was found to be .773.

Bioethical Values Inventory (BVI)

The 'Bioethical Values Inventory' designed by Keskin (2009) was used to find out the prospective teachers' values in their decision-making processes regarding the scenarios on the inventory. To this end, the inventory was administered as a pre-test and a post-test. It included eight scenarios of ethical dilemmas involving the use of animals in experiments, prenatal genetic screening and abortion, pre-determination of the gender and physical features of babies, and cloning for treatment purposes. The values that could be considered by the students in their decision making processes were given in the choices and the students were asked to choose the one that suited them best. The students' answers to the inventory were evaluated according to the ethical principle represented by each choice. These ethical principles were the Utilitarian Approach, Rights Approach, Justice Approach, Virtue Approach, Normative Approach, Theological Approach, Preference for the Natural, Science and Technology Based Approach, and Belief in Humans' Superiority to Other Living Beings.

Semi-Structured Interviews

Semi-structured interviews were conducted with 12 prospective

teachers about GSTs and GMOs, the basic topics in the bioethics education process of the study. They were asked to state their opinions on the dilemmas in the scenarios.

The 12 interviewees were selected on the basis of their achievement test scores. The scores were listed from top to bottom and four students from each of the top, middle, and bottom ranges were randomly selected. Semi-structured interviews were conducted with these 12 prospective teachers.

The interviews were tape recorded and then the recordings were transcribed. These were used to reveal the quality of the students' argumentation skills. For this purpose, the 'Argumentation Quality Rubric' designed by Sadler and Fowler (2006) was revised and used. The revised argumentation quality rubric used in this study is given in Table 2.

The rubric has four different scores from 0 to 3 reflecting the quality of the claims (opinions/decisions) and justifications. If there is no claim or justification, the score is 0. If there is a claim and it is justified in detail, the score is 3. The students' argumentative responses to the scenarios were independently evaluated and scored by three researchers according to the rubric. The average of these scores reflects the score for each scenario. The basic criteria in the evaluation of the interview recordings and score samples are given in Table 3.

FINDINGS AND INTERPRETATIONS

Findings on Research Problem 1

'Does the process of bioethics education have an effect on the quality of prospective teachers' argumentation?'

In order to detect any effect that the process of argumentative bioethics education may have on prospective teachers' argumentation quality, their achievement test scores were listed from top to bottom and four students from each of the top, middle, and bottom ranges were randomly selected. This research problem was worked on with a total of 12 prospective teachers.

Semi-structured interviews were conducted with these prospective teachers about GSTs and GMOs, on the basis of the scenarios, prior to and following implementation. Their responses were evaluated by means of the argumentation quality rubric. The results from pre-and post-interviews were analyzed by means of the

Table 3. Examples from the evaluation of the answers given by the prospective teachers in the semi-structured interviews according to the argumentation quality rubric

Student	Score	Reference	Sample answer
-	0	No claim or justification	-
Ö3	1	Claim with no or scientifically wrong justification	"*I think it could be done.* Because if we carry cancer genes and it could be spread to others at work, the company would be right in demanding such a screening test.."
A1	2	Claim with a simple justification	"*….the company should have the right to demand GSTs from its employees.* It is necessary for the company and the individuals. If a person's health is too poor to do their work at the company, then the company has the right to not recruit that person. Other people's health shouldn't be put at risk either."
Ü1	3	Claim with one or more detailed justifications or counter-arguments	"*I think the company should have no such right.* Demanding a genetic screening test is a natural right – is the candidate physically and mentally up to the job? But they shouldn't have the right to refuse employment because of a cancer risk as with ever-developing technologies treatment is easier and more readily available. If however they refuse employment, Hakan might miss the treatment opportunities because of lack of income. But I believe the company should be able to demand the tests."

The table shows the claims in italics and the justifications underlined.

Table 4. Wilcoxon signed-rank test results on the effects of the framework on argumentation quality

Post-interview – Pre-interview	n	Rank average	Rank total	Z	p
Negative rank	0a	0.00	0.00	2.12	.034
Positive rank	5b	3	15	-	-
Equal	7c	-	-	-	-
Total	12	-	-	-	-

Wilcoxon signed-rank test and are shown below in Table 4.

The results summarized in Table 4 are indicative of a significant difference between the prospective teachers' scores from the semi-structured interviews prior to and following the bioethics education process (z=2,12; p<,05). When the rank average and total of the score differences are taken into account, the difference is seen to be in favor of the post-interview scores. These results could be interpreted as the bioethics education process had a positive effect on teachers' argumentation quality.

Findings on Research Problem 2

'Is prospective teachers' level of scientific knowledge a factor affecting the quality of argumentation?'

In order to detect any effect that the prospective teachers' level of scientific knowledge may have on their argumen-tation quality, the knowledge test scores and data from the semi-structured interviews obtained by means of the argumentation quality rubric were analyzed together. In the analysis of the data from the top, middle, and bottom ranges, separate Wilcoxon signed-rank tests were carried out for each subgroup, with the results shown in Table 5.

The results from the analysis of semi-structured pre- and post-interviews indicate no significant difference between the groups as far as argumentation quality is concerned (p_{top}=0,157; p_{mid}=0,317, p_{bot}=0,180). This could be interpreted as scientific knowledge not being a variable affecting students' argumentation quality.

Findings on Research Problem 3

'Does the process of bioethics education in place have an effect on prospective teachers' ethical values?'

In order to detect any effect that the process of bioethics education may have on prospective teachers' ethical values, the bioethical values inventory designed by

Table 5. Wilcoxon signed-rank test results on the effects of scientific knowledge on argumentation quality

	Post-Interview – Pre-Interview	n	Rank average	Rank total	z	p
TOP GROUP	Negative rank	0	.00	.00	1.414	.157
	Positive rank	2	3.00	1.50	-	-
	Equal	2	-	-	-	-
MIDDLE GROUP	Negative rank	0	.00	.00	1.000	.317
	Positive rank	1	3.00	1.00	-	-
	Equal	3				
BOTTOM GROUP	Negative rank	0	.00	.00	1.34	.180
	Positive rank	2	3.00	1.50	-	-
	Equal	2	-	-	-	-

Table 6. Findings on the effects of the bioethics education process in place on prospective teachers' ethical values

Approaches	PRE-TEST								POST-TEST							
	Scenario No (%)								Scenario No (%)							
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
U	-	22,2	-	9,1	3,1	15,6	19,4	23,3	-	29,6	-	3,0	3,1	6,3	48,4	50,0
R	3,1	40,7	-	-	96,9	9,4	48,4	-	3,1	37,0	6,3	-	96,9	12,5	35,5	-
J	9,4	-	-	6,1	-	-	-	-	3,1	-	-	3,0	-	-	-	-
V	-	-	53,1	-	-	-	-	6,7	-	-	31,3	6,1	-	-	-	-
N	46,9	-	3,1	48,5	-	-	-	36,7	56,3	-	3,1	63,6	-	-	-	26,7
T	-	25,9	15,6	-	-	-	-	6,7	-	18,5	18,8	-	-	-	3,2	6,7
PN	-	-	25,0	18,2	-	9,4	9,7	-	-	-	40,6	9,1	-	12,5	12,9	-
S	34,4	11,1	3,1	18,2	-	65,6	22,6	26,7	37,5	14,8	-	15,2	-	68,8	-	16,7
HS	6,3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

U: Utilitarian; R: Rights; J: Justice; V: Virtue; N: Normative; T: Theological; PN: Preference for Natural; S: Scientific; HS: Belief in Humans' Superiority to Other Living Beings

Keskin (2009) and consisting of eight scenarios was administered as a pre- and post-test. The students' answers to the inventory were evaluated according to the ethical principle represented by each choice. The findings are given in Table 6.

Table 6 showed that in the decision-making process for Scenario 1 from the Bioethical Values Inventory, 34.4% of the prospective teachers had a scientific approach. 46.9% of the prospective teachers had a normative approach. In the Bioethical Values Inventory administered as a post-test, 56.3% of the prospective teachers had a normative approach. For this scenario, they preferred the scientific approach (37.5%) too. The data for Scenario 2 showed that the prospective teachers prioritized a rights approach (40.7%), a theological approach (25.9%), and a utilitarian approach (22.2%). In the post-test, the balance was shifted to the rights (37.0%), the utilitarian (29.6%), the theological (18.5%) and the scientific (14.8%) approaches.

The data for Scenario 3 showed that 53.1% of the prospective teachers had a virtue approach. The percentage of a preference for the natural approaches was 25.0%. In the post-test, the percentages for the virtue and the preference for the natural approaches were 31.3% and 40.6%, respectively. For Scenario 4, the prospective teachers preferred the normative approach (48.5%), the scientific approach (18.2%) and preference for the natural (18.2%). In the post-test, the prospective teachers' preferences were changed. The percentages for the normative, the scientific and the preference for the natural were 63.6%, 15.2%, and 9.1%, respectively.

Table 6 suggests that in the pre-test and post-test decision making processes, the rights approach (96.9%) and the utilitarian approach (3.1%) were prioritized for Scenario 5. For Scenario 6, the scientific approach was the most common preference (65.6%), followed by the utilitarian approach (15.6%). In the post-test, the scientific approach was top (68.8%) followed by the rights

Table 7. Changes in ethical considerations by prospective teachers in decision-making processes

Scenario no	Change in ethical considerations (%)
Scenario 1	46.88
Scenario 2	33.33
Scenario 3	34.38
Scenario 4	48.48
Scenario 5	6.25
Scenario 6	46.88
Scenario 7	51.61
Scenario 8	46.88

approach and preference for the natural (12.5%).

For Scenario 7, 48.4% of the prospective teachers considered the rights approach. The scientific approach (22.6%), and the utilitarian approach (19.4%) were also taken into account in the pre-test. In the post-test, however, 48.4% of the prospective teachers considered the utilitarian approach. It was followed by the rights approach (35.5%). The findings for Scenario 8 suggest that the normative approach was preferred by 36.7% of the prospective teachers in the pre-test. It was followed by the scientific approach (26.7%). The post-test figures were 26.7% for the normative approach and 50.0% for the utilitarian approach.

In brief, Table 6 suggests that the ethical values considered by the prospective teachers before and after argumentative bioethical practices do indeed differ. For this reason, the percentage of this pre- and post-tests change in the whole inventory was also studied. The findings are presented in Table 7.

Table 7 shows that the change in ethical considerations before and after implementation is in the range of 33 to 51% for all scenarios with the exception of Scenario 5.

RESULTS AND DISCUSSION

'Questioning skills' form the basis of science literacy and are directly linked to the argumentation process, which is used in constructing scientific thoughts, reasoning, and testing knowledge, and which requires thinking and behaving like a scientist (Bricker and Bell, 2008). Studying the basic dynamics of today's science education reveals that scientists' methods for explaining the nature resemble those for solving daily problems (NRC, 1996). This perspective plainly shows the importance of argumentative learning processes for science education. These processes are conducive to a learning environment that supports students' perceptions of science literacy, which is directly related to the ability to ask questions about daily situations, to find answers to these questions, or to make decisions in such situations since individuals in our age must keep pace with developing

technologies and make informed decisions about the daily impact and possible future consequences of these technologies.

In both their private and professional lives, people make choices, consciously or unconsciously, among the possibilities that they encounter (Rue and Byars, 2003; p.68). Broadly speaking, decision making is 'to choose or prefer the most suitable of the available and possible ways of action in order to reach a goal'. From this point of view, it could be considered as a preference. However, making a preference is only one part of the decision making process, in which the individual first gets a grasp of the problem and relevant opportunities, and uses the resources available for the solution of the problem (Daft, 2003). It is therefore crucial that learning processes are constructed with an argumentative approach focused on problem solving skills so that individuals can gain decision making skills regarding ethical controversies caused by biological sciences. Research in this field suggests that tackling socio-scientific issues in science classes is a good way to improve students' informal reasoning and argumentation skills (Kortland, 1996; Zohar and Nemet, 2002; Sadler, 2004).

This was the starting point for the development of an argumentative bioethics education process tackling the issues of GMOs and GSTs in this study, which aimed to observe the change in prospective teachers' argumentation skills and their ethical considerations in decision-making. The findings suggest that the argumentative bioethics education process implemented had a positive effect on prospective teachers' argumentation skills. Many studies conclude that argumentative processes improve students' academic performance, conceptual comprehension, attitudes, and decision making and argumentation skills (Akkuş et al., 2007; Günel et al., 2010; Zeidler et al., 2009). Studies focusing on argumen-tative processes in our country have also drawn similar conclusions. Deveci (2009), for instance, found that, in chemistry classes with an argumentative focus, the students in the experiment group performed better than those in the control group in terms of their knowledge levels and cognitive thinking skills. Yeşiloğlu (2007) also found that argumentative learning activities have an impact on students' conceptual improvement.

This study also looks at the impact that content knowledge has on argumentation skills. The findings suggest, however, no statistically significant effect of genetics and biology knowledge – the basis of GMOs and GSTs – on skills affecting argumentation quality. Re-search in this field has comparatively studied the link between argumentation quality and content knowledge in scientists, lay people, and students. In those studies, scientists with more content knowledge were found to have better argumentation quality (Hogan and Maglienti, 2001; Kuhn, 1991). Sadler and Fowler (2006), however, looked at the link between the knowledge of genetics and argumentation quality, and found no statistically significant

correlation – a conclusion parallel to the findings of the present study. This study also detects a change in prospective teachers' ethical considerations in their decision making processes on the basis of scenarios involving ethical controversies. This could be interpreted as a link between bioethics education with an argumentative focus and discovering and adopting fresh points of view on ethical issues.

In brief, the relevant literature and the findings of this study conclude that bioethics education with an argumentative focus will improve individuals' questioning, researching, problem solving, informal reasoning, and decision making skills, highly prized in today's societies.

REFERENCES

Akbaş O (2004). Türk Milli eğitim sisteminin duyuşsal amaçlarının ilköğretim II. kademedeki gerçekleşme derecesinin değerlendirilmesi, Yayınlanmamış doktora tezi, Gazi Üniversitesi Eğitim Bilimleri Enstitüsü, Ankara.

Akkuş R, Günel M, Hand B (2007). Comparing an inquiry-based approach known as the science writing heuristic to traditional science teaching practices: Are there differences? Int. J. Sci. Educ. 14(5):1745-1765.

Bell P (2004). Promoting students' argument construction and collaborative debate in the science classroom. Mahwah, NJ: Erlbaum.

Bricker LA, Bell P (2008). Conceptualizations of argumentation from science studies and the learning sciences and their implications fort he practices of science education, Sci. Educ. 92:473-498.

Bybee RW, DeBoer G E (1994). Research on goals for the science curriculum. Handbook Res. Sci. Teach. Learn. pp.357-387.

Chowning JT, Griswold JC, Kovarik DN, Collins LJ (2012). Fostering Critical Thinking, Reasoning, and Argumentation Skills through Bioethics Education. PLoS ONE 7(5):e36791. doi:10.1371/journal.pone.0036791.

Daft R (2003). Management (6th Edition), South-Western College Pub.

Deveci A (2009). İlköğretim yedinci sınıf öğrencilerinin maddenin yapısı konusunda sosyobilimsel argümantasyon, bilgi seviyeleri ve bilissel düşünme becerilerini geliştirmek. Marmara Üniversitesi Eğitim Bilimleri Enstitüsü, İstanbul.

Doğanay A (2006). Dğereler eğitimi, Cemil Öztürk (Editör). Hayat Bilgisi ve Sosyal Bilgiler Öğretimi. Ankara: Pegem A Yayıncılık.

Günel M, Kabatas-Memis E, Büyükkasap E (2010). Yaparak yazarak bilim öğrenimi-YYBÖ yaklaşımının ilköğretim öğrencilerinin fen akademik başarısına ve fen dersine yönelik tutumuna etkisi. Eğitim ve Bilim 35(155):49-62.

Güngör E (1993). Değerler psikolojisi. Hollanda-Türk Akademisyenler Birliği Vakfı Yayınları, Amsterdam.

Harding P, Hare W (2000). Portraying science accurately in classrooms: emphasizing openmindedness rather than relativism. J. Res. Sci. Teach. 37:225-236.

Herrenkohl LR, Guerra MR (1998). Participant structures, scientific discourse, and student engagement in fourth grade. Cogn. Instr. 16:431-473.

Hogan K, Maglienti M (2001). Comparing the epistemological underpinnings of students' and scientists' reasoning about conclusions. J. Res. Sci. Teach. 38:663-687. doi: 10.1002/tea.1025.

Keskin SN (2009). Biyoetik Eğitimi Kapsamında Ortaöğretim Öğrencilerine Yönelik "Biyoetik Değer Envanteri" Geliştirilmesi. Yayınlanmamış doktora tezi, Gazi Üniversitesi Eğitim Bilimleri Enstitüsü, Ankara.

Kormondy EJ (1990). Ethics & Values in the Biology Classroom, Am. Biol. Teach. 52(7):403-407.

Kortland K (1996). An STS case study about students' decision making on the waste issue, Sci. Educ. 80:673-689.

Kuhn D (1991). The skills of argument. New York: Cambridge University Press.

NRC (National Research Council) (1996). National Science Education Satndarts; National Academy Pres: Washington, DC.

Macer D (2008). Moral games for tecahing bioethics, UNESCO Chair in Bioethics Office, The University of Haifa, Israel.

Pella MO, O'hearn GT, Gale CW (1966). Referents to scientific literacy. J. Res. Sci. Teach. 4:199-208. doi: 10.1002/tea.3660040317.

Rue LW, Byars L (2003). Management, Skills and Application, 10 ed., McGraw-Hill/Irwin, New York.

Sadler TD (2004) Informal reasoning regarding socioscientific issues: A critical review of research. J. Res. Sci. Teach. 41:513-536.

Sadler TD, Donnelly LA (2006). Socioscientific argumentation: The effects of content knowledge and morality. Int. J. Sci. Educ. 28(12):1463-1488.

Sadler TD, Fowler SR (2006). A threshold model of content knowledge transfer for socioscientific argumentation. Sci. Educ. 90:986-1004. doi: 10.1002/sce.20165.

Smith W (1992). A Process: Framework For Teaching Bioethics, Woodrow Wilson Biology Institute. Web: http://www.woodrow.org/teachers/bi/1992/teaching_bioethics.html.

Toulmin S (1969). The Uses of Argument. 1958. Reprint, New York: Cambridge.

Willmott C, Willis D (2008). The increasing significance of ethics in the bioscience curriculum, J. Biol. Educ. 42(3):99-102.

Yeşiloğlu NS (2007). Gazlar konusunun lise öğrencilerine bilimsel tartışma (argümantasyon) odaklı yöntem ile öğretimi. Gazi Üniversitesi Eğitim Bilimleri Enstitüsü, Ankara.

Zeidler DL, Sadler TD, Applebaum S, Callahan BE (2009). Advancing reflective judgment through Socioscientific Issues. J. Res. Sci. Teach. 46:74-101. doi: 10.1002/tea.20281.

Zohar A, Nemet F (2002). Fostering students' knowledge and argumentation skills through dilemmas in human genetics. J. Res. Sci. Teach. 36:35-62.