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The impact of teaching via educational films on science teacher candidates' perceptions of biotechnology applications

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Abstract

This study aims to investigate the influence of teaching viaeducational films on science teacher candidates' perceptions of biotechnology applications. This is a mixed-methods study aiming to investigate the influence of teaching with educational films on science teacher candidates' perceptions of biotechnology applications. In the quantitative data collection process of the research, a single group pre-test / post-test experimental design was used. And the phenomenology method was used, on the other hand, to collect the qualitative data of the study. For this research, which aims to investigate the influence of teaching with educational films on science teacher candidates' perceptions of biotechnology applications, 32 second-year science teacher candidates at a state university in Ankara were recruited. Two data collection tools were used in the study. The perception scale for biotechnology applications developed by the researchers was used to collect the quantitative data of the study. While the interview form was used to collect the qualitative data of the study. According to the results the study found that teaching with educational films increased the perceptions of science teacher candidates about biotechnology applications. within the scope of the research, the question of whether teaching a lesson with educational films has an effect on changing their perceptions about the subject, and if so, how this change occurs, was asked during the interview stage, and it was found that the majority of the teacher candidates perceived a meaningful change.

Keywords: biotechnology applications; educational films; perceptions; science teacher candidates'

1. Introduction

Countries need science and technology to maintain and raise their living standards. Scientifically and technologically nations play a pioneering role on the global stage. One of the most important fields of science and technology with a considerable impact on our

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lives is biotechnology (Pardo, Midden & Miller, 2002). Findings in biotechnology are reflected in developments in the fields of health, agriculture, environment, industry etc. (Bilen & Özel, 2012; Simonneaux, 2002). Biotechnology applications are products produced for a different or special situation by directly using living things or changing their structures with technological applications (Bruschi et al., 2011). Biotechnology is a general term that covers many fields. Genetically modified organisms, stem cells, nanotechnology and cloning are some of the newest biotechnology applications. Genetically modified organisms are organisms involve the altering of the gene sequences of living beings/organisms and replacing their existing characteristics with new ones (Oğur, Aksoy & Yılmaz, 2017). Genetically modified organism technology has many different uses, such as increasing the nutritional value/yield of food products, treating diseases, drug production, vaccine production and organ transplant as well as extending the shelf life of vegetables and fruits (Özel & Gökmen, 2020; Söyler, İpar & Kocatepe, 2021). One of the fields biotechnology focuses on is stem cells. Stem cells are cells that have the ability to constantly renew themselves and differentiate themselves into different cell types, and realize these properties through unique signals (Fortier, 2005; Kansu, 2002; Odorico, Kaufman & Thomson, 2001). Stem cells are currently used for treating different types of cancer, metabolic diseases, nervous system diseases, rheumatic diseases, organ failures, bone diseases, heart diseases (Thiemen & Palladino 2013). In addition, studies show that stem cell technologies can be used in the future for new organ production, reproduction, development and growth, and the regeneration of extinct animals (Çelik & Balık, 2016). In light of these studies, it can be said that stem cell technology can improve human health and raise living standards (Antonica, 2015; Lathia, Mack, Mulkearns-Hubert, Valentim & Rich, 2015). Another field of biotechnology is nanotechnology. Nano means one billionth of a meter. Nanotechnology works on atomic and molecular structures between 1 and 100 nanometers in size and the interactions between them (Katz, Shipway & Willner, 2004; Liz-Marzan & Kamat, 2004; Whitesides, 2005). Nanotechnology aims at synthesizing new nanostructures or giving these nanostructures new properties (Çıracı, 2006). Thanks to nanotechnology, it is possible to make new nano-scale devices and materials by processing matter at the nanometer level and making use of their different properties (Karataş & Ülker, 2014). Another field of biotechnology is cloning. Cloning a living thing means the creation of an identical being in terms of its genetic content, that is, the production of its genetic twin (Turan, 2020). However, applying this technology in practical terms is not as straightforward as it sounds. Cloned creatures tend to suffer from respiratory failure, liver, kidney, brain and heart damage, obesity and premature death (Seyalıoğlu, Eraslan, Hot, Demircan & Çetin, 2007).

Although biotechnological applications have emerged for the benefit of humanity and are therefore developing rapidly, they cause anxiety and fear as they bring with them certain issues. (Bogner & Torgersen, 2014; Çoban, 2004; Edmondston, Dawson &

Schibeci, 2010; Kulaç, Ağırdil & Yakın, 2006; Öktem, 2007; Simonneaux, 2002). To address these concerns and lead biotechnology in the desired direction, individuals should be aware of the issues and concepts related to these technologies, as well as their ethical and legal dimensions (Mehta & Gair, 2001).

However, research shows that many people in our country and in the world have little knowledge about biotechnology and its applications (Bal, Keskin Samancı & Bozkurt, 2007; Darçın & Türkmen, 2006; Prokop, Lešková, Kubiatko & Diran, 2007). This is attributable to the abstract and complex nature of biotechnology subjects, their constant updating and teachers improperly qualified to teach the subject (Kidman 2009; Turan & Koç 2012). Therefore, it is of great importance that teachers raising future generations have sufficient knowledge about biotechnology. The responsibility falls on teacher training institutions to address these issues. When the science teaching undergraduate program is examined, it is seen that biotechnology subjects are included in the Biology III course. In addition, biotechnology is taught as a socio- scientific subject within the scope of the Interdisciplinary Science Teaching Course. (Council of Higher Education, 2018). It is important for individuals with biotechnology training to have both conceptual knowledge and analytical and synthesis skills to transfer them to actual life situations so that people can have better standards of life (Kirkpatrick, Orvis & Pittendrigh, 2002). However, the multidisciplinary nature of biotechnology subjects and the fact that they contain complex information from many disciplines create difficulties for those trying to learn the field, as mentioned above. (Thieman & Palladino, 2013). Therefore, the use of different tools in the teaching of these subjects can increase the quality of teaching (Taşdelen & Güven, 2021). One of these tools is educational films. Films can be defined as teaching materials or resources that deal with events that have occurred or are likely to occur, engage multiple senses of students and create an impactful educational environment (Korkmaz, 2017). Using films to teach a subject facilitates the understanding of complex information and enables the dynamic, visual and acoustic transmission of information. This ensures that students are also exposed to exemplary behavioral patterns (Birkök, 2008). Furthermore, Demircioğlu (2007) states that through films students can acquire synthesis, analysis and evaluation skills, which are high- level thinking skills. People's life spans are not long enough to experience many situations. At this point, films can compensate for the limited lifespan of people by providing them with different experiences (Blasco, Moreto, Blasco, Levites & Janaudis, 2015). In addition, films contribute to the development of students' social skills (Lindgren, Sparrman, & Barajas, 2012). Along with these, movies also nurture the creative side of people as they allow the expression of thoughts, events or situations using their imagination (Demircioğlu, 2007). Considering all these contributions of films, using films in teaching biotechnology, which is a difficult subject to learn and internalize, can contribute to learning outcomes. In this context, this study aims to investigate the influence of

teaching with educational films on science teacher candidates' perceptions of biotechnology applications.

2. Method

2.1. Research design

This is a mixed-methods study aiming to investigate the influence of teaching with educational films on science teacher candidates' perceptions of biotechnology applications. In a mixed methods study, quantitative and qualitative data are collected and evaluated together (Creswell, 2013). More specifically, it employs the explanatory design approach, a component of the mixed methods study. With explanatory design, firstly, quantitative data is collected, then qualitative data is collected and quantitative data is buttressed by qualitative data. (Gültekin, Bayır & Yaşar, 2020). In the quantitative data collection process of the research, a single group pre-test / post-test experimental design was used. In a single group pre-test post-test design, pre- and post-process data from the partner group are collected and analyzed (Büyüköztürk, Akgün, Karadeniz, Demirel & Kılıç, 2013; Karasar, 2012). The phenomenology method was used, on the other hand, to collect the qualitative data of the study. Phenomenology research aims to reveal individuals' perceptions of facts and events (Rose, Beeby & Parker, 1995).

2.2. Study group

For this research, which aims to investigate the influence of teaching with educational films on science teacher candidates' perceptions of biotechnology applications, 32 second-year science teacher candidates at a state university in Ankara were recruited.

2.3. Data collection tool

Two data collection tools were used in the study. The perception scale for biotechnology applications developed by the researchers was used to collect the quantitative data of the study. While the interview form was used to collect the qualitative data of the study. The semi- structured interview form, prepared by the researchers, consists of two questions. The interview questions prepared by the researchers were presented to four faculty members in the areas of science education, biology education, and measurement and evaluation, and necessary arrangements were made according to the suggestions. The interview questions used in the research are as follows.

1. When you think about the implementation process, did your perceptions about the subject change? how?
2. Rate your level of change in your perception on a scale of 0 to 10'.

2.3.1. Development process of the perception scale for biotechnology applications

Looking at the literature, researches developed a range scales, such as the Attitude Scale towards Genetically Modified Organisms (Güney, 2018), the Perception Scale for Stem Cells (Gönültaş, Ateş & Taflı, 2018), the Knowledge Scale of Biotechnology (Atasoy, Atıcı, Taşar & Taflı, 2020), and the Attitude Scale of Nanotechnology (Kurnaz & Bayraktar, 2012). However, there is no perception scale dealing with genetically modified organisms, stem cell technology, genetic cloning and nanotechnology included in the scope of this research. The reason why the subjects genetically modified organisms, stem cell technology, genetic cloning and nanotechnology were chosen for the purposes of the research study is that these four subjects are among current biotechnological applications. The study intends to make a contribution to the existing literature by investigating the level of perception of teacher candidates by developing a perception scale for biotechnological applications that address these four biotechnological topics together.

In the first stage of the scale development process, a 32-item pool was created to determine science teacher candidates' perceptions of biotechnology applications. When preparing the items, care was taken to ensure that all items contain a single judgement and that they are clear and understandable. The scale was prepared as a 3-point Likert-type scale, including the points of "yes", "no" and "I don't have an opinion".

Experts were consulted for their opinions to ensure the content validity of the draft scale which was prepared as a 3-point Likert-type scale with 32 items. The scale was reviewed by two faculty members serving at the science education department and one faculty member serving at the biology education department for content validity; by one faculty member serving at the assessment and evaluation department for compliance with the assessment and evaluation criteria; and finally, by a linguist for compliance with grammar rules and clarity. Necessary adjustments were made to the scale items in line with expert feedback.

Then, interviews were conducted with 15 science teacher candidates on the intelligibility of the items in the scale. At the end of the interviews, it was determined that the scale items were understandable and it was decided that the application time of the scale would be 10 minutes.

The draft scale was applied to a total of 277 teacher candidates studying in the biology and science teaching departments of a state university in Ankara. The data obtained were analyzed with the SPSS 21 statistical program.

The Kaiser-Meyer-Olkin (KMO) value of the scale was calculated as .76 and it was found through the Bartlett's Sphericity test ($p < .05$) was a significant. A significant difference in the Bartlett sphericity test and a KMO value above 0.70 indicate that the scale is suitable for factor analysis (Leech, Barrett & Morgan, 2005; Tavşancıl, 2010).

After factor analysis, items with a factor load of less than 0.30 and items under more than one factor simultaneously (M4, M6, M7, M12, M13, M15, M17, M20, M27, M28) with a difference of less than 0.1 were excluded from the scale. After the analyzes were repeated, there were 22 items in the final version of the scale. The factor load values of 22 items were given in Table 1, after determining the number of factors. It was determined that the factor load values of the items in the perception scale for biotechnology applications varied between .37 and .78. It is sufficient for the factor load values to be above .30 according to Bryman & Cramer (2001).

Table 1. Distribution of items in the perception scale for biotechnology applications by factors and their load values

Item no	Factor 1	Item no	Factor 2	Item no	Factor 3	Item no	Factor 4
I1	.70	I11	.40	I19	.41	I26	.54
I2	.69	I14	.66	I21	.71	I29	.71
I3	.78	I16	.69	I22	.53	I30	.65
I5	.66	I18	.37	I23	.75	I31	.72
I8	.53			I24	.71	I32	.69
I9	.67			I25	.76		
I10	.55						

It was determined that there were four factors with an eigenvalue greater than 1. The eigenvalues of the first four factors were significantly greater than the eigenvalues of the other factors, while the eigenvalues of the factors other than these four factors were close to each other and did not show sharp declines in the scree plot chart. For this reason, the scale was accepted as having four factors and the scree plot chart was given in Figure 1.

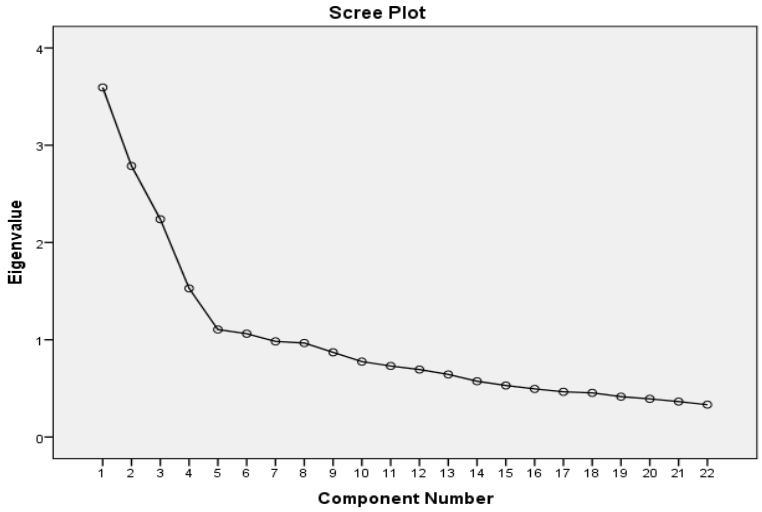

Figure 1. Scree plot

Then, the variance values explained for the factors in the scale were determined and the

data regarding these values were given in Table 2.

Table 2. Findings obtained regarding the factors included in the scale

Factor	Eigenvalue	Percentage of Variance	Total Percentage of Variance
1	3.59	16.33	16.33
2	2.78	12.66	29.00
3	2.23	10.17	39.18
4	1.52	6.94	46.12

Looking at Table 2 illustrating the variance values for the factors in the scale, the first factor accounts for 16.33% of the variance, the second factor 12.66%, the third factor 10.17%, and finally the fourth factor 6.94%. The four factors account for 46.12% of the total variance.

After the factor analysis process, the first factor with 7 items in the scale was named “perception dimension regarding genetically modified organisms”; the second factor with 4 items was named “perception dimension regarding stem cell technology”; the third factor with 6 items was named “perception dimension regarding genetic cloning” and finally, the fourth factor, which included 5 items, was named "perception dimension for nanotechnology".

The internal consistency coefficient (Cronbach alpha) was calculated to determine the reliability of the scale. The consistency coefficients of the sub-dimensions of the scale were .72, .68, .71 and .70, respectively. The general internal consistency coefficient of the scale was .78.

Finally, the lowest and highest scores that can be received from the scale were as 0 and 44, respectively. The final version of the scale is given in Appendix-A.

2.4. Data collection process

The data collection process of the study was carried out within the scope of the Science and Technology Based Problems course in the second year of the science teaching undergraduate program. Previously, the perception scale for biotechnology applications was applied to the study group as a pre-test. The experimental process took a total of 4 weeks during the teaching of genetically modified organisms, stem cell technology, nanotechnology and genetic cloning. In the study group, the lessons were taught with educational films. 12 educational short films, with potential to contribute to the increase of students' perceptions on the subject, were selected, expert opinions were consulted on the suitability of the selected educational films in terms of content and level, and four educational films that were found to be unsuitable for the study were excluded. Afterwards, students were shown eight educational films selected within the scope of the course. During the process, the films were paused a couple of times to promote

discussion/exchange of ideas between students. At the end of the process, interviews were held with teacher candidates. All data obtained from the interviews were recorded with a voice recorder to convert them into written text in a computer environment, after obtaining the consent of the participants. Since the teachers' own sentences are given directly in the results, each teacher candidate was given code names such as T1, T2, T3....

2.5. Data analysis

The data obtained from the research were analyzed with the SPSS 21 statistical program. Descriptive statistics techniques were used to determine the general distribution of the answers given by the students to the scale used in the research. The dependent sample t-test was used to determine whether there was a statistically significant difference between the pre-test and post- test scores of the students. The significance level was accepted as .05 across all analyzes conducted in the study (Büyüköztürk, 2016).

Content analysis method was used to analyze the qualitative data from the research. With content analysis, similar expressions are brought together around certain concepts and themes (Yıldırım & Şimşek, 2008; Neuman, 2012). In order to add to the reliability of the research, direct quotations were included. In addition, the data were examined by two researchers and after the codes for the related questions were extracted, the compatibility and consistency between these codes were investigated by the researchers. As Miles and Huberman (1994) stated, the consistency of the codes made by researchers independently was determined by the markings "Agreed" or "Disagreed". The consensus correlation coefficient between researchers was found .81.

3. Findings

In quantitative studies, it impacts on the analysis whether the data is normally distributed or not. In order to use parametric analysis methods, the quantitative data obtained from the scales during the research process should have a normal distribution (Çepni, 2007; Sim & Wright, 2002). For this reason, first of all, descriptive analyzes were applied to the data. The results obtained are given in Table 3.

Table 3. *Descriptive data on the perception pre- and post-test scores of the study group*

Measurement	N	M	Sd	Med.	Mod	Kurt.	Skew.	Var.
Pre-test	32	26.90	4.05	26.00	26.50	.91	.29	16.47
Post-test	32	31.90	3.89	29.00	32.00	-.57	-.03	15.18

The closeness of the mean, mode and median values for the data obtained from the perception scale for biotechnology applications is interpreted as a normal distribution of

the data (Köklü, Büyüköztürk & Bökeoğlu, 2006). A review of the kurtosis and skewness values in Table 3 shows that the data have once again a normal distribution, since these values were also in the range of -2 and +2 (George & Mallery, 2003). As a result of the descriptive statistics, it was decided to use parametric tests.

For purposes of this study, aiming to determine the effect of teaching with educational films on the perceptions of science teacher candidates towards biotechnology applications, the dependent sample t-test analysis was performed to determine the extent of the change in the perceptions of the teacher candidates before and after the test. Data on the results are given in Table 4.

Table 4. Dependent sample T test results

Measurement	N	M	SS	Sd	t	p
Pretest	32	26.90	4.05	6.43	-4.39	.00
Post-test	32	31.90	3.89			

According to Table 4, the pre-test mean score of the teacher candidates was M=26.90, while the post-test mean score was M=31.90. It was determined that there was a statistically significant difference between the pretest perception scores of teacher candidates for biotechnology applications and their post-test scores for biotechnology applications. In other words, it was concluded that teaching with educational films increased the perceptions of science teacher candidates about biotechnology applications.

In line with the qualitative data of the research, the teacher candidates were asked two open-ended questions, 'When you think about the process, did your perceptions about the subject change? how?', and 'Rate your level of change in your perception on a scale of 1 to 10'. The answers given by the teachers to these questions are given in Table 5 and Table 6.

Table 5. *The code theme and frequency values for answers given by science teacher candidates to the question 'When you think about the implementation process, did your perceptions about the subject change? how?'*

Theme	Code	Frequency
It changed	Having knowledge	26
	Raising awareness	13
	Becoming aware of its importance	9
	Encouragement to do research	6
	Raising curiosity	5
	Getting rid of bias	3
	Paying extra attention	2
	Enjoying it	2
Did not change	No changes in knowledge level	5
	Lack of interest	2
	Not raising awareness	2
	No change in thoughts	2

Out of the responses given by the teacher candidates to the question, 'When you think about the implementation process, did your perceptions about the subject change? how?', two patterns emerged: changed/did not change. Teacher candidates who stated that their perceptions had changed mostly stated that they had attained knowledge (f=26) and had gained more awareness (f=13). Teacher candidates who stated that their perceptions had not changed, mostly stated that their level of knowledge remained the same (f=5) and it did not attract their attention (f=2). Excerpts from the answers given by teacher candidates are given below.

T3: "I had no pre-existing knowledge about these topics. I can say that I now have more knowledge about the taught subjects. Also, the films raised my curiosity a bit. I also found the topics very entertaining.'

*T28: '…*I was thinking the same way. *Frankly, I cannot say that my perception level has increased.'*

T30: 'I think very negatively about these issues. Like these technologies should never be used... But now I see that I was wrong. I think I got rid of my prejudices*…'*

Table 6. *Data regarding the response given by science teacher candidates to the question 'Rate your level of change in your perception on a scale of 0 to 10'.*

Change	Scores	Frequency
A little/ None at all	0	8
	1	2
	2	-
	3	-
Moderate	4	-
	5	3
	6	2
A lot	7	3
	8	4
	9	1
	10	9

A review of the responses given by teacher candidates to the question 'Rate your level of change in your perception on a scale of 0 to 10' shows that while 10 teacher candidates gave 0-1- 2-3 points to the change in themselves stating that the change was little/no change, 5 teacher candidates gave 4--5-6 points stating that there was a moderate change. On the other hand, 17 teacher candidates emphasized that the change in their perceptions was very high by giving 7-8-9-10 points to rate the level of change that transpired.

4. Conclusion and discussion

Aiming to investigate the influence of teaching with educational films on science teacher candidates' perceptions of biotechnology applications, both quantitative and qualitative data were collected and evaluated. Within the scope of the research, first of all, a perception scale for biotechnology applications was developed. Looking at the literature, researches developed a range scales, such as the Attitude Scale towards

Genetically Modified Organisms (Güney, 2018), the Perception Scale for Stem Cells (Gönültaş, Ateş & Taflı, 2018), the Knowledge Scale of Biotechnology (Atasoy, Atıcı, Taşar & Taflı, 2020), and the Attitude Scale of Nanotechnology (Kurnaz & Bayraktar, 2012). However, there is no perception scale dealing with genetically modified organisms, stem cell technology, genetic cloning and nanotechnology included in the scope of this research.

After the perception scale for valid and reliable biotechnology applications was developed within the scope of the research, the scale was applied to the study group as both a pre-test and a post-test in order to determine the effect of teaching with educational films on the perceptions of science teacher candidates towards biotechnology applications. The study found that teaching with educational films increased the perceptions of science teacher candidates about biotechnology applications. A review of the literature revealed no studies using educational films for teaching biotechnology. However, there are similar studies in the literature on biotechnology teaching conducted with other methods and techniques. For example, a study conducted by Zengin Kırbağ, Alan and Keçeci (2016) to determine the impact of the academic conflict technique on the conceptual understanding levels of science teacher candidates about cloning and their scientific competencies argued that the academic conflict technique contributes to science teacher candidates' knowledge about biotechnological applications, as well as their scientific competencies. Similarly, Ural Keleş (2018), in his study to determine the effect of stem cell seminar on the cognitive patterns of science teacher candidates about stem cells, found that stem cell seminar improved the cognitive patterns of science teacher candidates about stem cells. Similarly, there are studies arguing that activities such as seminars/conferences on stem cells help teacher candidates keep up with the latest developments in the field and increase their level of knowledge in biotechnology (Chabalengula, Mumba & Chitiyo 2011; Gürkan, 2013; İmirzi, 2011; Sürmeli & Şahin, 2010; Turan & Koç 2012). In parallel with these studies, Hasançebi and Konak (2021) investigated the impact of the theoretical and applied activities held within the TÜBİTAK 4005 Science and Society funded project "Technology of the Future Biotechnology-2" on biology teachers' knowledge and attitudes towards biotechnology and its applications. The study found that the theoretical and applied biotechnology activities had a positive impact on the level of knowledge and attitudes of biology teachers towards biotechnology and its applications. Konak, Hasançebi, and Çakıcı (2018), on the other hand, stated that theoretical and practical training on biotechnology was instrumental in increasing teachers' attitudes towards biotechnology. Dawson and Soames (2006) and Sinan (2015), on the other hand, found in their studies that applied education had no influence on students' attitudes towards biotechnology applications. Similarly, Olsher and Dreyful (1999) found that the biotechnology and genetics course did not change students' attitudes towards biotechnology and its applications. Leslie and Schibeci (2003) similarly emphasized the need to improve teachers' knowledge about biotechnology in their studies with science

teachers. The above studies indicate that the courses attended or the training delivered on biotechnology may fall short of creating the desired impact. In this context, it is argued that the supplementing training program or courses offered to the students with certain methods, techniques or materials can reverse this situation. This study found that one of these tools, teaching with educational films, increased the perceptions of science teacher candidates about biotechnology applications. This may be due to the fact that educational films are teaching materials that appeal to students' multiple senses and create an impressive educational environment (Korkmaz, 2017). Because, educational films enable complex information to be understood more easily, enabling all of the constructed information to be transferred both dynamically, visually and aurally (Birkök, 2008), while also contributing to the development of synthesis, analysis and evaluation skills, which are high-level thinking skills (Demircioğlu, 2007). A study conducted by Selanik Ay (2010) states that educational films contribute to increasing students' knowledge and awareness on environmental issues. In addition to their positive contributions to students' knowledge and awareness levels, educational films also contribute positively to students' mental development and perception of scientific issues (Barnett, Wagner, Gatling, Anderson, Houle & Kafka, 2006). In a similar vein, Tatlı and Şahin (2020) concluded that watching science fiction movies had a positive effect on science teacher candidates' learning of scientific concepts.

Finally, within the scope of the research, the question of whether teaching a lesson with educational films has an effect on changing their perceptions about the subject, and if so, how this change occurs, was asked during the interview stage, and it was found that the majority of the teacher candidates perceived a meaningful change. It was determined that they attributed the change to the following; gaining knowledge through teaching with educational films, creating awareness, realizing the importance of the subject, encouragement to do research, arousing curiosity, overcoming prejudices, paying extra attention and finding the subject entertaining. Because educational films create strong experiences about the subject for people watching them (Champoux, 1999).

On the whole, studies tend to emphasize that science teachers' knowledge of biotechnology should be improved (Leslie & Schibeci, 2003). The responsibility falls on teacher training institutions to address this issue. The underwhelming nature of the education given at teacher training institutions, at least in some aspects, is another topic mentioned by studies. For this reason, the assumption is that combining the education given in the field of biotechnology with tools such as educational films that concretize concepts and phenomena and make the learning environment more entertaining would be effective in raising the perceptions of science teacher candidates. Accordingly, further studies can be conducted to pinpoint the effects of teaching biotechnology with educational films on the knowledge, attitudes and awareness levels of teacher candidates. In addition, educational films can be employed with other fields of

biotechnology (organ donation, individualized medical applications, nuclear energy, etc.) that are not included in this research.

Limitations

The scale developed within the scope of this research study is limited to genetically modified organisms, stem cell technology, nanotechnology and genetic cloning. Also, using the scale, the same subjects were included in the teaching process involving educational films.

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Appendix-A. Perception Scale for Biotechnology Applications

İfadeler	Evet	Fikrim Yok	Hayır
1. Alt Boyut: Genetiği Değiştirilmiş Organizmalara Yönelik Algı			
1. GDO'nun tarım ve hayvancılıkta daha fazla kullanılması gerektiğini düşünüyorum. (I1)			
2. GDO'lu yiyeceklerin yenilmesine tamamen karşıyım. (I2)			
3. Toprak kirliliğine neden olabileceğini düşündüğüm için GDO kullanımına destek vermiyorum.(I3)			
4. Hiçbir GDO'lu ürünün ülkemizde kullanılmasından rahatsız oluyorum. (I 5)			
5. Ülkemizdeki GDO çalışmalarına destek veriyorum. (I 8)			
6. Hızlı nüfus artışını karşılayabilmek için geliştirilen/ kullanılan GDO'nun gerekliliğine inanıyorum. (I 9)			
7. Hiçbir GDO'nun hayvanlar üzerinde kullanılmasını doğru bulmuyorum. (I10)			
2. Alt Boyut: Kök Hücre Teknolojisine Yönelik Algı			
8. Kök hücre teknolojisinin tedavi amaçlı kullanılması gerektiğine inanıyorum. (I11)			
9. Kök hücre teknolojisinin asla kullanılmaması gerektiğini düşünüyorum. (I14)			
10. Kök hücre çalışmalarını etik bulmuyorum. (I16)			
11. Kök hücre teknolojisinin tüp bebek tedavisinde önemli bir yeri olduğuna inanıyorum. (I18)			
3. Alt Boyut: Genetik Klonlamaya Yönelik Algı			
12. Doğal bir insan klonlama mekanizmasının olmadığını düşünüyorum.(I19)			
13. Faydalarını göz önüne alınca klonlama uygulamalarının etik olduğuna inanıyorum.(I21)			
14. Her ne sebeple olursa olsun hiçbir klonlama işlemini onaylamıyorum. (I22)			
15. Klonlamanın biyoçeşitlilik üzerinde büyük bir tehdit olduğuna inanıyorum.(I23)			
16. İnsan klonlamanın yasal ve etik açılardan birçok soruna yol açacağını düşünüyorum.			

(I24)			
17. Genetik hastalıkların artışına neden olacağı için klonlama çalışmalarını desteklemiyorum. (I25)			
4. Alt Boyut: Nanoteknolojiye Yönelik Algı			
18. Nanometre boyutundaki yapıların özelliklerinin anlaşılması için nanoteknolojinin gerekli olduğunu düşünüyorum. (I26)			
19. Nanoteknoloji ile üretilen, suyu iten araba camı gibi gelişmelerin, ülkemiz için çok önemli olduğunu düşünüyorum. (I29)			
20. Uygulama alanları düşünüldüğünde nanoteknolojinin ülkemizde daha fazla gelişmesini önemli buluyorum. (I30)			
21. Kalıtsal hastalıkların giderilmesinde nanoteknolojinin çok gerekli olduğunu düşünüyorum. (I31)			
22. Kanserli hücrelere müdahale edebilmesi açısından nanoteknoloji çalışmalarına daha fazla yer verilmesini destekliyorum. (I32)			