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Effectiveness of Socioconstructivist Paradigm to Promote Biotechnology Education at Lebanese High School

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Abstract: ***This study aims to analyze the effect of teaching a biotechnology module according to the socioconstructivist paradigm on attitudes and arguments of students. The module has been conducted in four sessions in a grade 11 class (N=53) by two biology teachers having received two training workshops on the teaching of socioscientific themes. Results showed that the cognitive component of attitudes (scientific knowledge) about biotechnology concepts increased at the end of the teaching of this module. Similarly, the emotional component of attitudes (opinions) became more positive towards biotechnology applications. An argumentative debate was performed during the teaching sessions in order to improve the argumentation skills of the students. Results of pre and post test showed that arguments used by students at the beginning of teaching sessions were simple with one justification while at the end of sessions students used in their debate more complex arguments with multiple justifications.***

Keywords: Biotechnology, teaching, socioconstructivist**,** attitudes**,** arguments.

1. Introduction

Modern biotechnology is a complex area that encompasses a wide range of applications and opens new perspectives in the fields of environment, agriculture, health, etc. However, the powerful potential of modern biotechnology goes hand in hand with the controversy surrounding its applications. Issues such as stem cell research, cloning, and the production of transgenic organisms are constantly challenging public opinion, as the rapid advancement of biotechnology outpaces the public's ability to keep up-to-date with the progress in this scope and with the societal meaningfulness of biotechnology applications [1].

The awareness of the relevance of biotechnology education has led to the curricular integration of biotechnology related topics in many countries, mainly in UK, Australia and USA [2]. Furthermore, numerous educational resources and initiatives have been developed to promote students' scientific literacy.

The educational challenge is to enable students to develop an informed opinion on the socioscientific issues of biotechnology to be able to debate and make choices for prevention, action, and use [3]. In this context, argumentation skills seem to be one of the major challenges of scientific citizenship education.

In fact, interactive teaching methods that encourage students to think in an auto-reflective way about their attitudes as well as to construct a scientific and logical argumentation is necessary when there are complex areas of applications such as in biotechnology.

Among the various types of active learning methods, the socioconstructivist approach highlights a distinctive feature of science education which stresses the role of the interaction between students in the process of knowledge construction, mainly in the themes that have many domains such as biotechnology. This approach aims to enhance personal expression, creativity, and development of autonomy in students.

In this teaching approach, three dimensions are inseparable during the learning progress:

- Constructivist dimension that refers to the subject that learns: the student.
- Social dimension that refers to partners who are present: other students and the teacher.
- Interactive dimension that refers to the environment: learning situations [4].

In their study, Klop and Severiens (2007) show that the application of a science module according to socioconstructivist paradigm has a significant effect on the attitudes of students use [5]. Offering a such science module can indeed encourage students to become more aware of modern biotechnology, although promoting a more critical attitude towards modern biotechnology should receive more attention.

In Lebanon, modern biotechnology teaching has been introduced in the biology curriculum since 1998. In the secondary classes, the introduced concepts are concerned with the techniques of genetic engineering such as transgenesis, genetic screening, cloning, production of high performance plants, and production of hormones and antibodies.

However, the approach that dominates in the teaching of scientific themes is still based on lecturing even if the teacher uses new technologies such as the internet [6].

In this study, a science module in biotechnology about the therapeutic use of embryonic stem cells was taught to 53 Lebanese high school students (age of 16-17 years) according to the socioconstructivist approach. We investigate to what extent the application of this module can affect students' attitudes and argumentation skills about biotechnology applications in different fields related to everyday life.

2. Literature Survey

2.1 Attitudes towards biotechnology

Among the numerous studies addressing public perceptions of biotechnology, some have focused specifically on young people's knowledge and attitudes [5]-[7]-[8], although this remains comparatively an under-researched area [9].

The outcomes of these studies reiterate the need to promote biotechnology education by drawing a picture of superficial knowledge and misperceptions amongst the younger population segments [7]-[8]-[9]. In his study, Dawson (2007) reported that Australian high school students, especially the younger ones, had difficulties in defining and providing examples of biotechnology and they were particularly unaware of agro-food applications [7]. Prokop et al. (2007) noticed that Slovakian students' knowledge about the meaning of genetic engineering was poor [9]. Turkish students, although relatively aware of practical applications, have shown to possess an insufficient understanding about basic biotechnology processes involved in DNA manipulation [8]. These studies have also looked into students' attitudes and how they might relate to knowledge, providing varying results [5]-[7]-[8]-[9].

For instance, students' attitudes towards biotechnology, mostly measured as acceptance and approval of applications, are known to vary from skeptic responses to a complete support according to features such as age, gender, or level of education [5]-[7]-[8]-[10]. Studies have shown that biomedical applications are generally associated with high levels of tolerance while the opposite is observed with the agriculture and food applications [11]-[12].

In the case of human cloning, several researchers showed that therapeutic cloning is generally considered acceptable by individuals, but most people refuse reproductive cloning[13]-[14] -[15].

However, compared to research on stem cells, the critics' rate among individuals in several countries is high when the research is performed on human embryos as this raises serious ethical questions related to the moral status of this subject [15]-[16]. Similarly, applications including genetic engineering of animals are generally refused because procedures tend to be seen as risky and morally unacceptable [16]-[17]-[18]-[19]-[20].

As argued by several researchers, there are literacy deficits that can be attributed to the complexity resulting from the multidisciplinary, sophisticated and abstract nature of the knowledge required to understand biotechnology processes and implications [7]-[19]-[20]. This assumption is in harmony with the increasing number of studies identifying misconceptions about the notion of microorganism and difficulties in understanding molecular biology and genetics concepts [1]. This stresses the importance of enhancing the efficiency of educational measures to promote biotechnology learning and teaching.

2.2 Socioconstructivist Approach

Under a socioconstructivist perspective of learning, science education frameworks such as Socio-Scientific-Issues (SSI), sustain the students' ability to mobilize scientific knowledge into real life situations [21]. It is intended that in addition to simply acquiring a set of baseline knowledge, students develop an integrated array of competencies and attitudes that allow them to apply that knowledge and face the challenges posed by science and technology [22].

In the context of SSI approach to science education, the implementation of educational strategies should favor active learning and teaching methods [1]. In their study, Kanasa and Nichols (2008) tested the effect of teaching a science module concerning Genetically Modified Organisms (GMO) according to the investigation method by incorporating activities that encourage students to compare their attitudes towards biotechnology and interact with their parents [23]. They showed that this type of education allows students to analyze the advantages and disadvantages about GMO in different perspectives, and it results in a significant change in both cognitive (knowledge) and affective domains of secondary class students.

Similarly, to promote awareness about antibiotic resistance at high school levels (15-17 year old) in Portuguese schools, Fonsesca (2012) studied the educational benefits of incorporating hands-on activities in science education programs [1]. The results indicated that the participants developed a more comprehensive picture of antibiotic resistance and enhanced consciousness towards measures that can be taken to mitigate the problem.

Other studies focused on students' argumentation skills about SSI. Most of them revealed the weakness of students' skills in argumentation regardless of their age, and the lack of correlation between the science concepts and argumentation skills [24]-[25]. Students argue mainly relying on their own knowledge and ideas which are based on their personal experiences and values outside school [26].

However, in the study of attitude, it is important to construct a measure that is sufficiently sensitive to detect changes in the structure of its composition [5]. The tripartite theory of attitude provides a helpful framework in the construction of this measure of changes [27]. In general, an attitude can be described as a summary of evaluations, representing favorable or unfavorable feelings towards a specific or psychological object [28].

According to the tripartite model, there are three dimensions or components:

- An affective component that corresponds to positive or negative emotions that the individual possesses towards a specific object.
- A cognitive component which refers to the knowledge that the individual holds about the object and the credibility that he gives to this information. The social representations shared by the individuals are related to this domain.
- A behavioral component which is described as behavioral intentions [27]-[29].

However, these components do not form an attitude. The attitude depends on the tendency of the individual to base his position on the cognitive or the affective component [30]. In addition, the attitudes towards complex objects such as biotechnology are based on emotional reactions (gut reactions) rather than on logical thinking [28].

3. Methodology

3.1 Participants

The study involves 53 secondary school science students of age 16-17 years (grade 11) in a public high school in Beirut and their two biology teachers. According to the Lebanese biology curriculum, the 11th grade biology program includes contents related to cell structure, cell cycle, genes and protein synthesis. However, the concept of therapeutic use of stem cells is totally absent in the program of secondary cycle.

3.2 Selection of teaching module

A teaching module (teaching sequence) about the therapeutic use of human embryonic cells for the treatment of Parkinson disease was prepared in collaboration with two biology teachers. The module was applied in four sessions according to socioconstructivist paradigm.

After application of the module in the classroom, the data was collected using several instruments: a pre/post-test, an observation grid, audiovisual recording sessions, and written evaluation questions for students (figure 1).

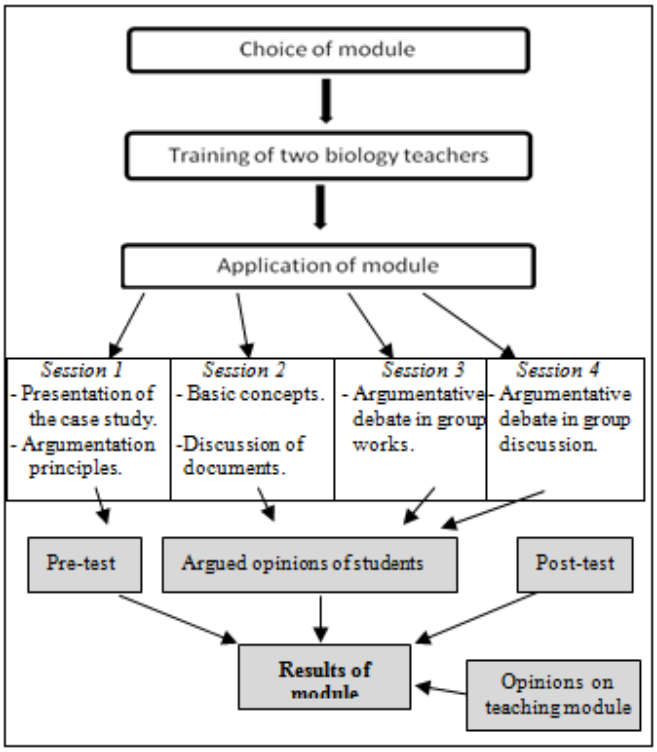

Figure 1: Work plan of the biotechnology module

3.3 Cooperative work of biology teachers

The two biology teachers voluntarily participated in this study (table 1). They attended two training workshops to learn how to apply the teaching sequence.

Table 1: Characteristics of the two teachers

Teacher	*Age*	*Experience years*	*University diplomas*
Mrs. A.	31	9	- BS in Life sciences - Secondary School Teaching Certificate - Master in Education
Mr. B.	32	10	- BS in Life sciences - Secondary School Teaching Certificate - Master in biology didactics

The workshops were audio-visually recorded and had a total time of 120 minutes (figure 2).

3.4 Statistical analyses

IBM SPSS Statistics software was used to conduct statistical analyses. Paired samples t-tests were used to compare the pre/post-test variation in the opinions and types of arguments provided by students on the use of embryonic stem cells for therapeutic use in the case studied. Variations were considered significant for $p<0.05$.

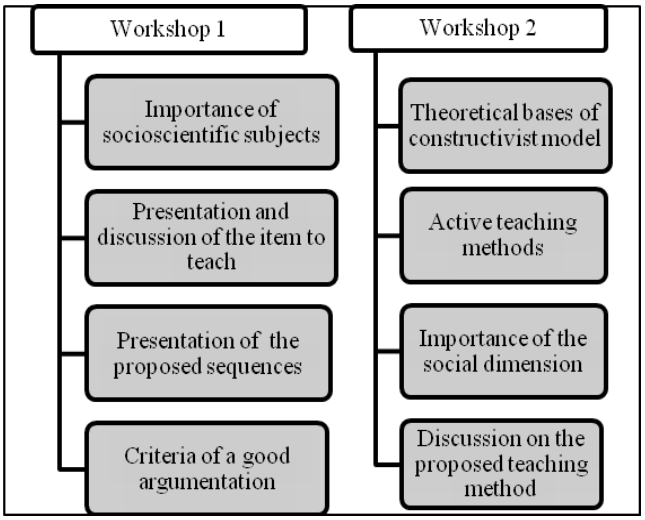

Figure 2: Content of training workshops followed by the two biology teachers

4. Results and Discussion

4.1 Application of module

4.1.1 First session

A hand out is distributed to students on a fictional case about orphan embryos. This case is a problem situation that does not have a simple solution: one couple kept frozen embryos in a hospital after in vitro fertilization. This couple dies in a car accident, and the hospital director must make a decision about the donation of these embryos for therapeutic research center for Parkinson's disease.

Students are invited to take the role of the hospital director and make a decision (Role-play). So, each student expresses his opinion by writing his decision. The written data is used as a pre-test. Then, students discuss their opinions in groups to perceive the differences in their views.

After this work, the teacher presents the principles of a strong argumentation by choosing some arguments made by students and discussing them in class.

4.1.2Second session

In this session, the teacher introduces the lesson with examples related to real life: he gives students some examples about famous people who suffer from Parkinson's disease.

Next, students are divided into groups, and the teacher distributes a scientific text about Parkinson's disease and the prospects of its treatment. Students read and reply in groups on issues related to the text.

After finishing the discussion of this text, another scientific text about human embryonic cells is distributed to the groups. Students also discuss scientific ideas related to the text and answer questions set on it. However, when the teacher perceives that students have difficulty in assimilating a concept, he explains this concept to all groups.

4.1.3Third and Fourth sessions

These two sessions are devoted to reasonable debate. According to Simonneaux (2003), the debate favors conceptual change, improves understanding of the nature of science, develops the investigative skills and improves decision making on socio-scientific issues [31].
In these sessions, the teacher questions students' views on the case studied. Then students in each group discuss their answers together.
Then the argued answers (convergent or divergent) of each group are presented (open discussion). In fact, in this type of teaching strategy, the teacher becomes the debate monitor instead of the knowledge holder [26].

Two ideas dominate during the debate between students: the importance of saving the lives of patients against the importance of frozen embryos survival. Religious, ethical, medical, scientific and even commercial dimensions are presented during the debate and are also used by students to produce their arguments. The various aspects of socioconstructivist learning appear more clearly in this session where students become more courageous to discuss their ideas.

At the end of these sessions, the evaluation questions are distributed to students. These questions are used to assess students' knowledge, opinions about these sessions, as well as their opinions and arguments on the theme. These are compared with the opinions of students at the beginning of the lesson (post-test).

The total distribution time in 4 sessions is calculated based on the teacher's interventions and students (figure 3).

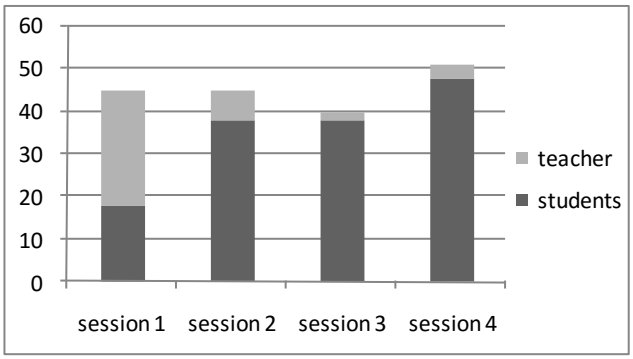

Figure 3: Total distribution time (in minutes) for contribution of teacher and students in each session

4.2 Data analysis

To obtain a broader, more inclusive depiction of the effectiveness of the project, the analysis is performed according to four levels:

- An analysis of the structure of the sessions based on classroom observations and the recorded discussions.
- A comparative questionnaire analysis (pre-test and post-test) of written answers of the students.
- An analysis of knowledge and opinions written by students about these sessions.

- An analysis of the arguments used by students during the debate.

Hence, qualitative and quantitative data were gathered on the participants' understanding, opinion, interest and argumentation.

The analyses of the participants' pre- and post-test responses were conducted with the purpose of measuring the range of impact of the project and unveiling the qualitative variations in the participants' reasoning. The content of students' responses was scrutinized. For every response, the number of notions was quantified and its pre/post-test variation was measured.

4.2.1Opinions and arguments of students

Regarding the opinions of students in the beginning of the first session (Figure 4), we notice that most of the students support the use of embryonic cells: 96% support this manipulation (and almost agree) and 4% are neutral. Students' responses vary significantly after the achievement of the teaching module ($p < 0.05$).

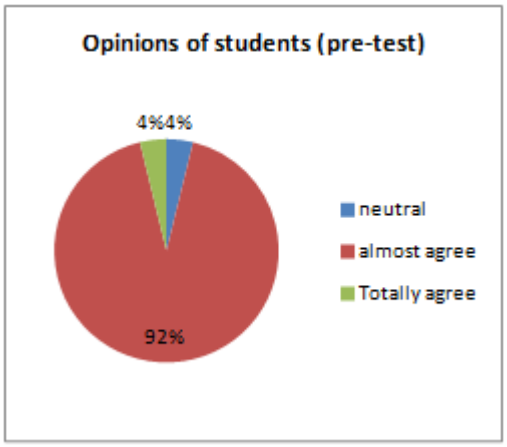

Figure 4: Opinions of students in the first session

Indeed, at the end of these sessions (Figure 5), the percentage of students who are with the use of embryonic cells decreases to 81% and neutral opinions increase to 7%. In addition, there is appearance of students who expressed negative opinions towards the use of embryonic cells (12%).

In fact, the opinions of the students are the emotional component of attitudes toward the therapeutic use of human embryonic stem cells.

The significant change in the opinions of students at the end of the teaching module confirms our initial hypothesis about the effect of a socioconstructivist science module on the development of students' attitudes.

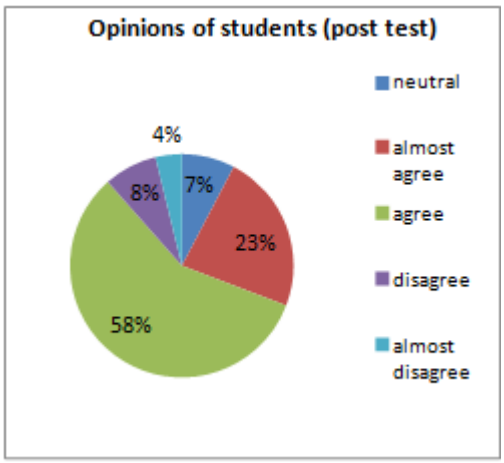

Figure 5: Opinions of students at the end of four sessions

Indeed, several researchers reported the influence of debate about socio-scientific subjects on the attitudes of students [32]-[7]-[33]. Klop and Severiens (2007) consider that a small module based on the combination of socioconstructivist principles, with a relatively new subject, can bring a change in students' attitudes [7].

In addition, these authors postulate that the increased positive attitudes among students after the application of a scientific module, such as the treatment of cancer, could be due to extra exposure to the positive effects of biotechnology in this module. So, they suggest that teaching modules should include all aspects of biotechnology: the pros and cons, technical, and ethical aspects [7].

At the level of types of arguments used by students, the pre-test shows that most of the arguments at the beginning are simple type having a single justification (61%). Linear type arguments (composed of several justifications) constitute 31% of student responses while complex arguments (which are formed of several interconnected justifications) constitute only 4% of responses. Without justification, arguments constitute only 4% of total responses (Figure 6).

Statistical analysis shows that the types of arguments used by students in the pre/post-test were significantly different ($p < 0.05$). Indeed, at the end of the sessions, complex arguments increase from 4% to 35%, and the linear justification arguments decrease from 31% to 27% while the simple arguments decrease from 61% to 38% (Figure 7).

The justifications used in the arguments are of medical, ethical, scientific and social nature (tables 2 and 3).

The main idea of the arguments that are against the use of embryonic cells is that these embryonic cells have a certain life to be respected. On the other hand, the idea that predominates in the case of students who are with this use is that these cells exhibit no life. These two contradictory ideas have led to a debate during the group discussion.

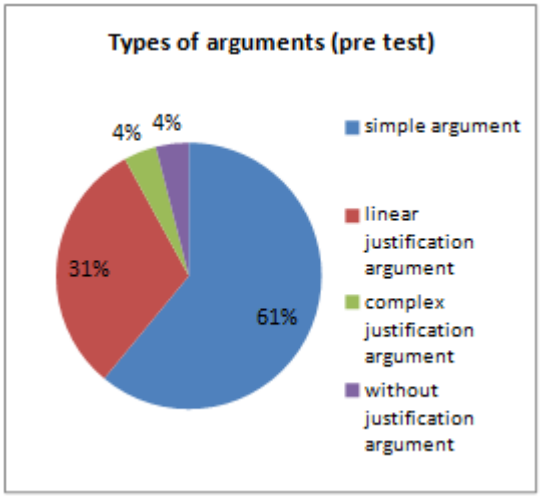

Figure 6: Arguments of students in the first session

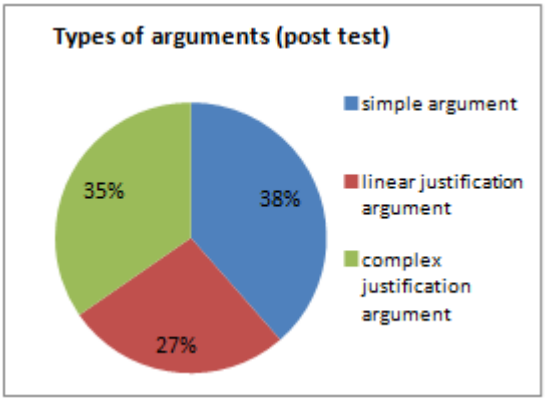

Figure 7: Arguments of students at the end of sessions

Thus, a student defends his opinion, saying: "they are simply groups of cells such as skin cells. Can we say that the skin cells represent life? ". Another student replies: "Embryonic cells can give a human if implanted into a uterus, but skin cells cannot."

Therefore, students use in this argumentation the form of questions and examples. In fact, this indicates a high level of students' oral arguments

Table 2: Some arguments of students "with" the therapeutic use of embryonic cells

Arguments "with" the therapeutic use of embryonic cells	Nature of argument
•The life of sick individuals is very important	Medical
•Medical progress is necessary to discover medicines.	Medical
•Saving the life of people is more important than the embryonic cells.	Ethical
•Embryonic cells do not have life.	Bioethical
•The scientific progress necessitates traversing some ethical barriers.	Scientific

Table 3: Some arguments of students "against" the therapeutic use of embryonic cells

Arguments "against" the therapeutic use of embryonic cells	Nature of argument
• Embryos have the right to live.	Legal
• The success of these experiments is not evident and there will be a lot of "victims".	Bioethical
• Offering life to these embryos which represent a future generation is more important than treating old persons.	Social
• All religions don't allow killing embryos.	Religious

The confrontations of students within groups and between groups allow enhancing the students' ability to argue. In fact, the explanation of the principles of argumentation by the teachers before the debate helps students in formulating their arguments.

During the discussions, a variety of arguments with several justifications is given by students. The arguments used in the post test differ significantly from those used in the pre-test: The number of simple arguments decreases while the plural arguments of linear and inter-linked type increases. This indicates that this teaching module has enabled students to develop their arguments to a socioscientific subject.

4.2.2Scientific knowledge of students

At the end of the teaching module, three scientific questions are asked to students to evaluate their scientific knowledge.

- Q1: Why is Parkinson's disease considered a disease of the nervous system?

The correct answers which state that it is due to a decrease in dopamine secreted by nerve cells constitute 69% of total responses.

- Q2: What is the definition of human embryonic cells?

69% of students correctly answered this question indicating that they are pluripotent cells derived from the inner cell mass of the blastocyst.

- Q3: How are human embryonic cells used to treat Parkinson's disease?

The number of correct answers on this issue was 85% by stating that embryonic cells are differentiated into nerve cells to replace damaged cells.

These results show a high level of scientific knowledge of students (cognitive component of attitudes) about the topic discussed at the end of the sessions.

In fact, the application of this module reveals students' need of training to proceed in an active way with the documents and scientific texts.

In this context, Simonneaux and Simonneaux (2008) show that if students are placed in a global case study environment, their level of knowledge acquisition and critical analysis is higher than that acquired in a study of a local case [3]. Furthermore, teachers in all disciplines need more training on how to encourage students and help them develop their intellectual and critical thinking skills.

4.2.3Opinions of students on learning module

All the concerned students (100%) indicate that the biotechnology learned subject is pertinent. Most of them (96%) assume that the subject is taught in a clear and appropriate way. With respect to the role of teacher in this

module, 77% reveal a positive opinion about the interactive role of the teacher.

Considering the relevant aspects in the debate, 26% of students consider that all the discussed aspects of the subject are pertinent while 19% of them indicate that the arguments related to "kill the embryos" are the less pertinent. Other 26% believe that the religious dimension of this subject is the less relevant; 26% of them consider that transplanting the embryos in a sterile women uterus is not a pertinent idea to discuss; 3% of students consider that giving the embryos to a commercial company is not an important aspect.

The most interesting aspects in this lesson for students are in decreasing order: the scientific progress ensured by using embryonic cells in treatment of diseases, the group discussion for this case study, the role of students to take a decision about the use of embryonic cells, and finally the discussion of the role of emotions and religion in this case.

5. Conclusion

This research aimed to investigate the effect of the application of a biotechnology module on the attitudes and argumentation of Lebanese secondary school students. Four sessions were applied by two biology teachers for 53 students of grade 11 in two classes of a public high school.
Results showed that students have expressed a development of their scientific knowledge as well as their reasonable opinions. During the debate, students construct their knowledge in confrontation of the ideas. Their decisions are based on scientific knowledge and arguments of various kinds: social, ethical, medical, scientific and religious. The presentation of arguments has encouraged students to do a self-review of their opinions. Moreover, the number of simple arguments decreases while the complex arguments of linear and inter-linked types increase.

6. Recommendations

Although limitations have to be taken into account, the findings of this study highlight issues that may have to be considered by curriculum planners and science teachers who wish to incorporate scientific literacy into science curricula.

When educating students about modern biotechnology and its implications, one has to keep in mind that students hold different starting points regarding modern biotechnology. Not only should science education focus on knowledge and understanding, but also on the affective side of biotechnology. This change in emphasis might help students to create a more balanced attitude towards biotechnology.

This experiment has opened a new perspective on the relationship between the educational environment of teaching and the development of attitudes and arguments of the students. It would be necessary to train teachers on this type of socioconstructivist education to change their passive education.

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