AMERICAN UNIVERSITY OF BEIRUT

IMPACT OF ARGUMENTATION ON LEBANESE STUDENTS' ARGUMENTATION SKILLS, INFORMAL REASONING AND ACHIEVEMENT IN BIOLOGY

by
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ABSTRACT OF THE THESIS

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Title: Impact of Argumentation on Lebanese Students' Argumentation Skills, Informal Reasoning and Achievement in Biology

Argumentation is commonly used to expose people's opinions and beliefs that may conflict with the beliefs of others. According to Driver, Newton, and Osborne (2000), argumentation requires higher-order thinking skills and thus, has been integrated in the teaching learning process. Argumentation has become an important teaching method since it has the potential to enhance learning and prepare future citizens capable of making informed decisions about everyday socio-scientific issues. According to Osborne (2010), this method enhances students' learning more than traditional teaching methods.

Although some studies suggest that engaging in argumentation enhances the quality of argumentation, informal reasoning, and achievement, other studies show that no or little progress occurs. Moreover, no studies examined the effect of argumentation on informal reasoning or achievement in Lebanon. Also, the studies that examined this relation showed that few students are able to reach high level arguments. Therefore, the purpose of this study was to investigate whether or not effective argumentation teaching strategies can scaffold student learning in a Lebanese context. It further examined how effective argumentation can enhance students' informal reasoning and argumentation skills. This study was embedded in Design-Based-Research (DBR) that has an iterative nature and thus, allowed (after some time) the modification of certain factors in the intervention which helped better implement the study in a particular context. The study included two iterations in which during iteration two, changes were made to better implement the study. Hence, the study investigated the following research questions: (a) does engaging Lebanese Grade 8 students in argumentation enhance achievement in biology? (b) does teaching argumentation skills to Grade 8 Lebanese students enhance the level of their arguments? (c) does engaging Grade 8 Lebanese students in argumentation enhance the level of their informal reasoning skills?

The study used a pre-test/post-test experimental design. The participants were forty-nine grade eight students distributed among two groups: experimental group and control group. The experimental group was taught the argumentation skills during the intervention and the comparison group was taught the same unit but using conventional teaching methods (no argumentation involved). However, students in the control group students were involved in more activities relevant to the content of the unit in order to balance the instructional time between both groups. Both groups studied the same science unit "The Immune Response" by the same teacher for twelve weeks. Data analysis for student achievement was conducted through the completion of an 'Immunology Knowledge Test' at the beginning and end of the study as well as three Biology chapter tests during the study in order to track any gains in student achievement of biology concepts. Moreover, students' written work during the activities were collected and analyzed in order to determine the level of informal reasoning (rational, intuitive, emotive, or mixture) and the level of argumentation skills. A model adapted from Toulmin's was used to analyze students' understanding of argumentation skills and the elements of an argument.

The results of the post-test show that students in the experimental group achieved higher than students in the control group but the difference was not significant. Likewise, students' scores on the three biology chapter tests that were administered during the study did not show significant gains in achievement between both groups during iterations one and two. In depth analysis of the immunology knowledge test was carried out where the percentages of correct and incorrect responses on each test item were computed. This finding showed that the intervention improved the achievement of students in certain concepts but not in others which are abstract and might require much more background knowledge and abstract thinking than what is available to intermediate level students. Moreover, results of the impact of argumentation on the level of argumentation showed that in all activities in which students were required to provide an argument and a counterargument, the majority showed higher levels of arguments than counterarguments. Furthermore, the level of argumentation and the level of informal reasoning were not consistent across the activities and seemed to be dependent on the type of support provided to students when working on an activity. Students provided high level arguments when they were given explicit evidence in support of an explanation. Students showed rational informal reasoning in almost all the activities before and after the intervention. However, students had some levels of emotive and intuitive reasoning skills in familiar activities regarding which they might have had prior conceptions or beliefs. The implications of this study include the need for more research on using argumentation at the intermediate school level because of the unresolved issue of the developmental nature of argumentation and the need to identify effective argumentation activities that are relevant to students' lives.

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Chapter I

Introduction

Argumentation is a common verbal and public activity that reveals people's beliefs and judgments that often conflict the beliefs of others (Van Eemeren, Grootendorst, & Henkemans, 1996). Therefore, people try to defend their opinions and convince others with their standpoint. This process, which requires a high level of thinking and reasoning skills, has become an important part of the teaching and learning educational cycle (Osborne, Driver, & Newton, 2000) because learners are able to make use of scientific evidence in order to justify and debate science-related everyday issues. These issues such as using genetically modified food are often discussed in the media and thus relate to our daily life. Therefore, teaching learners how to justify a socio-scientific issue helps them acquire the skills needed to become active citizens in the society.

The integration of science and argumentation in the past years has encouraged researchers to explore the effect of argumentation on teaching and learning. Although studies have shown that argumentation can improve students' reasoning, few students in these studies were able to reach rational informal reasoning. Moreover, engaging students in argumentation ensures significant gains in the level of their arguments. Yet, few students were able to achieve high-level arguments that require the incorporation of counterarguments and rebuttals to support a claim. Furthermore, several researchers have addressed argumentation in science classrooms in an attempt to justify the claim which suggests that teaching argumentation skills has the potential to enhance student achievement in biology. However, the findings of these studies showed mixed results. While many studies have shown that argumentation can improve student understanding of science (e.g. Venville & Dawson, 2010; Zohar &

Nemet, 2002), other studies have shown that argumentation does not significantly enhance student achievement (Osborne, Simon, Christodoulou, Howell-Richardson, & Richardson, 2013). Consequently, it was important to further examine the effect of argumentation on the understanding of science, the level of students' informal reasons, and the level of their arguments.

Background

In the following section, the findings of some studies that addressed argumentation and student achievement, informal reasoning, and level of arguments are briefly discussed. The purpose was to highlight the mixed results and show the need for further research. Then, the ways this study helped explain these results and plan the most effective argumentation instruction methods in a specific context are indicated.

Argumentation and Student Achievement

Research has shown that engaging students in argumentation can enhance their understanding of scientific concepts. Some studies showed a significant gain in student learning after an argumentation intervention while others did not.

Venville and Dawson (2010) examined the effect of a short argumentation intervention on grade 10 students' achievement about genetics concepts. One group of students was engaged in argumentation while the other was involved in the same genetics lessons but did not learn the argumentation skills. Data was collected by administering surveys at the beginning and end of the intervention. Results showed gains in student learning in both groups but these gains were more significant in the group engaged in the argumentation which shows that students were able to link different isolated concepts and develop high-order thinking skills which lead to improved learning.

In a similar study, Venville and Dawson (2013) studied the impact of argumentation on grade 10 achievement in genetics. In this study, the experimental group was given Genetic scenarios and asked to argue with or against the case presented, provide justifications and counterarguments, as well as evaluate the evidence. Students discussed the scenarios in small groups and with the whole class. Data was collected by administering a survey before and after the intervention and one of its sections evaluated students' content knowledge. Students' responses on the survey were scored before and after the intervention and the scores were compared to detect any gains in the level of content knowledge or achievement. The results showed significant gains in achievement in the control and experimental groups after the genetics unit. However, the improved achievement was more significant in the group involved in argumentation.

Osborne et al.'s (2013) study aimed to integrate argumentation teaching methods in the science curriculum and ensure that students work in small groups during the argumentation activities. Participants in the study were two groups of students (ages 11-16) from 4 schools, one of which was involved in argumentation teaching. Experienced teachers who underwent professional development on argumentation were responsible for developing the argumentation methods and integrating them in their classes. In order to study the effect of argumentation on student achievement, a test (adopted from the country's national standard test questions) was administered before and after the intervention. The test included questions about general scientific knowledge related to topics included in the science curriculum. Results of the study showed that after the intervention, a significant gain occurred in the experimental group of 15-16 year old students when compared to the control group. However, no significant differences were detected in the performance of 11-12 year old students in the experimental group when compared to the comparison one.

The results above show mixed results concerning the effect of argumentation on student achievement in science. Some studies show significant gains while others do not. Further research should explain these findings and determine whether or not argumentation enhances achievement at the middle school level which is rarely studied. Moreover, Genetics is the major topic chosen for argumentation since it relates to everyday socio-scientific issues while other biology topics are ignored.

Argumentation and Improving the Level of Arguments

Several studies examined how interventions where learners acquire argumentation skills can enhance the level of their arguments. These studies were conducted at different grade levels: college, high school, middle school, or elementary school levels. In general, many studies showed a significant gain in the level of students' arguments as a result of the intervention. However, only few students were able to articulate high-level arguments. Moreover, other studies showed no significant gain at the level of the arguments. For example, Walker and Sampson (2013) studied the impact of an ADI (argument-driven inquiry) intervention on the level of college chemistry students' arguments in the USA. Data was collected from students' performance tasks and lab reports. Group discussions were videotaped to ensure authenticity of the intervention. Students were engaged in five investigations with increasing difficulty. In each investigation, students engaged in a guided process starting with identifying the problem until they articulated a final argument which could be modified after group discussions. Results of the study showed an overall gain in the level of written and oral arguments as indicated when comparing the analyzed statements of the students before and after the investigations. Also, the quality of the arguments improved significantly after engaging in the investigations. However, no significant gain in the quality of arguments was detected when comparing the results in the middle and at the end of the investigations. Many students failed to provide evidence to the claim. The researchers explained that the reason was because the third investigation was more difficult than the previous ones.

Khishfe (2012) examined the relation between students' understanding about NOS and their argumentation skills upon debating controversial socio-scientific topics. Thus, no argumentation intervention was conducted to study the impact of argumentation on students' understanding. Her study involved grade 11 students from different schools in Beirut. Students were given a survey about two different socio-scientific issues which included questions related to NOS and argumentation. Students' answers that are related to NOS were grouped as subjective, tentative, or empirical. Argumentation answers were grouped depending on whether they include arguments, counterarguments, or rebuttals. In order to analyze students' level of argument, each answer is grouped into one of three levels depending on whether it does not include any justification, includes one valid reason, or more than one justified reason. Results showed that less than 20 % of the students constructed justified arguments, counterarguments, and rebuttals. Also, the majority of students constructed an argument with one or no valid justification. With regard to NOS results, most of the students showed naïve views of the subjective nature of NOS as well as its tentative and empirical natures.

Also, a study conducted by Zohar and Nemet (2002) supported the claim that teaching argumentation skills enhances the level of students' arguments even after a short intervention. These researchers examined the effect of a 12-hour intervention on grade nine students' arguments and understanding of science. This study included a control group that was taught a unit of genetics using the traditional teaching methods. On the other hand, another experimental group was taught the same unit along with argumentation skills. Students' written arguments and discussions were analyzed based on whether no argument was constructed, an argument was provided with one justification, or a strong justified argument was constructed. The results showed a significant gain in the quality of the arguments.

In a similar but more recent study, Venville and Dawson (2010) studied the effect of an argumentation intervention on the level of grade 10 students' arguments. Similar to Zohar and Nemet's (2002) study, a control group studied genetics and sexual reproduction and an experimental group engaged in the same unit in addition to argumentation lessons. Data was collected using open-ended surveys where students individually constructed written arguments. In order to evaluate the quality of students' arguments, the researchers used a framework based on Toulmin's model where arguments were grouped into four levels according to what elements of an argument are provided by the students. Level 1 included the arguments with only a claim. In Level 2, the arguments included claims and data (or warrants) to construct an argument. However, in levels 3 and 4 the argument revealed higher argumentation skills because it included backings, qualifiers, and counterarguments in addition to claims and data. Results of the study showed that students engaged in the intervention demonstrated significantly better argumentation quality than students in the control group. Results showed that most of students' arguments were at level 2 before and after the intervention. Nonetheless, the group engaged in argumentation showed more improvement in level 3 and level 4 arguments than the control group but only a few students achieved high quality arguments. Furthermore, Venville and Dawson performed a similar study in 2013. This study is different from the previous one in the sense that it examined the extent to which teachers included argumentation methods in their teaching. Also, students' arguments were evaluated based on how they discussed a socio-scientific issue in groups or with the whole class and not how they constructed arguments individually. Students' arguments, which were collected by using a survey before and after the intervention, were evaluated based on Toulmin's framework. Results showed a significant gain in argumentation skills in the group engaged in argumentation compared to the control group. However, few students reached a high level of argumentation because they did not use backings and qualifiers in order to justify their arguments. Thus, their justifications were limited to claims, data, and warrants.

On the middle school level, Khishfe (2014) examined the effect of both argumentation and Nature of Science (NOS) activities on grade seven students' argumentation skills and NOS views. Grade 7 students from two schools in the USA as well as two experienced teachers who were trained to acquire knowledge about argumentation skills and NOS elements were involved in the study. One group of students was engaged in learning about NOS elements while the other group learned argumentation skills and NOS. Students in both groups learned about different socio-scientific scenarios. Data was collected by conducting an open-ended questionnaire followed by interviews for both groups at the beginning and end of the study. In the questionnaire, students provided reasons for their arguments and provided counterarguments. Then, the answers were discussed in small groups and with the whole class. Arguments were evaluated based on a rubric according to how well an argument is justified. Results showed that the group engaged in both NOS and argumentation improved significantly in the quality of arguments and understanding of NOS. Also, the group engaged in learning about NOS (without learning any argumentation skills) showed improvement in NOS views while a slight improvement was detected in the level of students' arguments after the intervention. In the same study, students' argumentation skills also improved when other socio-scientific issues were introduced but the gain was not significant when students (who learned only NOS views) were engaged in unfamiliar socio-scientific scenarios (Khishfe, 2014).

Also on the middle school level, Osborne et al. (2004) studied how engaging grade eight students in argumentation about scientific and socio-scientific issues can improve their argumentation abilities. This study extended over two years where in the first year, teachers were trained to acquire the needed knowledge about argumentation and develop a variety of teaching methods. In the second year, the intervention was conducted to study the impact of argumentation on the level of students' arguments. The study also included a control group (no teaching of argumentation skills) and an experimental group (taught the same lesson in addition to argumentation skills). The data was collected through video and audiotapes of students' discussions. Toulmin's model was adapted and used for the evaluation of arguments. Results of this study showed that the teachers' skills in incorporating argumentation in their teaching significantly improved. Upon comparing students' arguments before and after the intervention, results showed a gain in the quality of arguments but this improvement was not significant.

Hong, Lin, Wang, Chen, and Yang (2013) pointed out that most studies on argumentation were conducted at the high school or college levels and only a few at the middle or elementary levels. According to Sadler and Fowler (2006), learners need to acquire a minimum level of scientific knowledge in order to construct rational arguments. However, in an attempt to show that an argumentation intervention can enhance learners' argumentation skills at the elementary level, Hong et al. (2013)

conducted a 12-week intervention on students in grades 5 and 6. Two groups were involved: an experimental group that engaged in the argumentation intervention and a control group that learned the same lessons without including argumentation skills and through teacher-centered methods. The experimental group discussed and debated, in groups and with the whole class, different socio-scientific issues. Also, they provided other elements of an argument such as data, warrants, and rebuttals. Data was collected from both groups at the beginning and the end of the study by using a questionnaire, observing classrooms, and interviewing teachers and students. The questionnaire's questions urged students to provide a claim and reasons to support the socio-scientific case presented. Students' responses were analyzed using Osborne et al.'s (2004) framework that was adapted from Toulmin's model. Results showed that the quality of the arguments in the group engaged in the intervention improved significantly compared to the level of the arguments in the control group. Moreover, students who showed more progress in the level of their arguments were low achievers.

In brief, results concerning the effect of an argumentation intervention on the level of arguments showed mixed results. Some studies showed significant improvement while others did not. Moreover, few students achieved high-level arguments. Therefore, this study attempted to explain these results and determine the factors that lead to achieving well-justified scientific arguments (that provide counterarguments and rebuttals). Moreover, we notice that few studies were performed at the middle school level although students at this level should engage in argumentations taking into consideration their level of content knowledge. This is important because it familiarizes students at an early stage with the elements of an argument and the process needed to construct strong rational arguments. Furthermore, few studies focused on biology and those that did particularly addressed argumentation in topics related to genetics. This is because genetics provides a solid ground for debatable socio-scientific issues. However, argumentation is rarely integrated in other topics such as the effect of drugs on the body, plant science, neurology, and immunology. In addition, almost no studies took place in the Lebanese context taking into consideration its curriculum and objectives.

Argumentation and Informal Reasoning

Evaluating arguments using the previously discussed models provides an insight into the structure of an argument rather than the process of thinking that the learner has engaged in to construct the argument. Therefore, few studies focused on the impact of argumentation on students' informal reasoning which reveals the thinking process that lead to the construction of the argument. In most studies, students' written statements that were discussed during the intervention were grouped into one the following levels of informal reasoning: intuitive, emotive, rational, or a combination of two or more levels (e.g. intuitive and emotive). A rational argument shows that students were able to distinguish between strong and weak arguments and have a scientific knowledge base. An emotive argument shows that the students' feeling toward another person in a scenario dominate their choice of a claim. An intuitive argument is the first instinctive feeling toward the situation and thus, students' prior belief about a situation controls their judgment. Rational informal reason, that shows the scientific thinking process, can be assessed during an argumentation intervention because as students try to resolve two conflicting scenarios, they construct knowledge and reveal the process of learning (Osborne et al., 2013).

Researchers claim that engaging students in argumentation has the potential to enhance their quality of reasoning (Osborne, Erduran, & Simon, 2004; Venville & Dawson, 2010). Yet achieving rational informal reasoning is often rare. It is important to note that rational reasoning is valued more than the emotive and intuitive reasoning because it is related to the process of constructing scientific knowledge. For example, Venville and Dawson (2010) examined the effect of an argumentation intervention on grade 10 students' informal reasoning. A control group studied through traditional teaching methods and an experimental group studied the same lesson in addition to argumentation skills. Data was collected through an open-ended survey before and after the intervention that included questions to assess their argumentation and reasoning skills as well as their genetic knowledge. Results showed that prior to the intervention, no significant differences in informal reasoning were detected between the experimental and comparison groups. However, there was significant difference in the nature of informal reasoning of the group engaged in argumentation compared to the control group after the intervention. In another study, Venville and Dawson (2009) examined high school students' informal reasoning abilities when they were faced with debatable genetics topics without being previously engaged in an argumentation intervention. Students were interviewed in groups in which they were asked about debatable genetics topics. The interviews were audio-taped and students' responses were grouped as emotive, intuitive, or rational informal reasoning. Results showed that the majority of students' responses included emotive or intuitive reasoning but they rarely used rational reasoning in their arguments. Moreover, results showed that rational reasoning statements were associated with high-quality arguments (level 4 of Toulmin's model) that include a claim and a clear rebuttal. On the other hand, emotive and intuitive reasoning statements were linked with level 2 arguments that include a claim but do not consist of any rebuttals.

Hence, there exists a gap in the literature in which few studies examined the relation between argumentation and informal reasoning and those conducted showed unsatisfactory results. Few students reached rational informal reason that is valued since it requires scientific evidence in order to justify an argument. Further research should help determine the best methods to achieve high-level arguments and/or explain the difficulty in attaining them. Moreover, no studies were done at the middle school level and in the Lebanese context which was the focus of this study. Therefore, there is a need to identify the type of reasoning that middle school students can engage in and whether or not they are able to provide high-level arguments.

Statement of the Problem

Although some studies suggest that engaging in argumentation enhances the quality of argumentation, informal reasoning, and achievement, other studies show that no or little progress occurs. Therefore, future studies need to explain these conflicting findings. The gap in knowledge that was addressed in this study was that the research which examines the effect of argumentation on the level of arguments, informal reasoning, and achievement at the middle school level and among different biology topics is often rare. Moreover, no studies that engage students in an argumentation intervention were conducted in the Lebanese context. Therefore, the purpose of this study was to identify the level of arguments and the types of reasoning that can be achieved and whether or not this intervention can enhance Lebanese students' knowledge of science.

Rationale and Significance of the Study

Argumentation has become an important teaching method since it has the potential to enhance learning and prepare future citizens capable of making informed decisions about everyday socio-scientific issues. The ultimate purpose of education is to help students to use what they learn and apply it in their everyday life and not only to test their ability to memorize facts and procedures. Therefore, engaging students in activities about familiar debatable public topics related to science that constitute an important part of their culture, helps them develop rational decisions and support them with valid evidence. As a result, research studies should be conducted in Lebanon to examine the effect of integrating argumentation interventions that discuss scientific and socio-scientific topics on student learning and reasoning and argumentation skills. However, no studies in Lebanon examined the impact of an argumentation intervention in science classrooms on students' informal reasoning or achievement (e.g. Khishfe, 2012). Also, other studies that examined this relation showed that few students are able to reach high level arguments. Therefore, this study is important because it attempted to investigate whether or not effective argumentation teaching strategies can scaffold student learning in a Lebanese context. It further examined how effective argumentation can enhance students' informal reasoning and argumentation skills. This may extend previous literature by explaining the reasons for the mixed results concerning the progress in learning after an argumentation intervention.

Research questions

1. Does engaging Lebanese Grade 8 students in argumentation enhance achievement in biology?

2. Does teaching argumentation skills to Grade 8 Lebanese students enhance the level of their arguments?
3. Does engaging Grade 8 Lebanese students in argumentation enhance the level of their informal reasoning skills?

Chapter II

Literature Review

The society's needs today are different from those emphasized several years ago. Learners today are expected to acquire upon graduation the knowledge, skills, and attitudes that allow them to become active citizens in society. Some of these skills allow learners to discuss and debate, using scientific evidence, the socio-scientific issues that often overlap with personal experiences and ethical dilemmas (Osborne, Erduran, Simon, & Monk, 2001). These issues, such as genetic engineering, genetically modified organisms, food safety, and economic plants, are often discussed in the media or the press. However, students often do not relate them to the science they learn in their classrooms. In order for students to become effective decision-makers in society, they need to assess whether the evidence that supports an issue is reliable and valid. Thus, there is an urgent need to enhance the quality of students' arguments with regard to these issues that have become common among people's everyday discussions and conversations (Osborne et al., 2001). Thus, teaching argumentation in science classrooms should become a crucial activity of science education (Osborne, Driver, & Newton, 2000). Introducing argumentation in science classrooms gained more importance after the claim which suggests that teaching argumentation skills can positively influence students' understanding of scientific concepts.

While some research studies have shown that teaching argumentation has the potential to enhance the understanding of science and prepare citizens who are capable of making informed decisions about socio-scientific issues (e.g. Venville & Dawson, 2010; Zohar & Nemet, 2002), other studies have shown that argumentation does not significantly enhance learning (Osborne et al., 2013). Today, the shift towards student-centered learning in the classroom, of which argumentation constitutes an integral part, still promises to improve learning and teaching. In the following section an overview of the evolution of argumentation from a social activity into a teaching method that can enhance learning is presented and the methods developed by researchers in order to evaluate the level of arguments are discussed. Moreover, research on using argumentation in teaching to help students develop argumentation skills, informal reasoning, and conceptual understanding is presented.

Overview on the meaning of argumentation

Argumentation is a common activity in most people's lives that requires significant thinking and reasoning skills. In fact, argumentation determines people's beliefs and judgments. Although most people are familiar with argumentation, there has not been an agreed on definition of this skill. Many people link argumentation to logic, but the two terms are quite different (Driver, Newton, & Osborne, 2000; Van Eemeren et al., 1996). Van Eemeren et al. (1996) described argumentation as a verbal and public activity as well as an action of reason. Therefore, they claim that people often argue in a certain language-about a subject which they think they are highly knowledgeable in and experienced about-targeting a specific group of individuals. In such a case, argumentation occurs when two individuals who have opposite views try to convince the other with his or her standpoint.

Two main types of arguments, rhetorical and dialogical, are described in the literature. Dialogical arguments are described as social arguments where a dialogue occurs between people holding opposing views (Kuhn, 1991). In this type of argument, each person offers related evidence or justifications in order to support his or her argument and also attempts to refute the other's view by providing a counterargument (Kuhn, 1991). Then, both the supporting and refuting evidence are weighed and evaluated in order to resolve the argument (Kuhn, 1991). On the other hand, rhetorical or didactic arguments are individual arguments and their structure is not shaped by an audience. Rhetorical arguments are described as “a connected series of statements intended to establish a position” (Andrew, Goldberg, Kremer, Telenius, Theilmann, Adam, & Hayden, 1993, p. 16). Although it may appear that a dialogical argument is more cognitively complex than a rhetoric one, the same skills are involved in both types of arguments but are implicit in a rhetorical argument (Kuhn, 1991). In a rhetorical argument, an individual places two opposing assertions in his or her mind (hence, the process is implicit) and relates both supporting and refuting evidence to each assertion. Then, the individual chooses one over the other by implicitly weighing the supporting and refuting evidence for each assertion. Therefore, even though in rhetorical arguments no direct dialogue is established between the arguer and the audience, the same argumentative skills are implicitly involved where an arguer must consider an opposing assertion and evaluate all evidence with and against his assertion (Kuhn, 1991).

Meaning of an Argument: Toulmin’s Model

Until the 1950s, argumentation was not widely applied to teaching. Its role was limited to seeking the “truth”; that is to say each individual viewed his or her argument as being the only correct one (Van Eemeren et al., 1996). One of the most well-known philosophers to initiate a theoretical change in this regard was Stephen Toulmin. Toulmin (1958) studied argumentation and argued that the evaluation and construction of some aspects of arguments would differ according to the context (e.g., everyday life situations). Thus, he believed that there were no general rules in order to assess or construct arguments (Van Eemeren et al., 1996; Driver et al., 2000). Even though Toulmin recognized some variations in argumentation from field to field, he proposed a general pattern in order to evaluate arguments (Osborne, Erduran, & Simon, 2004; Driver, Newton, & Osborne, 2000; Van Eemeren et al., 1996). The major elements in Toulmin's pattern or model are: claim, data, and warrants. A claim is the basic element of any argument. The proposer of a claim defends it even when it consists of unjustified statements that lack supporting evidence. However, in order for a claim to be accepted, it should include a set of data (which constitute the evidence) that support a claim. A warrant is similar to the data that validate a claim (Osborne et al., 2004; Driver et al., 2000; Van Eemeren et al., 1996). Warrants justify a claim and show how the supporting data are relevant to the claim and why they make it valid. According to Toulmin (1988), one feature that differentiates warrants from data is that warrants may be implicit or unspoken while data are explicitly expressed. However, these elements are closely related since the data that support or challenge a claim depend on the warrants – which are the implicit steps followed from data to claims (Toulmin, 1988)

More complex arguments would include the following additional elements: backings, qualifiers and rebuttals. Backings are a set of theoretical assumptions or general conditions required to support the acceptability of a warrant (Osborne et al., 2004). Qualifiers are crucial in order for a claim to be valid and objective. The reason is because qualifiers limit the range of strength of data and warrants through which a claim can be generalized to different situations. Rebuttals (or counterarguments) indicate the conditions when the argument is not valid or true.

Although Toulmin's argumentation pattern is usually adopted in order to analyze and construct arguments, (e.g. Driver et al., 2000; Osborne et al., 2004) some authors have indicated limitations in this framework. For instance, Van Eemeren et al. (1996), pointed out that it can be difficult to differentiate between data and warrants because of their contradictory definitions. In order to better distinguish data and warrants, these authors recommended interpreting data as containing factual information and warrants as general statements based on the argumentation scheme.

Toulmin’s pattern describes argumentation in a science classroom (Schwarz & Lederman, 2002; Zohar & Nemet, 2002). As a result, several alternative argumentation models, based on that of Toulmin, were developed. For example, Zohar and Nemet (2002) modified Toulmin’s method to suit their study. The purpose of their study was to assess student learning by explicitly teaching argumentation skills in a unit on human genetics. Then, they evaluated students’ written responses depending on whether these responses included a conclusion with at least one relevant justification. Also, they evaluated argument structure depending on whether zero, one, or more reasons were given to support a conclusion. However, Sampson and Clark (2008) noted that one limitation to this method is that while it can be used to evaluate student discourse, which occurs in socio-scientific issues (that have multiple perspectives), it is difficult to implement in a scientific discourse.

Driver et al. (2000) argued that Toulmin’s model is not helpful for analyzing dynamic small group interactions that take place during classroom discussions. To resolve this problem, Osborne et al. (2004) adopted a revised version of Toulmin’s framework for the purpose of their study in order to enhance student argumentation regarding group work in science classrooms. To attain their aim, Osborne et al. (2004) revised Toulmin’s model to improve its ambiguous argument structure. They did so by resolving the most problematic elements of Toulmin’s pattern (i.e., warrants, data, and backings) and evaluating the counterarguments provided by the students. In other words, they differentiated data, warrants, and backings from rebuttals or counterarguments. Therefore, in this framework, Osborne et al. (2004) evaluated students' arguments by grouping them into five different levels depending on the different elements of an argument that students provided as well as the presence of a clear rebuttal in their argument. Level 1 includes the arguments with only a claim or a counterclaim. In Level 2, the arguments include claims and one of the following elements: data, backings, or warrant. However, Level 2 arguments do not include any rebuttals. Level 3 arguments contain a claim with a weak rebuttal in addition warrants, data, or backings. Level 4 arguments reveal higher argumentation skills because they include a clear and understandable rebuttal in addition to the other elements of level 3. Finally, Level 5 arguments include the best quality arguments because the argument is explained and detailed and include more than one rebuttal. This approach is powerful for certain research contexts that involve group work. However, some researchers still consider it a methodological limitation because it is sometimes important to study group as well as individual performances.

Argumentation and Student Achievement

Research has shown that engaging students in argumentation can enhance their understanding of scientific concepts. In 2010, Venville and Dawson argued that although many studies examined the effect of a person's conceptual understanding on the ability to construct arguments (e.g. Lewis & Leach, 2006; Aufschnaiter, Erduran, Osborne, & Simon, 2008; Sadler & Zeidler, 2004), less research attention has been given to the relationship between the process of argumentation and student learning. Therefore, further consideration was given to this relation in later studies. Researchers claim that engaging in argumentation requires students to use high cognitive skills which may lead to better learning. In this section the results of studies that examined the effect of argumentation on student achievement in science are discussed.

In an attempt to examine how argumentation affects university students' understanding of genetic concepts, Demirbag and Gunel (2014) conducted an argumentation intervention based on integrating ABSI (argumentation-based science inquiry) approach with multi-modal representations (texts, graphs, mathematical formulas, pictures, and tables). Participants in this study were university students enrolled in teacher preparation science education program. ABSI approach was administered in all sections. However, only two of these sections were also taught using the modal awareness and integration instruction. Data came from students' written and oral arguments. Results of this study showed that students, who were instructed by using ABSI approach and modal representations outscored the comparison group on the science achievement tests. The researchers concluded that the ABSI approach and modal representations should be integrated in the activities and teaching methods developed by educators in order to engage students in argumentation.

Zohar and Nemet (2002) investigated the teaching of argumentation skills and its effect on student learning in genetics. The study involved two groups of grade 9 students in which the experimental group was engaged in argumentation while the comparison group learned the same lessons but without argumentation. The researchers administered tests before and after the intervention to assess student learning. Results of this study showed that after a short intervention, a significant gain in the genetic knowledge was detected in the experimental group compared to the control group.

Venville and Dawson (2010) examined the effect of an argumentation intervention on student achievement about genetics concepts. Participants of the study included two groups of grade 10 students in which one group was engaged in argumentation while the other studied the same genetics lessons but did not learn the argumentation skills. Data was collected by administering surveys at the beginning and end of the intervention. Results showed gains in student achievement in both groups but were more significant in the group engaged in the argumentation compared to the group that was not involved in argumentation. The researchers concluded that after a short intervention, students engaged in argumentation were able to link different isolated concepts and develop high-order thinking skills which lead to improved achievement in science.

In another study, Venville and Dawson (2013) studied the impact of argumentation on achievement in science. The researchers worked with grade 10 students who were divided into an experimental and a comparison group. The comparison group was taught a unit of genetics while the experimental group studies the same unit as well as argumentation skills. The experimental group was given Genetic scenarios and asked to argue with or against the case presented, provide justifications and counterarguments, as well as evaluate evidence. Students discussed the scenarios in small groups and with the whole class. Data from this quasi experiment was collected over 8-10 weeks. In order to collect data, they conducted a survey before and after the intervention. The survey consisted of different parts used to assess the quality of arguments, the level of reasoning, and content knowledge. The part of the survey that tested for student achievement consisted of multiple choice questions and short answer questions about genetics concepts. The results showed significant gains in student achievement in both groups after the genetics unit. However, the improved achievement was more significant in the group involved in argumentation compared to the comparison group. The researchers concluded that the knowledge of students improved because they participated in oral group and whole-class discussions. Thus, students could further relate different concepts and justify arguments which led to better learning.

Osborne et al.'s study conducted in 2013 was reviewed in the first section of this chapter. It investigated the effect of argumentation on achievement as well as levels of argumentation. It also aimed to integrate argumentation teaching methods in the science curriculum and ensure that students work in small groups during the argumentation activities. This process required that teachers participate in professional development to develop the skills needed to teach argumentation. Moreover, the researchers tested how engaging students in argumentation affects their reasoning and learning. Participants in this study were two groups of students (ages 11-16) from 4 schools, one of which was involved in argumentation teaching. The experienced teachers were responsible for developing the argumentation methods and integrating them in their classes. In order to study the effect of argumentation on student learning, a test (adopted from the country's national standard test questions) was administered before and after the intervention. The test questions tested for students' general scientific knowledge related to topics included in the science curriculum.

Results of the study showed that prior to the intervention, there were no significant differences in the performance between the 11 and 12 year-old students between the comparison and experimental groups while 15-16 year old students showed differences in their performance. After the intervention, the results showed a significant gain in the comparison group of 15-16 year old students when compared to the experimental group. However, no significant differences were detected in the performance of 11-12 year old students in the experimental group when compared to the comparison one. The researchers explained that one of the reasons for the lack of improvement in the 11 and 12 year group was that the professional development provided for the teachers was not enough to induce an improvement in students' outcomes. The weaknesses in the professional development could be due to different variables such as the time of the professional development, teachers' motivation to engage in the intervention, or the methods adopted to improve teachers' argumentation skills and help them introduce argumentation in their classrooms. Another reason could be the instruments used to evaluate students' arguments which may have led to the insignificant results.

Cross, Taasoobshirazi, Hendricks, and Hickey's (2008) performed a two-week argumentation intervention with high school biology students in the USA. The purpose was to examine the effect of engaging high school students in argumentation on their learning and achievement in science. Students worked in groups and the researchers focused on one of these groups in order to evaluate their discussions during the intervention. The researchers claimed that engaging students in argumentation links students' prior knowledge to their new knowledge which ensures a better understanding of science concepts. In order to examine the gains in student learning, the researchers conducted four quizzes related to the lesson activities during the whole intervention period. Students completed a quiz after each biology unit. Also, the researchers conducted curriculum examinations which were specific to the curriculum objectives determined by the state and standard tests that consisted of questions that focused on general scientific knowledge. The researchers studied students' grades on these tests to determine the gain in learning. In order to evaluate the improvement in students' argumentation, they videotaped the discussions of the selected group of students. These discussions took place after students had individually completed the unit quiz. In groups, students provide an argument which they believe best explains the proposed scenario and they use the elements of argumentation (data, warrants, or backings) to support it. Moreover, students were engaged in activities to differentiate between weak and strong arguments to be able to evaluate their own arguments. Results in this study showed significant improvements in student achievement when measured by one multiple choice test but very small improvement when another similar test was used. The researchers concluded that both argumentation and students' prior knowledge are important. The high quality arguments that contain rebuttals and qualifiers (that show that students were able to evaluate the strength of an argument) lead to better understanding. Also, students' prior knowledge affects the quality of their arguments.

Argumentation and Improving the Level of Arguments

Research studies have claimed that engaging students in argumentation results in significant improvement in the level of their arguments (Osborne et al., 2004). This situation requires educators to include this teaching method in the science curriculum in order to meet the society's needs and raise citizens who are capable of making informed decisions about socio-scientific issues. Although several studies showed significant gains in the level of students' arguments, few students were able to reach high level arguments. Moreover, results from other studies showed no gain in the level of arguments after teaching argumentation. In the following section the results of these studies as well as the reasons for the insignificant gains in argumentation are discussed.

Several research studies examined the impact of an argumentation intervention on the level of students' arguments. Some studies were conducted on college or high school students. Others chose middle school students to be engaged in an argumentation intervention while a few studies implemented an intervention with elementary students. The methods that were developed to introduce argumentation in science lessons as well as the results of the intervention on the level of students' arguments varied.

Walker and Sampson (2013) examined how an ADI (argumentation-driven inquiry) intervention affects students' written and oral arguments. Students enrolled in two General Chemistry Lab sections in a college in the USA were selected for this study. Also, the researchers selected an experienced competent teacher to teach the lab course. The data collected included students' performance tasks, lab reports and transcripts from video recordings during group discussions. It is important to note that during ADI, students conducted lab investigations related to basic chemistry concepts such as chemical reactions, solutions, and molecular structures. During the intervention, students were engaged in five different investigations with increasing difficulty. To perform each investigation, students followed seven steps of ADI in which argumentation constitutes a basic part. First, students (in groups) identified the problem and developed the procedure necessary to investigate and resolve it. Then, they collected and analyzed the data. After that, each group constructed an argument and discussed it with the other groups. As a result of the discussion, the argument was modified. When the final argument was established, they wrote a report that was revised by another group before it was submitted to the teacher. Students' written and oral arguments were evaluated before, in the middle, and after the intervention in order to track the development of students' arguments throughout the course. Students' arguments in videos and audios were transcribed and coded according to the model ASAC (Assessment of Scientific Argumentation in the Classroom). This model consists of three sections: Conceptual (which focuses on students' ability to evaluate and construct an argument), Epistemic (which shows the ability to challenge an argument), and Social (which deals with the student's interaction in his/her group). Researchers set a score from one to four depending on how frequently each item occurred in the recordings. However, lab reports were scored using a rubric depending on whether or not certain elements of argumentation were attained such as providing a well-constructed claim, rational supporting evidence, and evaluating arguments with the group.

Results of the study showed an overall gain in the level of arguments as indicated when comparing the pre-test and post-test. Also, the quality of the arguments improved significantly from the pre-test till the mid-test. However, no significant gain in the quality of arguments was detected when the results of the mid-test and post-test were compared apparently because many students failed to provide evidence to the claim. The researchers explained that the reason was because the third investigation was more difficult than the previous ones. Moreover, the results of the oral and written arguments showed a significant improvement in the level of arguments upon engaging in the intervention. The researchers concluded that there is a need to explicitly teach the nature and elements of argumentation to better develop argumentation skills and construct high-quality arguments.

Zohar and Nemet (2002) investigated the impact of a short intervention on the quality of grade 9 students' arguments and their understanding of scientific concepts. In a twelve-hour intervention study in two schools, the researchers collected students' written worksheets and audiotapes of whole class discussions in order to evaluate their argumentation level. The study included two groups of students. In the first group, students were taught a unit of genetics using traditional teaching strategies while the other group experienced the "Genetics Revolution Unit" in which argumentation skills were introduced. The genetics unit included moral dilemmas and activities related to modern technologies in genetics. Prior to the study, both groups received basic knowledge about genetics and during the intervention they learned more advanced concepts. Prior to the intervention, a pre-test was administered to ensure that both groups had the same prior argumentation abilities. Students' transcripts from written arguments and discussions were analyzed using a scale from 0 to 2 where a score of 0 indicated the absence of argumentation, a score of 1 indicated that students provided an argument with one justification, and a score of 2 revealed that students provided a strong argument that includes justifications as well as reasons for these justifications. The results showed a significant gain in the quality of the arguments. The researchers concluded that teaching argumentation skills in an explicit manner can improve students' argumentation.

In another study, Venville and Dawson (2010) evaluated the impact of an argumentation intervention on grade10 students' argumentation levels. Also, they assessed the effect of this intervention on students' informal reasoning and understanding of genetic concepts. The participants in the study were 46 students in the control group who studied about genetics and sexual reproduction, while 46 students in the intervention group were engaged the same unit and received additional argumentation lessons on topics such as cloning, genetic diseases, genetic engineering. The researchers purposefully selected a competent biology teacher who had experience in teaching genetics for grade 10. Prior to teaching the experimental group, the teacher participated in a professional development session in order to improve his knowledge about the nature and structure of argumentation as well as his skills in developing and integrating argumentation activities. Data was collected using open ended surveys where students individually expressed their opinions in a written form (no group work discussions). In order to evaluate the quality of students' arguments, the researchers used a framework based on Toulmin's model where arguments were grouped into four levels according to what elements of an argument are provided by the students. Level 1 included the arguments with only a claim. In Level 2, the arguments included claims and data (or warrants) to construct an argument. However, in levels 3 and 4 the argument revealed higher argumentation skills because it included backings, qualifiers, and counterarguments in addition to claims and data. Results of the study showed that students engaged in the intervention demonstrated significantly better argumentation quality than students in the control group. However, most of students' arguments were at level 2 before and after the intervention. Nonetheless, the group engaged in argumentation showed more improvement in levels 3 and 4 arguments than the control group, although a few students achieved high quality arguments.

In a recent and similar study, Venville and Dawson (2013) also examined the impact of argumentation on the development of students' argumentation skills. Also, they investigated how engaging students in argumentation affected their informal reasoning skills and conceptual understanding in genetics (discussed in next sections). This study is different from the previous one in the sense that it examined the extent to which teachers included argumentation methods in their teaching. Also, students' arguments were evaluated based on how they discussed the socio-scientific issue in groups or with the whole class and not how they constructed arguments individually. Participants in this study included 9 experienced biology teachers and 133 grade 10 students from 3 schools. Prior to the study, the teachers selected to teach the classes engaged in argumentation attended a professional development session in which they were introduced to the nature of argumentation and informal reasoning. Also, they discussed with the researcher how to include argumentation in their teaching. The researchers studied the extent to which teachers included the argumentation methods in their teaching. As for students, they were given genetic scenarios and asked to argue with or against the case presented, provide justifications and counterarguments, as well as evaluate evidences. Students discussed the scenarios in small groups and with the whole class. Data from this quasi experiment was collected over 8-10 weeks. The data regarding the teachers' argumentation strategies was obtained by audio taping lessons and studying field notes and writing frames. In order to collect students' data, the researchers administered a survey before and after the intervention. The survey consisted of different questions to assess the quality of arguments, the level of reasoning, and content knowledge. The quality of student's arguments was evaluated using a framework adopted from Toulmin's model which is similar to the framework used by Venville and Dawson in the 2010 study. Results showed a significant gain in argumentation skills in the group engaged in argumentation compared to the control group. However, few students reached a high level of argumentation because they did not use backings and qualifiers in order to justify their arguments. Thus, their justifications were limited to claims, data, and warrants. The researchers concluded that it is difficult to help students achieve high-level arguments and recommended teaching argumentation skills in the different science subjects. They stressed the need to educate students about the value of using backings and qualifiers to construct high-level arguments.

In a study conducted in Lebanon, Khishfe (2012) examined the relation between students' views about nature of science (NOS) and their level of argumentation when engaging in debatable socio-scientific issues. Participants were 219 grade 11 students from five different schools in Beirut, Lebanon. The researcher administrated open-ended questionnaires that examined students' views about NOS and argumentation skills when presented with two debatable cases: genetically modified food and the fluoridation of water. The questions related to argumentation required students to make decisions about the case discussed and generate arguments, rebuttals, and counterarguments. In addition to the questionnaire, the researcher conducted interviews after the questionnaire in order to allow students to explain their responses in an attempt to better understand the process of argument construction. In order to evaluate students' arguments, the researcher focused on three elements of argumentation (argument, rebuttal, and counterargument). Students' statements were grouped as: no valid claim, valid claim with one reason, or valid claim with more than one reason. This method for evaluating arguments was adapted from a model used by Mason and Scirica in 2006. Results showed that, for both scenarios, few students (less than 20%) constructed arguments, rebuttals, or counterarguments with claims that are supported with more than one explanation. The researcher explained that the reason for these results is the difficulty that students face when constructing well-structured arguments as was evident in other research studies (e.g. Driver et al., 2000; Kuhn, 1991). Moreover, results revealed a relation between the different elements of argumentation (counterarguments, arguments, and rebuttals) as well as a relation between argumentation and NOS.

In another study, Khishfe (2014) examined the effect of an intervention that engaged grade 7 students in both argumentation and NOS activities on students' argumentation skills and NOS views. Also, the researcher studied whether or not students can apply the acquired argumentation skills and knowledge about NOS in different familiar and unfamiliar socio-scientific scenarios. It is important to note that the teaching of both argumentation and NOS was done in an explicit manner to allow students to focus on and learn the different elements that lead to constructing high-quality arguments and understanding the components of NOS. Participants included 121 grade 7 students from two schools in the USA and two experienced teachers. Prior to the study the teachers were engaged in a course in order to improve their knowledge and skills about NOS as well as their argumentation skills. Their views about NOS and argumentation significantly improved after the course. Also, before the intervention, the teachers and the researcher discussed the unit that was planned to be taught during the intervention. The teachers designed together the instructional methods that were to be used to teach argumentation and NOS in their classrooms. Moreover, there were two groups of students. The first group was engaged in learning about NOS. The other group was engaged in learning argumentation in addition to NOS. During the intervention, students were introduced to debatable socio-scientific scenarios about water safety, water fluoridation, and genetically modified food. Data was collected by using an open-ended questionnaire followed by interviews for both groups at the beginning and end of the study. Students responded to the questions about argumentation by providing arguments and reasons to justify them as well as counterarguments or rebuttals. Similarly, students answered questions related to the elements of NOS (its tentative, empirical, and subjective nature). After discussing the scenarios in small groups and answering the related questions, the students discussed their answers with the whole class in order to differentiate between the different components of arguments. Students' arguments were evaluated based on a rubric in which every element of the argumentation (argument, rebuttal, and counterargument) was grouped as weak (argument lacks explanation), intermediary (argument is explained by one valid reason), or well-informed (argument is justified using more than one reason). Results showed that the group engaged in both NOS and argumentation improved significantly in the quality of arguments and understanding of NOS. Also, the group engaged in learning about NOS (without learning any argumentation skills) showed improvement in NOS views while a slight improvement was detected in the level of students' arguments after the intervention. Moreover, students in both groups applied their understanding of NOS in other familiar and unfamiliar contexts. Students' argumentation skills also improved in other contexts but the gain was not significant when students (who learned only NOS views) were engaged in unfamiliar scenarios.

In an attempt to evaluate the improvement of students' argumentation abilities, Osborne et al. (2004) engaged grade 8 students in argumentation about socio-scientific and scientific issues. The study was conducted over two years and included two phases. During the first year, the researchers trained 12 experienced teachers to teach argumentation in the classroom and develop a variety of teaching material and activities. In the second year, the trained teachers taught argumentation and the researchers studied the impact of this intervention on the level of students' arguments. Participants in the study included students in the control group who were not involved in argumentation, while students in the experimental group studied the same lessons and acquired additional argumentation skills. For example, the experimental group was presented with two competing ideas and asked to discuss and evaluate each one. Then, they were required to give an argument that supports one of these ideas and defend it based on the validity of the evidence that supports it. Another method to engage students in argumentation was to teach them how to write an argument. In order to do so, students were guided by specific words or phrases (such as my reasons to support this argument are…) in order to uncover students' thoughts about argumentation. A third strategy included presenting students with weak and strong arguments. Students would then discuss both types of arguments and identify the elements that make an argument strong or weak. The data was collected using video and audio recordings of students' and teachers' transcripts during their discussions. The qualities of the arguments were evaluated by using a model based on Toulmin's pattern where arguments are grouped into five levels and level 5 includes the high-quality arguments (please refer to the model presented above). Results of this study showed that the teachers' skills in incorporating argumentation in their teaching significantly improved. Upon comparing students' arguments before and after the intervention, results showed a gain in the quality of arguments but this improvement was not significant. The researchers concluded that argumentation is a long-term process and students' arguments, which require high cognitive skills, cannot develop after a short intervention.

Hong et al. (2013) examined the effect of an argumentation intervention on elementary students' argumentation skills. Participants included 111 grade 5 students who were engaged in the intervention (experimental group) and 107 grade 6 students who did not engage in the intervention (control group). During the intervention, the experimental group was presented with socio-scientific scenarios that the students discussed in small groups in order to generate claims and suggest evidence. Also, students engaged in hands-on-activities related to the scenario. After the discussion and the hands-on activity, students presented their results that included their claim along with the different elements of their argument (data, rebuttals, warrants, backings, and qualifiers). Finally, students debated and explained their different arguments in whole-group discussions. These steps were followed during the 12-week intervention whenever a new socio-scientific case was introduced. On the other hand, the control group learned the same lessons by using teacher-centered teaching methods. Data was collected from both groups at the beginning and the end of the study by using a questionnaire, observing classrooms, and interviewing teachers and students. The questionnaire included scenarios about socio-scientific issues and questions that urge students to take a stand with or against the case presented and provide reasons for their claim. Students' responses were analyzed using Osborne et al.'s (2004) framework that was adapted from Toulmin's model. Results showed that the quality of the arguments in the group engaged in the intervention improved significantly compared to the level of the arguments in the control group. It is important to note that the students who showed more progress in the level of their arguments were low achievers. The researchers concluded that their teaching method, based on scaffolding students' ideas to construct arguments, is more suitable for low achievers.

It is important to note that engaging in argumentation is essential for all citizens because it allows them to make wise decisions and argue rationally about different socio-scientific issues. However, Hong et al. (2013) explained that most studies have focused on teaching argumentation to high school or university students. Thus, few research studies examined the argumentation skills of elementary or middle school students. Sadler and Fowler (2006) explained that the reason is because in order to construct rational arguments, a certain knowledge level is required and this knowledge is attained at the college level. Moreover, Cross et al. (2008) explained that students who are more knowledgeable about the topic are more likely to show improvements in their learning (after an argumentation intervention) compared to those who possess less knowledge. Sadler and Zeidler (2005) showed similar findings as they investigated undergraduate students' understanding of genetics. Their results indicated that students, who were more knowledgeable about genetics, demonstrated better reasoning skills and accommodated new knowledge during argumentation than those who were less informed about the subject. Later studies showed that engaging high school or middle students in argumentation improved their argumentation skills as well as their understanding of scientific concepts (Venville & Dawson, 2010; Zohar & Nemet, 2002). Finally, Hong et al.'s (2013) study showed that even students at the elementary level can develop arguments. Also, it is important to engage children in argumentation because their commitment to science at this age (especially when engaging in social and debatable issues) helps them develop positive attitudes toward science in the future.

Argumentation and Informal Reasoning

In the previous section, the importance of educating learners about argumentation in order to raise better citizens who are capable of making informed decisions about SSI were explained. However, the models used to evaluate the quality of arguments (such as Toulmin's model) reveal the structure of the final argument constructed by learners and do not provide insights about the thinking processes that occur as students construct an argument. Therefore, researchers were interested in uncovering students' reasoning and thinking processes when they are engaged in argumentation. In order to evaluate the quality of informal reasoning, researchers developed different models. One model is the informal reasoning model that groups students' statements as emotive, intuitive, rational, or a combination. This method was initially used in some research studies (e.g. Sadler & Zeidler, 2005; Venville & Dawson, 2009) and later it was commonly adapted in other studies. An argument is rational when the student uses his/her scientific knowledge about a topic and considers the factors that distinguish weak and strong arguments. An emotive argument is an argument constructed based on students' feelings (caring or worrying) toward another person in a certain scenario. An intuitive argument is given based on someone's presumed belief that something is true. Thus, the intuitive argument is stated without thinking about the advantages or disadvantages of this argument and is based on the students' first instinctive feeling toward the scenario. Researchers claim that rational reasoning is more important than other forms of reasoning since it requires engaging in the process of scientific thinking. Moreover, emotive reasoning is more valued than intuitive reasoning since it necessitates the consideration of others' feelings (Sadler & Zeidler, 2005).

Informal reasoning can be assessed when students engage in argumentation. This is because human reasoning occurs when individuals assess conflicting ideas or alternatives and construct knowledge in the process (Osborne et al., 2013). Thus, learning to argue in order to resolve a conflict is integral to the process of constructing knowledge (Osborne et al., 2013).

Several research studies examined the effect of argumentation on the development of students' informal reasoning. Researchers claim that engaging students in argumentation has the potential to enhance their quality of reasoning (Venville & Dawson, 2010; Osborne et al., 2004). Yet achieving rational informal reasoning is often rare. In the following section I the results of the studies that examined the impact of involving students in argumentation on informal reasoning and explain the reasons of the results are highlighted.

Sadler and Zeidler (2005) investigated students' informal reasoning when engaging in different genetics scenarios. The researchers did not perform an intervention as their aim was to understand students' initial informal reasoning patterns when presented with debatable socio-scientific scenarios. Participants included 30 college students in the USA. The researchers conducted two interviews with individual students. In the first interview, the students read a genetics scenario and were asked to provide an argument, another argument that opposes their initial one, and a rebuttal that refutes the argument which opposes their initial argument. In the second interview, the researchers restated students' responses in the first interview and the students had the chance to explain their answers. In particular, students were asked to provide the factors which influenced their positions such as caring about the feelings of the individuals in the scenario or immediately responding to the scenario without involving their emotions. The interviews were audio recorded and analyzed and categorized as rational, intuitive, emotive, or a combination. Results showed that the students used the three types of informal reasoning and in most cases their responses were a combination of two of these types. It is important to note that the frequency of using one type compared to another differed between the scenarios. It seems that students interact differently when they are familiar with or more knowledgeable about a scenario compared to another. The researchers concluded that there is a need to focus on and value rational, emotive, and intuitive reasoning in all science classrooms.

Venville and Dawson (2010) examined how engaging grade 10 students in an argumentation intervention influenced the nature of their informal reasoning. The study involved a group of students who were engaged in the intervention and a control group that was not involved in argumentation but was taught the same topics through traditional teaching methods. Data was collected by administering an open-ended survey before and after the intervention. Students' responses to the survey questions were analyzed by grouping them in one of the categories of the informal reasoning model, specifically emotive, intuitive, rational, or a combination. According to the researchers, rational reasoning is more important than the emotive and intuitive reasoning because it is related to the process of constructing scientific knowledge. Moreover, emotive reasoning is valued more that intuitive reasoning because it requires thinking from the perspective of others while intuitive is an immediate response to a certain issue. Results showed that prior to the intervention, no significant differences in informal reasoning were detected between the experimental and comparison groups. However, there was significant difference in the nature of informal reasoning of the group engaged in argumentation compared to the control group after the intervention. Also, no significant gain in the level of informal reasoning was shown when comparing the pre- and post-test results of the comparison group while a significant gain was revealed when comparing those of the experimental group. It is important to note that the occurrence of rational informal reasoning increased in both groups; yet this improvement was significantly better in the experimental group.

In a similar study, Venville and Dawson (2013) examined how an argumentation intervention affects the type of students' informal reasoning. The study included two groups of grade 10 students in which one group was involved in argumentation while the other group learned the same lessons (related to Genetics) without the argumentation skills. The researchers administered open-ended surveys before and after the intervention for both groups in which they were presented with scenarios related to genetics and they answered related questions to assess their argumentation and reasoning skills as well as their genetic knowledge. In order to evaluate the level of informal reasoning, students' statements were grouped as emotive, intuitive, rational, or a combination. Results of the study showed a significant change in the nature of informal after the intervention in the group which was engaged in argumentation but not in the control group. The researchers concluded that students used rational informal reasoning more frequently because they gained knowledge about the topic during the course of the Genetics unit.

Venville and Dawson (2009) examined the relationship between students' arguments and their informal reasoning as well as the structure of their arguments. The purpose of the study was to examine students' argumentation levels and informal reasoning abilities when they were faced with debatable genetics topics without being previously engaged in an argumentation intervention. Participants in this study included 30 high school Australian students with ages ranging between 12 and 17 years. Data was collected by conducting interviews at the end of the year with the students and asking questions about debatable genetic topics such as cloning and biotechnology. The students were interviewed in groups of 2 or 3 and the interviews were audiotaped and then transcribed. Interview transcripts were analyzed using Toulmin's model to determine the quality of the arguments and by using the informal reasoning model that categorizes statements as emotive, intuitive, rational, or a combination, to determine the level of informal reasoning. Results showed that the majority of students' responses included emotive or intuitive reasoning but they rarely used rational reasoning in their arguments. Moreover, results showed that rational reasoning statements were associated with high-quality arguments (level 4 of Toulmin's model) that include a claim and a clear rebuttal. On the other hand, emotive and intuitive reasoning statements were linked with level 2 arguments that include a claim but do not consist of any rebuttals.

In summary, although some studies suggest that engaging in argumentation enhances the quality of argumentation, informal reasoning, and achievement, other studies show that no or little progress occurs. Therefore, this study aims to explain these conflicting findings and address the gap in literature by examining the impact of argumentation on the level of arguments, informal reasoning, and achievement at the middle school level and among different biology topics which is often rare.

Chapter III

Methodology

In this chapter, the design of the study including its qualitative and quantitative components, the participants, the tools for data collection, and data analysis are described. Also, Design-based Research (DBR) in which this study is embedded is presented. DBR is more practical than other research designs since it allows the refinement of some factors in a way that better suits the context of the study. This renders the development and implementation of the intervention more realistic and practical because they are based on continuous observations of the intervention, and the instructional approach and because the materials are modified to better suit the context of the study.

Purpose of the Study

This study aims to examine, using DBR, the effect of an argumentation intervention on students' achievement in science, informal reasoning skills, and level of arguments. In particular, the following research questions were examined:

1. Does engaging Lebanese Grade 8 students in argumentation enhance their achievement in biology?
2. Does teaching argumentation skills to Grade 8 Lebanese students enhance the level of their arguments?
3. Does engaging grade 8 Lebanese students in argumentation enhance the level of their informal reasoning skills?

Variables. The argumentation intervention (that is applied in the experimental group and absent in the control group) is the independent variable in this study. Moreover, students' achievement in biology, level of informal reasoning, and level of arguments are the dependent variables.

Students' achievement in biology. The process of learning science is based on the ability of students to analyze scientific problems and transfer what they learn to new situations rather than only receiving and regurgitating information or facts (BouJaoude, 2007). Therefore, students' achievement in biology (one of the dependent variables) considers the above characteristics. In order to test for any gains in student achievement, tests were administered prior to and following the intervention.

Students' informal reasoning. Informal reasoning is the process that enables learners to construct and evaluate arguments about a scientific issue. Students are said to have good reasoning abilities if they use scientific evidence in order to justify an argument and are not influenced by personal experiences (Osborne et al., 2013). Hence, if we are able to measure informal reasoning, we understand how students think and guide their thinking process to develop better arguments. Informal reasoning is a dependent variable in this study where students' statements are grouped as rational, emotive, or intuitive in which rational arguments show a high level of reasoning skills. Data that measure the progress in the level of informal reasoning were collected from students' work and responses on the classroom activities during the study.

Students' level of arguments. This dependent variable takes into consideration the different elements of an argument (data, evidence, warrants, rebuttals, counterarguments). The argument that considers all these elements is classified as a high-level argument. Toulmin (1988) developed a framework for grouping arguments into four levels. Level 1 included the arguments with only a claim. In Level 2, the arguments included claims and data (or warrants). However, in levels 3 and 4 the argument revealed higher argumentation skills because it included backings, qualifiers, and counterarguments in addition to claims and data.

Study Design

The study is a pre-test/post-test experimental design. It involves two groups: an experimental group (that is taught the argumentation skills during the intervention) and a comparison group (taught the same lesson but using conventional teaching methods). The students were randomly assigned to each class (group) prior to the beginning of the school year by the administrators. Conventional teaching methods do not engage learners in any argumentation activities. The only common factor between this group of students and the one engaging in argumentation was that they both learn the same science content by the same teacher. Also, both classes studied the same lessons for the same period of time. All the lesson activities and tests were developed by the teacher and researcher based on the new Bloom's Taxonomy that considers testing for students' different levels of cognitive development. For example, some items test for students' knowledge level while others examine their ability to analyze a document or apply a certain procedure, which necessitates a higher thinking level.

This study involved both quantitative and qualitative research components. The quantitative data was used to determine the impact of an argumentation intervention on students' achievement in biology (research question one) while the qualitative data was used to study how this intervention affects the quality of arguments and the quality of informal reasoning for grade 8 students engaged in this intervention (research questions two and three). For this purpose, qualitative and quantitative data were collected prior to and following the study and the results were compared to detect any gains in achievement, informal reasoning skills, and level of arguments.

One biology teacher taught both groups of students. The intervention was comprised of the argumentation activities taught to the experimental group only. Moreover, the study adopted Design-Based Research (DBR) and included two iterations. DBR is discussed in detail later.

Setting and Participants

This research was conducted in a private school in Beirut. This school was selected because its administration supports the implementation of the study. The study included two Grade 8 biology classes (2 different sections) with 25 students in the control group and 24 in the experimental group (total of 49 students). The male participants are 24 and the female students are 25. According to the school policy, the students are randomly assigned to each section. This ensures that students have similar basic knowledge about scientific topics. The students were informed about their participation in the study but without knowing which group (control or experimental) they belong to. The ethical responsibility towards the students was ensured according to the requirements of the university Institutional Research Board (IRB). Also, no names or personal informal were published. Moreover, the activities are part of everyday school practices and thus do not harm students in any group. To ensure that the experimental and the control groups spent the same time during the study, students in the control group were engaged in student-centered activities, research, and readings to compensate for the extra time spent in the experimental group on argumentation. Also, at the end of the study, the control group learned argumentation in order not to be disadvantaged.

One female biology teacher agreed to participate in the study and taught both control and experimental groups. She is a graduate of Bio-medical engineering who has not used argumentation in her instruction yet. Therefore, the researcher provided professional development for the teacher (one one-on-one session) to teach her the definition of argumentation, its elements, and the ways it could be incorporated in science activities. This professional development occurred prior to the study in which the teacher read about Toulmin's argumentation model and its elements. The researcher further explained this model and encouraged the teacher to use debate and reflection, listen well to students' responses and challenge their views in order to reach effective argumentation. Then, the teacher was provided with the lesson plans for both experimental and control groups. These lesson plans which were developed by the researcher were discussed with the teacher to modify any unclear idea and help overcome any obstacle that the teacher believes could be faced during the study. The teacher's lessons were videotaped to observe and monitor the implementation of the lesson plans in both experimental and control groups. During the implementation of the activities, the researcher and the teacher met about once per week in order to reflect on the flow of the lessons and discuss possible difficulties. Some necessary modifications to the lesson plans or activities were made to overcome any difficulty or obstacle faced by the teacher. This process was made easier due the nature of study which is embedded in Design-Based Research (DBR) which allowed the modification of instruction or lesson plans in order to better suit the context of the study. DBR is discussed in details in the following section. Argumentation was integrated during teaching the following unit: 'The Immune Response" that includes three chapters. The reason for selecting this unit is that it is required by the Lebanese curriculum for Grade 8. Also, argumentation can be integrated in this unit in which students can argue about socio-scientific issues related to diseases and medications. The classes were videotaped in order to ensure the authenticity of the intervention in both sections and to make sure that the teacher followed the assigned lesson plan for each group. It is important to note that the implementation of the study did not start until the approval of the AUB Institutional Review Boards (IRB) was granted.

Description of Design-based Research (DBR)

Design-Based Research (DBR) is an integration of many research methods such as the quantitative and qualitative research designs; based on the needs of the research. DBR is a flexible methodology and its purpose is to enhance educational practices in a specific learning environment. This aim is attained through the continuous refinement and improvement of pre-existing theories (Wang & Hannafin, 2005). DBR is based on existing theories that have been previously implemented and have produced positive results on learning. However, instead of only testing an existing theory, DBR develops a new theory through the process. The reason is because teachers and researchers cooperate in order to refine old theories to better apply to the specific case of the study (Edelson, 2002).

DBR is based on performing iterative developments and implementations of educational practices to suit the context of the study. It is important to document the research process and then analyze it. Depending on the results of the analyses (that take into consideration the context where the study is applied), the researcher develops his/her educational practices and re-implements them in an iterative process (Wang & Hannafin, 2005).

Design-based research Iterations. As described above, DBR has an iterative nature. This research design includes two iterations done with two groups of students and using the same biology instructional unit (The Immune Response). However, only one group had argumentation integrated with the biology unit (varying instructional method). The first iteration is based on the analysis of previous theories and research concerning the implementation of argumentation in science classrooms (iteration I).

However, based on data collected from iteration 1, some factors of the design were evaluated and changed to better suit the study context and achieve its purpose. Hence, a second iteration was implemented (iteration II). Both iterations are described in the following section.

The first Iteration. The entire study extended over a period of approximately twelve weeks with two biology periods per week. During the first iteration, chapter one is covered (this chapter includes three activities) and chapter two (two activities are covered out of the four activities in this chapter). Hence, the first iteration lasted about five weeks. The same biology content was taught to each class. In the experimental group, argumentation was integrated in the activities but in the control group, the activities do not include argumentation. Students in both groups have the same prior knowledge about the topic (Immunology) but exposed to different teaching methods.

Only the experimental group was introduced to argumentation and its elements. Later, during the lesson activities, the teacher introduced the activity then; students discussed and reflected on their work. Based on the difficulties faced in iteration one, changes in the lesson plans or teaching strategies were applied in iteration two. The teacher documented classroom practices, including the difficulties resulting from students' interaction and participation, their ability to construct meaningful arguments, their spelling and language skills, among other factors. The teacher and researcher met to discuss the problems that the teacher is facing, the alignment of the lesson with the lesson plans, and the possible ways to improve their implementation.

The Second Iteration. The second iteration lasted seven weeks where chapter two is continued (the last two activities are covered out of the five) and chapter three (that includes three activities) are covered. Based on the difficulties faced during the first iteration, the teacher and the researcher agreed to modify the intervention during iteration two in order to better implement the study. Similar to what was done during iteration one, the researcher documented research practices, including the difficulties faced during the second iteration.

Design and Development of the Argumentation Intervention

The argumentation intervention consists of a set of activities related to the following unit: ‘The Immune Response’ that engages students through different activities in argumentation about scientific and socio-scientific topics. These activities belong to a general framework that lists the activities needed to support argumentation in the classroom (Osborne et al., 2004). This framework is represented in Table 3.1. According to the topic or issue discussed, the teacher and researcher selected the activity (argumentation worksheet, experiment, lab report…) that best facilitates the construction, analysis, or evaluation of the argument. According to Osborne et al. (2004), the activity model is needed because it helps guide the teacher’s work throughout the process. In order to ensure a successful implementation of these activities, both the researcher and the teacher discuss the activities and agree on performing any necessary changes to suit the context of the classroom. It is important to note that both experimental and control group activities are student-centered. However, only the experimental group activities engage students in argumentation and teach them argumentation skills based on Toulmin’s argumentation model. The following section describes the development of the argumentation activities as well as their implementation in the classroom.

Developing the Argumentation Activities

According to cognitive theories, students should be provided with a context (in this case: argumentation) in which they actively engage in meaningful learning and interact with the teacher, other students, and the content in order to construct knowledge (Venville & Dawson, 2010). The argumentation intervention in this study consisted of a set of activities that guide the students throughout the process. At the beginning of the intervention which started in the middle of the school year 2016-2017, students were introduced to argumentation and its elements leading them to appreciate the importance of argumentation in science (Osborne et al., 2004). The main purpose of the introductory activities was to allow students to justify their argument and convince others about it regardless whether their argument is right or wrong. Also, students learned what evidence is and why it is important especially since an essential aspect of science is the commitment to the evidence needed to justify any scientific argument. For example, students appreciated the importance of an argument in constructing scientific theories that are based on arguing about the best model that explains a certain phenomenon. In order to achieve this purpose, activities that provide students with competing theories (in the form of cartoon, story, or ideas) were used (Table 3.1).

Table 3.1

Framework of General Activities that Foster Argumentation in the Classroom

(adopted from Osborne et al. (2004)

Activity	**Description**	**Purpose**
1. Competing theories (cartoons)	Students are given two or more opposing theories in the form of a cartoon. Students argue in favor of one of theories and indicate their reasons. Adapted from the work of Keogh and Naylor (Keogh & Naylor, 1999; Naylor & Keogh, 2000)	Introduce argumentation to students (its importance and elements). Students justify their arguments
2. Competing theories (stories)	Students are given, in the form of a story, two or more competing ideas. They give reasons to support one of these ideas.	Introduce argumentation to students (its importance and elements).
3. Competing theories (arguments and evidence)	Students are presented with a physical observation. They are then provided with two explanations for the observation where they argue with or against each one.	Introduce argumentation to students (its importance and elements).
4. Constructing an argument	Students are given several explanations of a physical observation. They evaluate the explanations and select the ones that strongly support the observation.	Teach argumentation and construct and evaluate arguments. Construct a written argument using writing frames.
5. Table of stated arguments	Students are presented with arguments on a specific scientific idea. They argue whether each statement is correct or not.	Teach argumentation and construct and evaluate arguments. Construct a written argument using writing frames.
6. A report of scientific experiments on the work of other students	Students are introduced to an experiment and provided with the arguments of other students. They evaluate these arguments providing evidence.	Evaluate the arguments of others.
7. Predict observe explain (POE)	Students predict a certain phenomenon without observing what actually happens. Then, the phenomenon is demonstrated and students are asked to reevaluate their initial arguments.	Construct and evaluate arguments.

Then, the activities that followed focused on constructing meaningful arguments. Students used their understanding of the components of an argument to develop arguments. They evaluated and analyzed different types of evidence and select those that best support a scientific idea. This activity helped students to construct better arguments because they were able to differentiate between weak and strong arguments as well as counterarguments. It is crucial that learners value counterarguments since, according to many researchers, high quality arguments are those in which students are able to argue against the argument of others. Activities such as 'constructing an argument', 'table of stated arguments' or 'Predict, Observe, Explain' (Table 3.1) help students evaluate arguments and construct a well-justified one.

Students' ability to construct better written arguments was further improved through the introduction of strategies that guide their writing such as writing frames. Writing frames such as 'my idea is…' or 'the reasons are…' or 'an idea against mine might be…' uncover learners' thoughts. They require learners to think in depth about expressing and relating reasons to claims, convincing others with their point of view, and relating different ideas.

In brief, the developed material should challenge students to provide more than one justified type of evidence for an argument. Moreover, the developed material engaged students in constructing arguments. In addition to designing proper argumentation activities, other factors were considered during the development of the intervention such as the content of the activities and its format.

Implementing Argumentation Activities

During the course of the intervention, several factors were considered such as the interaction between students during the discussions as well as the teacher's role in guiding the discussions.

Students' Interaction. Over the past years, many education projects and studies that worked on teaching argumentation in classrooms have also discussed the significance of cooperative learning (e.g. Jimenex-Aleixandre, Rodriguez, & Duschl, 2000; Zohar & Nemet, 2002). Unfortunately, research suggests that students in science classrooms rarely engage in small group discussions mainly because they are afraid to expose their thoughts that might be incorrect (Newton, Driver, & Osborne, 2000; Osborne et al., 2004). However, small group discussions are necessary because engaging in argumentation and reasoning processes occurs only when learners explicitly express their ideas and present them to others (Osborne et al., 2004). It is the teachers' role to properly organize and structure group work because small group discussions have the potential to develop students' abilities with practice. In a successful cooperative environment all group members should perceive that every fellow member in the group should master the content and that the effort of all the members is recognized regardless of their ability. In this study, students work in groups of two and the simplest cooperative method (the Think Pair Share method) is used. In this method, students think individually about a problem and then discuss their ideas in pairs. Finally, students share their ideas in groups in which they ask for facts and reasoning.

Teaching through argumentation activities fosters interaction between the students and between the students and their teachers (Osborne et al., 2004; Zohar & Nemet, 2002). For example, during argumentation students are asked to provide alternative explanations of a certain scientific idea or to compare two competing ones. This process requires discussing and sharing their views with others which secures their understanding of scientific knowledge especially since they evaluate alternative views (Osborne et al., 2004). Moreover, student-student interaction enhances argumentation and increases student reasoning. Thus, the argumentation activities are designed in a way that promotes collaborative work and problem solving (Osborne et al., 2004; Zohar & Nemet, 2002).

Teacher support and training before and during the argumentation process. The training of the teacher started before the study. The researcher and the teacher met once prior to the study in order to introduce the teacher to argumentation and its elements. Also, both developed lesson plans for the biology lessons covered during the study in the experimental and control groups. During the study, the researcher and the teacher met to discuss how the lesson plans align with the actual lesson flow in the classroom. In order to better evaluate this alignment, the teacher described the course of the session such as the way students interact and how she facilitated class discussions. These notes were discussed during the teacher and researcher's meetings in which the teacher reflected on some difficulties faced in the classroom. Therefore, a dialogic approach was applied in which the teacher and researcher shared their ideas regarding the teacher's performance. Moreover, and prior to iteration two, they decided on the factor or factors to be modified in the design of the study for better implementation based on the data collected by the researcher during iteration one.

The teacher continuously supported students through learning activities by providing guidelines, hints, and suggestions. Research has shown that guiding learners is more effective than providing minimal or no support from the teacher

(Kirschner, Sweller, & Clark, 2006; Mayer, 2004). Proper teacher guidance ensures better learning and more efficient transfer of knowledge to new settings (Simon, Richardson, & Amos; 2011). This is because the teacher scaffolds students' thoughts instead of only delivering new information. This is achieved through asking guiding questions that trigger thinking and keeps the learners focused on the purpose of the activity (such as 'How can you prove your idea is correct?').

Pilot Testing. A pilot test was carried out before conducting the study in order to ensure that the students were able to comprehend the biology topics and activities that were prepared to teach the intended biology concepts. The pilot study ensured that the data collected from these activities are credible for later analysis and interpretation of results. Participants in the pilot study were Grade 9 students from the same school in which the study took place who did not participate in the study. The reason grade 9 students were selected was that these students have already taken the same curriculum and thus were able to identify possible problems in the materials to be used in the intervention.

Argumentation Activities Improve Achievement and Reasoning Skills

The argumentation activities were designed to help scaffold students' thoughts in order to construct and evaluate arguments. This process requires in-depth thinking and allows learners to link previous information to new content. Hence, students were presented with different scientific issues and learned argumentation skills in order to use scientific evidence to justify their arguments. As a result, students who used scientific evidence have high reasoning skills and are able to evaluate arguments which unfold their thinking process and can enhance learning (Venville & Dawson, 2010).

Data Collection Tools

The tools used to collect quantitative data included an Immunology Knowledge Test administered before and after the study as well as three Immunology Chapter Tests that were administered after completing each biology chapter. Moreover, in order to evaluate informal reasoning and level of arguments, students' responses to the activity worksheets were analyzed before, during, and at the end of the study. The responses on the worksheets were later analyzed and grouped to detect any gains in student achievement.

The Immunology Knowledge Test. This test was used as a pre- and post-test and was developed by the teacher and the researcher. The test included multiple choice questions about general immunology concepts and two open-ended questions that discuss socio-scientific issues. The same test was administered at the end of the study. The results in both experimental and control groups were compared to detect any gains in students' knowledge. Moreover, the multiple choice questions varied in their cognitive levels based on Bloom's Taxonomy and included question at all levels of this taxonomy. Results of the test were used to detect any gains in achievement before and after the intervention or among the experimental and control group prior to the study (Appendix I).

The Immunology Chapter Tests. The purpose of these tests was to assess students' understanding of the science concepts learned during each chapter. A biology chapter test is conducted upon the completion of each chapter. The immune system unit included three chapters and a total of nine lessons within these chapters. Thus, a total of three chapters were conducted. The teacher and the researcher developed these tests to ensure that they aligned with the objectives of the lessons and that the test items vary according to Bloom's taxonomy so they include different cognitive levels. These tests included exercises related to the chapter and varied to suit different levels of Bloom's Taxonomy such as 'State, ''Apply', 'Analyze', …. These tests results detected progress in student achievement (Appendix II).

Students' Work. Students in each class worked in pairs to complete the lesson activities. In order to collect data for evaluating students' informal reasoning and level of arguments, data was collected from the work of students on the activities. The experimental group lesson plans and worksheets are presented in Appendix III and Appendix IV, respectively while the control group lesson plans and worksheets are shown in Appendix V and Appendix VI, respectively. It is important to note that both classes were videotaped but the purpose of video-taping is to ensure the authenticity of the intervention and not to collect data on the actual work of students in class.

In each lesson, students were given activity worksheets with a specific task to work on. For example, students were presented with two competing theories where they had to choose one over the other and provide evidence to support their ideas. Therefore, the worksheets included questions that gave students the space to express their idea, explain evidence, and provide justifications. Data was collected from the activity worksheets of both groups at the beginning and end of the study. Data was compared in order to detect any gains in informal reasoning skills and the level of arguments.

Data Analysis Procedure

The students performed two types of tests: The Immunology Knowledge Test and the Immunology Chapter Tests. The Immunology knowledge test was administered prior to the study in order to evaluate students' knowledge before implementing the intervention. At the end of the study, the Immunology Knowledge

Test was administered again. Students' scores on both tests were compared between the experimental and control groups before and after the study to examine the effect of the intervention on students' achievement. Moreover, the Immunology chapter tests were conducted as follows: During iteration I, one Biology chapter test was administered at the end of finishing one chapter that covers five lesson activities. Another two tests were also administered during iteration II (one test after completing each chapter). Moreover, qualitative data from students' work during the activities were analyzed in order to answer the remaining research questions (2 and 3) concerning the effect of the intervention on students' informal reasoning and the quality of their arguments.

Qualitative Data Analysis. The data from students' work were analyzed in order to determine the quality of arguments during discussions. In this research, the rubric used by Khishfe (2012) to analyze the progress in the level of students' arguments is adopted. This rubric is similar to Toulmin's model for analysis of arguments but was more applicable and easier to use in this research. A response was categorized as naïve (or level 1) when no justification or an invalid justification was given. A response was categorized as intermediary (level 2) when the participant gave a valid justification supported by only one reason. A response was categorized as informed (level 3) when the participant gave a valid justification supported by more than one reason. Another level 0 was added to the responses that could not be analyzed or for the absence of an argument or counterargument. This plan enabled the analysis of all students' responses on the activities and compared the performances of the two groups as well as the improvement of the quality of their arguments.

To evaluate the quality of students' informal reasoning, the method used by Venville and Dawson (2010) was adopted (Table 3.3). According to this method, students' statements responses on lesson activities were analyzed and classified as rationalistic (logical and show scientific understanding), emotive (emotional), intuitive (immediate response), or NA (not able to classify). In science education, the transcripts that show rational informal reasoning are of better quality than the emotive and intuitive ones. Also, the emotive informal reasoning is more valued than the intuitive one because it shows a concern for the well-being of others. Students' levels of informal reasoning are compared before and after the study in both groups. Also, the quality of informal reasoning is compared in the experimental group before and after the argumentation intervention.

Quantitative Data Analysis. In order to answer research question 1 (Does engaging Lebanese Grade 8 students in argumentation enhance achievement in biology?), univariate ANCOVA (univariate analysis of covariance) was carried out. It was applied on the data from the immunology knowledge test in which the covariate is the pre-test and the dependent variable is the post-test. The purpose was to identify if any differences in students' knowledge exist between the control group (no argumentation skills learned) and the experimental group (argumentation skills learned) prior to the intervention. This method eliminates any factors affecting student achievement other than the intervention in order to accurately evaluate the effect of the intervention on achievement.

Table 3.2

Model for Assessing the Quality of Arguments (adopted from Khishfe (2012)

Level	**Description**
Level 0	Responses could not be analyzed or the absence of an argument or counterargument
Level 1(Naïve)	No justification or an invalid justification
Level 2 (intermediary)	Valid justification supported by only one reason
Level 3	Valid justification supported by more than one reason

Table 3.3

Levels of Informal Reasoning (adopted from Venville and Dawson (2010)

Category	Description
Rationalistic	Logical, uses scientific understanding and language, weighs up risks and benefits, advantages, and disadvantages.
Intuitive	Gut feeling, immediate response, strongly held, often a negative response, personal, often precedes rational or emotive.
Emotive	Emotional response towards stakeholders, care, empathy, sympathy, concern for plight of those affected
NA	Not able to classify

Chapter IV

Results

The results of this study are presented in two sections. In the first section, the quantitative results are provided acquired from the immunology knowledge test and the three biology chapter tests. The second section presents the qualitative results acquired from students' responses on seven argumentation activities. In this section, the results concerning students' level of argumentation as well as their informal reasoning skills are provided.

Quantitative Data Analysis

Before the implementation of the argumentation intervention, the same immunology knowledge test was administered to the students in the control and experimental sections. In addition, during the activities in the first iteration, one biology test and quiz were administered (after chapter one), and students completed two other biology tests during the activities in the second iteration. At the end of the study after a period of 12 weeks, students completed the immunology knowledge test again. Students' scores on the immunology knowledge test and the three tests were computed to be used in answering research question 1 (Does engaging Lebanese Grade 8 students in argumentation enhance achievement in biology?).

Quantitative Results

The total number of participants in this study was 49 with 25 participants in the control group and 24 participants in the experimental group. Among the 49 students in the study, 24 were male students and 25 were female students. The age of students ranged between 13 and 15. The number of participants in this study arranged by group type and gender is presented in Table 4.1.

Table 4.1

Numbers and Percentages of Participants Distributed According to Gender and Group Type

	Male	Percentage %	Female	Percentage %	Total
Control group	14	56.00	11	44.00	25
Experimental group	10	41.67	14	58.30	24
Total	24	48.97	25	51.02	49

Students in both experimental and control groups were administered the immunology knowledge test which was used as a pre-test and a post-test. Also, both groups were given the same chapter tests during the study. Chapter one test was administered at the end of chapter one (Self and Non-Self), chapter two test at the end of chapter two (The Defenses of the Immune System), and chapter three test at the end of chapter 3 (Vaccination, AIDS, and Allergies). The means and standard deviations of the pre/post tests and the three chapter tests were calculated and the results are presented in Table 4.2.

Knowing that the maximum grade that could be achieved on the knowledge test is 20, students in the experimental group scored higher on the pre-test (mean= 7.8) than students in the control group (mean=7.3). Students' scores in both groups increased in the post-tests (mean=11.4 for the experimental group and mean=10.5 for the control group). However, the standard deviation in the post-test of the experimental group (2.5) was less than that of the control group (3.9) indicating that students' scores of this group were closer to the mean and spread over a narrower range of values than the control group. Concerning the chapter tests: during iteration one (biology test 1 was administered), students' scores in both groups were almost the same (mean=10.99 for the control group and mean =10.94 for the experimental group). However, during iteration two (biology tests 2 and 3 were administered), students' scores in the experimental group on chapter two test were higher (mean=13.47) than students' scores in the control group (mean=12.69). Similarly, students' scores on chapter three test in the experimental group were higher (mean=13.1) than students' scores in the control group (mean=11.88).

As can be seen from Table 4.2, students' scores in both the experimental and control groups were relatively low reaching a maximum of 13.47 out of 20.

Table 4.2

Means and Standard Deviations of the Three Biology Chapter Test Scores and the Pre/post Test Scores of the Experimental and Control Groups

	Chapter 1		**Chapter 2**		**Chapter 3**		**pre-test**		**post-test**	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Control group	10.99	2.95	12.69	3.26	11.88	2.96	7.36	1.86	10.5	3.96
Experimental group	10.94	2.28	13.47	2.99	13.10	4.10	7.87	2.23	11.45	2.53

In order to answer the first research question (Does engaging Lebanese Grade 8 students in argumentation enhance achievement in biology?), a univariate analysis of covariance (Univariate ANCOVA) was conducted on the data from the immunology knowledge test with the pre-test as a covariate and post-test as dependent variable in order to determine if significant differences existed between the scores of students in the experimental group and control groups. Results from this univariate analysis appear in Table 4.3. These results showed that students in the experimental group scored higher but not significantly higher than students in the control group ($p=0.425>0.05$).

Table 4.3

Univariate ANCOVA for Post-test Scores of the Experimental and Control Groups with the Pre-test Scores as the Covariate

Source	**Sum of squares**	**df**	**Mean Square**	**F Ratio**	**Sig.***
Between Groups	7.1	1	7.102	0.648	0.425
Error	504.443	46	10.966		
Total	6444.000	49			
Corrected Total	536.980	48			

*p>0.05

As indicated above, in addition to the immunology knowledge test that was conducted as a pre- and post-test, the participants took three biology tests (one after each chapter). A univariate analysis of variance was conducted for each of the three biology chapter tests (one performed during iteration one and two other tests during iteration two). Results of the univariate test scores of the biology tests one, two, and three are summarized in Tables 4.4, 4.5, and 4.6, respectively. During iteration one (Chapter test one was administered), students' scores in the experimental group were not significantly higher than students' scores in the control group ($p=0.637>0.05$). Similarly, during iteration two (chapters two and three tests were conducted), students' scores in the experimental group were not significantly higher than students' scores in the control group ($p=0.558>0.05$ and $p=0.336>0.05$, respectively).

Table 4.4

Univariate Tests for Biology Chapter Test One Scores of the Experimental and Control Groups

Source	**Sum of squares**	**df**	**Mean Square**	**F Ratio**	**Sig.***
Between Groups	1.312	1	1.312	0.226	0.637
Error	266.900	46	5.802		
Total	6225.000	49			
Corrected Total	328.954	48			

*p>0.05

Table 4.5

Univariate Tests for Biology Chapter Test Two Scores of the Experimental and Control Groups

Source	**Sum of squares**	**df**	**Mean Square**	**F Ratio**	**Sig.***
Between Groups	3.033	1	3.033	0.348	0.558
Error	400.473	46	8.706		
Total	8848.688	49			
Corrected Total	469.901	48			

*p>0.05

Table 4.6

Univariate Tests for Biology Chapter Test Three Scores of the Experimental and Control Groups

Source	**Sum of squares**	**df**	**Mean Square**	**F Ratio**	**Sig.***
Between Groups	10.481	1	10.481	0.948	0.336
Error	486.612	44	11.059		
Total	7895.188	47			
Corrected Total	582.654	46			

*p>0.05

In order to further understand the results of the study, the percentages of correct and incorrect responses were computed for every immunology knowledge test item (that tested for a specific biology concept) before and after the intervention. These results are presented in Table 4.7 for the control group and in Table 4.8 for the experimental group.

Analyzing the scores for each test item showed that students' correct answers in both experimental and control groups were high at the beginning of the study in the following concepts: function of the immune system (96% correct in the control group and 95.8% correct in the experimental group), wound infection (80% correct in the control group and 93.3% correct in the experimental group), and bacterial infection (80% correct in the control group and 87.5% correct in the experimental group). In both groups, students' scores improved on all test items of the post-test except viral infections (48% correct in the control group and 33% correct in the experimental group), spread of pathogens infections (52% correct in the control group and 25% correct in the experimental group) and allergens vs pathogens (8% correct in the control group and 37.5% correct in the experimental group). In addition, the post-test scores for the control group did not improve on the following items: allergies (36% correct), physical barriers (44% correct), and body infection (48% correct). However, unlike the control group, students in the experimental group scored higher on the following items in the post-test: allergies (66.7% correct), physical barriers (62.5% correct), and body infection (70.8% correct).

Table 4.7

Percentage of Correct/Incorrect Responses on Pre and Post-Test Items of the Control Group

	Pre-test		Post-test	
	% incorrect	% correct	% incorrect	% correct
Function of immune system	4	96	0	100
Body defenses	80	20	20	80
Wound infection	20	80	12	88
Bacterial infection	20	80	8	92
Graft acceptance	60	40	20	80
Body infection	72	28	52	48
Viral infection	60	40	74	24
Fighting disease	40	60	36	64
Allergic reactions	92	8	40	60
Allergic reactions	24	76	16	84
Vaccination	64	36	24	76
Spread of pathogens	24	76	48	52
Antibiotics	20	80	28	72
Allergies	92	8	64	36
Physical barriers	100	0	56	44
Allergens vs pathogens	92	8	92	8

Table 4.8

Percentage of Correct/Incorrect Responses on Pre and Post-Test Items of the Experimental Group

	Pre-test		Post-test	
	% incorrect	% correct	% incorrect	% correct
Function of immune system	4.2	95.8	0	100
Body defenses	83.3	16.7	29.2	70.8
Wound infection	16.7	83.3	0	100
Bacterial infection	12.5	87.5	4.2	95.8
Graft acceptance	45.8	54.2	0	100
Body infection	62.5	37.5	29.2	70.8
Viral infection	83.3	16.7	66.7	33.3
Fighting disease	20.8	79.2	33.3	66.7
Allergic reactions	62.5	37.5	20.8	79.2
Allergic reactions	41.7	58.3	12.5	87.5
Vaccination	58.3	41.7	20.8	79.2
Spread of pathogens	29.2	70.8	75	25
Antibiotics	33.3	66.7	29.2	70.8
Allergies	79.2	20.8	33.3	66.7
Physical barriers	95.8	4.2	37.5	62.5
Allergens vs pathogens	83.3	16.7	62.5	37.5

Qualitative Data Analysis

In an attempt to understand the level of students' arguments in biology about topics related to SSI, students in the experimental group were required to complete seven argumentation activities over a 12-week period while studying immune response in the unit entitled "Immunology". This group was exposed to the different elements of an argument and involved in tasks that helped them distinguish weak and strong arguments. The activities covered the following topics: self and non-self antigens, organ donation, pathogens (such as viruses), immune system cells and organs, immune response mechanisms, allergies, immunodeficiency, antibiotics, and vaccination.

Qualitative Analysis of the Levels of Arguments

Students' written responses to the argumentation activities were analyzed to measure the levels of argumentation. The activities included different scenarios related to immunology in the context of a socio-scientific argumentative topic. Students were asked to support an argument in a given scenario and provide evidence for their choice. According to the scenario, students either support one argument out of two conflicting ones, or support one argument from several given ones, or stand for or against a given argument. Other questions in the activities required students to provide a counterargument against a claim (e.g. Why do think the other argument was wrong?). The table below presents a summary of students' responses that shows students argumentation level. The participants' responses for each of the two components of argumentation (argument and counterargument) were evaluated according to a rubric used in a study by Khishfe (2012). This rubric is similar to Toulmin's model for analysis of arguments but was more applicable and easier to use in this research. A response was categorized as naïve (or level 1) when no justification or an invalid justification was given. A response was categorized as intermediary (level 2) when the participant gave a valid justification supported by only one reason. A response was categorized as informed (level 3) when the participant gave a valid justification supported by more than one reason. Another level 0 was added to the responses that could not be analyzed or for the absence of an argument or counterargument.

During the first iteration of the study, which lasted for five weeks with two biology sessions per week, students were given the elements of argumentation according to Toulmin's model after activity 1. Therefore, activity 1 is the only activity done without any argumentation intervention. It is important to note that students were also given non-argumentative student-centered activities and guided worksheets during this period. After introducing Toulmin's model and the different elements of argumentation, students had trouble understanding new words such as warrants and backings. The teacher, with the help of the researcher, explained the terms to the students, by indicating that warrants and backings are similar to evidence in that they support the claim, and gave them examples to insure a full understanding of the terms. Thus, some students referred to warrants as 'second evidence' that further supports an argument. Students realized that the more the supporting evidence, the better the argument. However, students did not ask questions about rebuttals and seemed to understand their meaning. Another difficulty was faced during activity three. In this activity, students did not use evidence and counterarguments even though they understood these two terms. They only started using them when given a frame to do so.

Based on the previously mentioned obstacles, during iteration two (the remaining seven weeks of the intervention), the teacher and the students referred to data, warrants, backings, and qualifiers as evidence 1, evidence 2… Moreover, instead of orally reminding students of the elements of an argument, the teacher wrote them on the board to remind them that their responses should include a claim, evidence 1, evidence 2, evidence 3, and a counterargument. The second iteration started when students were working on activity 4. Results of students' level of argument or counterargument are shown in Table 4.9.

Table 4.9

Number of Students at each Level of Argument or Counterargument

		Activity 1	Activity 2	Activity 3	Activity 4	Activity 5	Activity 6	Activity 7
Arguments	L0	0	0	3	0	0	0	0
	L1	1	0	0	3	0	1	1
	L2	7	0	6	5	15	4	6
	L3	12	25	14	16	9	18	17
Counterarguments	L0	0	5	6	-	-	1	-
	L1	7	5	5	-	-	1	-
	L2	6	3	7	-	-	7	-
	L3	8	12	4	-	-	14	-

Results show that in all activities in which students were required to provide an argument and a counterargument, the majority showed higher levels of arguments than counterarguments. Concerning the level of arguments, most students' arguments were at level three during activity one which was conducted before introducing

Toulmin's model. After introducing Toulmin's model of argumentation, the level of argumentation was not consistent across the activities and the level of argumentation seemed to be dependent of the type of support provided to students when working on an activity. For example, in activity two all arguments were at the highest level (level three) while in activity five, there were more level two than level three arguments. In activity two students were provided with evidence cards that either supported or did not support the claim that viruses are alive. Also, students' arguments were at the high levels in other activities such as in activity 1 which discussed organ transplants. Since they studied that a successful transplant depends on HLA markers' compatibility, they were able to use this evidence to support their arguments. Also, in activities three and seven, students showed level three arguments. However, a relatively small number of students provided evidence different from the ones given to them in the activities. However, in activity five, more than half of the students showed level two arguments. In this activity entitled 'AIDS: Fact or myth', students were required to choose an argument to support, from several given arguments, and another argument to refute. This was different from other activities which required students to decide between two arguments only or to support one given argument.

Concerning counterarguments, students showed different levels of counterarguments during the course of the intervention. Their counterarguments improved only right after explaining the elements of argumentation (activity 2) and during iteration two (activity seven) upon writing the elements on the board to remind students of them. Although students seemed to understand the meaning of counterarguments and were able to give examples of counterarguments, a few students provided counterarguments with supporting evidence unless the activity explicitly asked for a counterargument using writing frames ('I disagree with the other theory because…') or when the teacher reminded them of their importance. Also, similar to activity two where students scored a high level of arguments, more than half of the students had level three counterarguments since they were given evidence cards for two opposing theories. Thus, the evidence opposing a student's argument was used to support his/her counterargument. In other activities (activities one and three), few students showed high level counterarguments since no evidence that opposes their argument was given in the description of the argument.

Qualitative analysis of the level of informal reasoning

In addition to assessing students' level of argumentation, the argumentation activities were used to analyze students' levels of informal reasoning. Students in the experimental group were required to complete the seven argumentation activities in biology about topics related to SSI over a 12-week period while studying immune response in the unit entitled "Immunology". The activities covered the same topics: self and non-self antigens, organ donation, pathogens (such as viruses), immune system cells and organs, immune response mechanisms, allergies, immunodeficiency, antibiotics, and vaccination.

Students were not exposed to a model that explained informal reasoning at the beginning of the intervention, but after activity one, the teacher wrote some of students' responses on the board to help them differentiate between the levels of informal reasoning. In activity one, students were asked to determine which criteria (age, gender, HLA markers, personal accomplishments, worth to community, intelligence, or lifestyle choices such as smoking) are important or not concerning who deserves an organ transplant. Then, they were asked to provide reasons to support their ideas. For example, the following responses were selected: 'It does not matter if the person is a criminal because organ transplant depends only on the similarity between the HLA markers of the donor and recipient' and 'I believe that a criminal is a bad person and does not deserve an organ transplant because no one likes him'. The teacher initiated a discussion that ended in students' deducing that the first response is more scientific while the other is not since student emotions and judgment about the individual influenced his argument. The teacher pointed out that the more scientific the argument, the stronger it is, and that emotions weaken the defense with or against an argument.

To evaluate the quality of students' informal reasoning, the method used by Venville and Dawson (2010) (Table 3.3) was adopted. According to this method, students' statements responses on lesson activities are analyzed and classified as rationalistic (logical and show scientific understanding), emotive (emotional), intuitive (immediate response), or NA (not able to classify). Students' levels of informal reasoning were analyzed in each activity and the results were recorded. Table 4.10 shows the number of students in each category of informal reasoning (rational, emotive, intuitive, combination of two or more, or NA).

During the first iteration of the study, which lasted for five weeks with two biology sessions per week, students differentiated between rational, emotive, and intuitive arguments after activity 1 as discussed earlier. Since students were learning about Toulmin's model and the level of arguments, informal reasoning was introduced at the same time.

Students did not have trouble differentiating scientific from emotive or intuitive arguments. Therefore, during iteration two (the remaining seven weeks of the intervention), the only addition to the intervention, which affected the level of reasoning, was orally reminding students of the importance of including evidence, scientific evidence in particular, to make their claim stronger. Results of students' level of informal reasoning are presented in Table 4.10.

Table 4.10

Number of Students at each Level of Informal Reasoning

	Activity 1	Activity 2	Activity 3	Activity 4	Activity 5	Activity 6	Activity 7
Rational	16	25	22	17	16	20	23
Emotive	1	0	0	0	0	4	0
Intuitive	1	0	0	0	0	1	0
Rational & Emotive	1	0	0	6	6	0	0
Rational & Intuitive	3	0	0	2	1	0	0
NA	3	0	3	0	2	0	3

**NA not applicable*

Results showed that most students had rational arguments even before learning the difference between the levels of reasoning (activity one). After introducing Toulmin's model of argumentation and explaining the levels of informal reasoning, students' reasoning skills were not consistent across the activities and the level reasoning seemed to be dependent on the nature of the activity and its relation to their prior conceptions. It is important to note that in all seven activities the majority of students showed rational informal reasoning skills. In activities two, three, and seven, all students showed rational levels and none of them had emotive or intuitive levels of reasoning. In activity two, students were given evidence cards to support the argument whether viruses are alive or not. In this activity, all twenty-five students scored at level three arguments as well as rational informal reasoning skills. The reason may be due to explicitly providing evidence in this scenario which has an academic nature unlike other activities with topics related to their everyday life. In activities three and seven, two arguments were given and students had to support either one. Since each argument had its scientific evidence which students used to support their choice, their responses were rational.

However, in activities four and five, eight and seven of the students, respectively showed emotive or intuitive informal reasoning skills. Both activities discussed AIDS, a topic which is debatable in the Lebanese society. Students probably hear that this disease is dangerous and scary, which was reflected in their responses.

Reliability

To ensure the reliability of the results of the level of argumentation, two researchers and two graduate students (who are also Biology teachers) met to discuss students' responses. Reliability was reached through inter-rater agreement by meeting to discuss the model for analyzing the level of students' arguments. The researchers applied the tool for analysis to one of the argumentation activities to ensure that they shared an understanding of its different elements. Differences in the results were discussed until consensus was reached. Then, in the second step, the two graduate students separately analyzed some of the responses (for about 10 students) and the results were compared. They met again with one of the researchers to discuss the results and agree on a resolution to the differences. Again the graduate students independently analyzed all other responses. The inter-rater reliability was α=0.9.,.

Concerning the levels of informal reasoning, the two graduate students/ science teachers and a science education researcher met to discuss students' responses. The model used for analyzing the level of reasoning was discussed until its elements were understood and some of students' responses were discussed and analyzed. Then, the graduate students independently analyzed students' responses for one of the activities. The results were then compared and 90% of the analysis was similar. The researcher conducting this study then pursued the analysis by herself.

Chapter V

Discussion

This study investigated the following research questions: (a) does engaging Lebanese Grade 8 students in argumentation enhance achievement in biology? (b) does teaching argumentation skills to Grade 8 Lebanese students enhance the level of their arguments? (c) does engaging Grade 8 Lebanese students in argumentation enhance the level of their informal reasoning skills?

In this chapter, the quantitative results of both control and experimental groups during iterations one and two are summarized and discussed. This is followed by presenting the qualitative results of students' level of arguments, discussing these findings, and explaining the reasons which led to them. Third, a summary of the qualitative results of students' informal reasoning skills is provided and discussed. Then, a reflection on the difficulties faced in the first iteration is provided and the changes that were adopted to improve the argumentation activities. Finally, the limitations and implications of this study to practice, teachers, and students are presented.

Students' Achievement in Biology

The results of the post-test show that students in the experimental group achieved higher than students in the control group but the difference was not significant. This result aligns with previous literature on using argumentation at the intermediate school level that showed conflicting findings concerning enhancing students' achievement upon an argumentation intervention. Out the few studies performed to test for the effect of argumentation on students' achievement, some suggest that engaging in argumentation enhances achievement (e.g. Venville & Dawson, 2010; Zohar & Nemet, 2002), while others studies showed that no or little progress occurs (Cross et al., 2008; Osborne et al., 2013). Osborne et al. (2013) showed that upon an argumentation intervention, no significant differences were detected in the performance of students (11-12 years old) between the experimental group and the control group. Likewise, students' scores on the three biology chapter tests that were administered during the study did not show significant gains in achievement between both groups during iterations one and two. Thus, the argumentation intervention did not significantly affect students' ability to construct a valid conclusion from given information.

These results provide evidence that the argumentation intervention did not enhance students' achievement in biology. This could be explained by the fact that students should be more knowledgeable about immunology in order to show gains in learning upon an argumentation intervention. Cross et al. (2008) explained that the reason is because students who are more knowledgeable about the topic are more likely to show improvements in their learning (after an argumentation intervention) compared to those who possess less knowledge. Therefore, some researchers claim that it is better to implement an argumentation intervention at the college or high school levels rather than at the elementary or middle school levels (Cross et al., 2008; Sadler & Fowler, 2006).

Moreover, the nature of teaching prevalent in the Lebanese educational system may have influenced the effect of the intervention on student learning. Lebanese students are rarely engaged in student-centered activities and only study for the purpose of getting a passing grade on the exams. During this intervention, middle school students constantly asked whether the argumentation activities would be included in the test and what information from the activity they should memorize. This could be attributed to the fact students in Lebanon, in their attempt to do well on exams, focus on rote memorization of facts or concepts and on applying specific guided scientific procedures, methods, or skills to a variety of exercise (e.g. plotting a graph, analyzing a document, comparing the results of experiments). Therefore, it was difficult to make students work seriously on the argumentation activities. This highlights the need to encourage teachers to integrate argumentation and other student-centered activities in their teaching. In addition, there is a need to change the grading system to insure that students are evaluated not only on the concepts or skills they memorize but also on their work during activities in which they apply what they have learned to a new context that relates to their everyday life. It is the task of the teacher to design proper assessment tools such as rubrics to evaluate students' work on such activities.

In order to further understand the results of the knowledge test, the percentages of the correct and incorrect answers in the pre and post-tests were computed for each test item in both groups. In the control group, students' scores improved on all test items except "body and viral infections", "spread of pathogens", "allergies", "physical barriers", and "allergens vs. pathogens". In the experimental group, students' scores improved in all test items except "viral infection", "spread of pathogens", and "allergens vs. pathogens'. This finding shows that the intervention might have improved the achievement of students in certain concepts. The reason could be because these concepts (body infection, allergies, and physical barriers) were discussed in some of the argumentation interventions. The process of argumentation enhances students' reasoning skills allowing them to articulate and evaluate their ideas and to reflect on them which enhance their knowledge. However, the concepts in which students' did not show improvement are abstract and discuss concepts at the molecular level which could be difficult for middle school students to comprehend even when argumentation is introduced to them. For example, during the argumentation activity ‘Are Viruses Alive”, students repeatedly inquired about how viruses infect cells which showed that they did not grasp the mechanism by which viruses cause disease which is an abstract concept that might require much more background knowledge and abstract thinking than what is available to intermediate level students. This necessitated two extra sessions to further explain the mode of action of viruses (including a video and a model of the virus structure). Nonetheless, students did not show improvement in learning this concept in the post-test.

Another reason for the non-significant results could be the teacher’s lack of experience in teaching argumentation or the short-term professional development that the teacher received. During the first iteration, the researcher and teacher met before the intervention to discuss Toulmin’s model of argumentation and its application in the classroom. Moreover, in addition to the professional development sessions prior to the study, the teacher and researcher met at least once every week throughout the 12-week intervention. This support did not seem to be sufficient for the teacher to implement the intervention effectively. According to Osborne et al. (2013), one of the reasons for the lack of improvement in the performance of students in their study was that the professional development provided for the teachers was not enough to induce an improvement in students’ outcomes. Thus, previous research recommended a long period of teacher professional development for better achievement. For example, Osborne et al. (2004) trained 12 experienced teachers for one year during which they learned about implementing argumentation in the classroom. Then, the intervention was applied in the following year.

In addition to the period of professional development, the one-on-one teaching method adopted to improve the teacher’s argumentation skills and help her introduce argumentation in the classrooms presents another weakness of this study. Other strategies such as cooperative and inquiry learning (as some research studies suggested, e.g. Osborne et al., 2004) could have improved the teacher's understanding of argumentation and its implementation and eventually provided better student achievement.

Students' Levels of Argumentation

Students' levels of arguments were evaluated by analyzing their responses according to a model similar to that of Toulmin's. Students' responses on the argumentation activities were grouped as level three arguments if they provide a claim with at least two valid evidences; as level two arguments if a claim is provided with one valid argument or as level one arguments if a claim is provided with no or unclear evidence.

Results showed that in all activities in which students were required to provide an argument and a counterargument, the majority showed higher levels of arguments than counterarguments. This aligns with previous research which explained that students face difficulty in providing counterarguments to an argument (Osborne, 2004; Venville & Dawson, 2010, 2013). According to many researchers, it is crucial that learners value counterarguments since high quality arguments are those in which students are able to argue against the argument of others (Khishfe, 2012; Venville & Dawson, 2013).

Concerning the level of arguments, most students' arguments were at level three during activity one which was conducted before any argumentation intervention. After introducing Toulmin's model of argumentation, the level of argumentation was not consistent across the activities and the level of argumentation seemed to be dependent on the type of support provided to students when working on an activity.

This is different from the results of previous research which showed either an improvement in the level of students' arguments or not across an argumentation intervention irrespective of the support given. Some studies showed an improvement in students' argumentation level upon an intervention (Venville & Dawson, 2010, 2013; Zohar & Nemet, 2002) while others showed that this improvement was not significant (Khishfe, 2012; Osborne, 2004).

In this study, students provided high level arguments when they were given explicit evidence to an explanation which might have guided them to provide evidence for either claim. Also, students had level three arguments when the topic of this activity was academic and scientific in nature and did not involve an everyday situation. Students may have been able score higher on argumentation because they were given several pieces of evidence, unlike in other activities where they had to provide their own evidence or the evidence was not clearly stated in evidence cards. Students' arguments were at high levels in activities two, six, and seven in which the given explanations included two or more pieces of evidence from which students could choose while a relatively small number of students provided evidence different from the ones given to them in the activities. However, in activity five, more than half of the students showed level two arguments. In this activity entitled 'AIDS: Fact or myth', students were required to choose an argument to support, from several given arguments, and another argument to refute. This result may have been due to the structure of the activity which was the only activity that gave students freedom to choose an argument from six given ones. Other activities required students to decide between two arguments only or to support one given argument. Therefore, students probably decided on the argument which related more to their background or prior conceptions about AIDS which, in turn, led to level two arguments. Previous studies explain that students come to the classroom with preconceived conceptions that are difficult to change (Carey, 2000; von Aufschnaiter et al., 2008). In this case, learning about argumentation failed to teach students to construct high level arguments unless the evidence for the argument is explicitly provided.

Students' Levels of Informal Reasoning

In addition to assessing students' level of argumentation, the argumentation activities were used to analyze students' levels of informal reasoning. Students' responses were grouped as rational, emotive, intuitive, or a combination of two or more levels of reasoning. Results showed that most students had rational arguments even before learning the difference between the levels of reasoning (activity one). After introducing Toulmin's model of argumentation and explaining the levels of informal reasoning, students' reasoning skills were not consistent across the activities and the level reasoning seemed to be dependent on the nature of the activity and its relation to their prior conceptions and knowledge. In activities two, three, and seven, all students showed rational reasoning levels and none of them had emotive or intuitive levels of reasoning. The reason may be due to explicitly providing two or more pieces of evidence in the scenarios which have an academic or scientific nature unlike other activities with topics related to students' everyday life. This is different from the results of previous research studies that showed either an improvement or not in the level of informal reasoning over a period of time during which argumentation is introduced (Venville & Dawson, 2010; Osborne et al., 2004).

However, in activities four and five students' level of reasoning was emotive while in activities seven and eight their reasoning level was intuitive. . This result could be explained by the fact that activities four and five discussed AIDS, a topic which is debatable in the Lebanese society. Students probably hear that this disease is dangerous and scary, which was reflected in their responses. Thus, their reasoning in these activities was slightly influenced by their prior conceptions and background about AIDS. Again, past research explained that students hold prior concepts and beliefs when they come to the classroom, which are hard to change (Carey, 2000).

These findings align with Ricco's (2015) dual system for the development of reasoning and cognition. He explained that the first system begins during early childhood and is based on the ability to perform procedural tasks in a specific context. However, the other cognitive system which he referred to as System 2 does not emerge before late childhood and adolescence. System 2 depends on the individual's cognitive effort and intelligence. Also, it is essential for comprehending abstract and more general content. This model explains the results in this study. Students showed rational informal reasoning in most activities since the nature of some of the activities guided them through a specific procedure to argue with or against a claim. However, in activity 5, fewer students provided rational reasoning since no evidence in support of the claims was provided to guide students in constructing their argument. However, Ricco (2015) stressed that both systems are important for the development of cognitive processes even if rational reasoning is not significant in early childhood. Thus, teaching argumentation at the elementary or middle school levels is essential for developing rational reasoning and high levels of arguments later at high school or college levels.

Difficulties Faced During Iteration One and the Modifications in Iteration Two

Since this study is embedded in design-based research (DBR) approach, many lessons were derived during iteration one and as a result, many changes were made to the implementation of the activities during iteration two. These difficulties are discussed below.

Students' Difficulty with Argumentation. The first obstacle was the difficulty that students in the intervention/experimental group faced in learning and applying argumentation. After introducing Toulmin's model and the different elements of argumentation, students had trouble understanding new words such as "warrants" and "backings". As a result, the teacher and the students referred to warrants as 'second evidence' that further supports an argument. Thus, during iteration two (the remaining seven weeks of the intervention), the teacher and the students referred to data, warrants, backings, and qualifiers as evidence 1, evidence 2… Moreover, instead of orally reminding students of the elements of an argument or counterargument, the teacher wrote them on the board to remind them that their responses should include a claim, evidence 1, evidence 2, and evidence 3. The fact that the elements of argumentation were made explicit might have influenced some students' abilities to use argumentation.

Moreover, students continuously inquired about the purpose of the argumentation activities and their relation with the biology lesson. They were concerned if argumentation is a topic that will show up on the exam. Sometimes, they even nagged about having to complete the argumentation activity worksheets. Even in the argumentation activities in which students showed high interest, such as AIDS, allergies, and organ transplantation, they preferred to discuss the topic only and not write their responses. This could explain why when students had difficulty supporting a counterargument, they left this section empty or just rewrote the same evidence used to support the argument. This shows that students are not used to student-centered activities and they only care about studying for the exam. This is because students are rarely engaged in inquiry activities when studying different subjects. During iteration two, the teacher and the researcher decided to explain, before proceeding with the argumentation activity, the importance of argumentation, specifically in the given activity, in science. Some of the elements of science were indirectly explained such as its empirical and tentative nature.

School Context. The school context in which the study was implemented played an important role in ability of the researcher to complete her work. The school principal was very open to implementing this design-based study even through it required that the strategies used be changed midway during the intervention study, a change that may not be favored by school principals because it involves "experimenting" with students. . Moreover, the principal and the science teacher were very cooperative throughout the study. For example, the teacher agreed to come to professional development sessions at any specified time. Also, the teacher and the researcher were given the freedom to apply the intervention in grade 8 and were encouraged to teach argumentation during the immunology unit even though in many Lebanese schools principals encourage teachers to start preparing students for the public examinations (Intermediate School certificate, the Brevet). The flexibility provided by the principal and teacher to implement the study and the school context were vital elements that helped accomplish the purposes of this study.

Teacher's professional development and guidance. The teacher in this study had no previous experience in teaching Grade 8 biology and was not knowledgeable about the elements of argumentation. Prior to the study, the researcher and teacher held one meeting before the intervention during which Toulmin's model was explained and examples were provided. However, since the researcher provided the teacher with the argumentation activities as well as the other student-centered activities that were used in the experimental and control groups, subsequent meetings occurred on a weekly base. During these meetings, the teacher and the researchers discussed daily lesson plans and reflected on the argumentation activities and their implementation. During the second iteration, the researcher provided the teacher with guiding questions to use during class discussions (‘Do you agree or disagree with your friend’s argument?’, ‘Your friend disagrees with your argument, how would you convince him?’). Also, wait-time was stressed in order to give students the chance to think in-depth about the explanation. However, as indicated above the meetings and the close support by the researcher did not seem to be sufficient, highlighting the necessity of consistent, long term, and content focused professional development for teachers to acquire mastery of teaching strategies (Wei, Darling-Hammond, Andree, Richardson & Orphanos, 2009).

Implications of the Study

This study adds suggestions to previous research and practice. The results of the study show that it is necessary to conduct more research studies to investigate the effect of argumentation on intermediate level students’ achievement, level of arguments, and informal reasoning especially that this kind of research has not been common at the middle school level in Lebanon. Results of this study showed that students construct better arguments and rational reasoning skills in specific activities where evidence is explicitly provided and the questions are guided. Consequently more research is needed in this area to explain possible reasons for this finding. In addition design-based research allowed the improvement of the quality of argumentation interventions in this study. As a result, more studies of this kind are recommended.

The results of the study are important for science teachers, science school coordinators, and administrators. Although the results in this study were not statistically significant, the student-centered activities and argumentation activities can be effective cognitive tools that help students learn science. Moreover, students need to develop the knowledge, skills and attitudes need to address everyday science-related issues because these are issues that many students will have to confront and possibly decide on in the future. Therefore, science teachers could plan and integrate such activities in teaching science rather than just prepare students for in-school and out-of-school exams.

Moreover, since previous research showed that it is important to start at an early age with the argumentation activities even if students can only reason when given guided procedures, more research should be conducted on implementing guided argumentation activities at the elementary and middle school levels (Ricco, 2015). Therefore, the educational system in Lebanon should integrate argumentation based on guided questions and explicit evidence in order to better develop students' reasoning levels at an older age when students have the cognitive ability to construct more rational arguments.

Limitations of the Study

The argumentation intervention was conducted over a period of 12 weeks and is therefore classified as a short intervention. This short period is may not have been sufficient to detect significant gains in learning and developing higher-order thinking skills (Zoller et al., 2000, 2002, cited in Osborne et al., 2004). Osborne et al. (2004) engaged students in argumentation for nine months and still recommended increasing the time of the study to insure that students had enough time to develop argumentation skills.

Moreover, the teacher's professional development was short with a total of 12 hours over the 12-week period (about one meeting per week). Past research suggested that longer professional development is needed to insure that students develop the knowledge and skills needed to implement new teaching/learning strategies. (Osborne et al, 2004). Also, the fact that the teacher had no prior experience in teaching Grade 8 biology might have affected the quality of her teaching.

Appendix I

Immunology Knowledge Test

Exercise 1

Choose the correct answer

1. The function of the immune system is to: (knowledge)
   a. Help germs enter the body
   b. Fight off sickness
   c. Make your nose run
   d. Give you diarrhea
2. All of the following are the body's defenses against pathogens except: (knowledge)
   a. A physical barrier such as the skin
   b. The inflammatory response
   c. The immune response
   d. The attack by red blood cells
3. A boy was injured during a football game. When he got back home, he did not take care of his wound. After a few days: (Comprehension)
   a. The boy would die
   b. The wound heals itself
   c. The wound is infected with bacteria
   d. The boy cannot walk due to pain
4. Upon examining a wound, we notice a large number of white blood cells. We conclude that white blood cells: (analysis)
   a. Fight bacteria
   b. Make the skin red and swollen
   c. Increase blood flow at the wound
   d. Cause pain

5. An experiment was conducted using Mouse A and Mouse B. A tissue from mouse A was transferred to another mouse A. Then, a tissue from mouse B was transferred to mouse A. The correct result of the experiments is: (analysis)

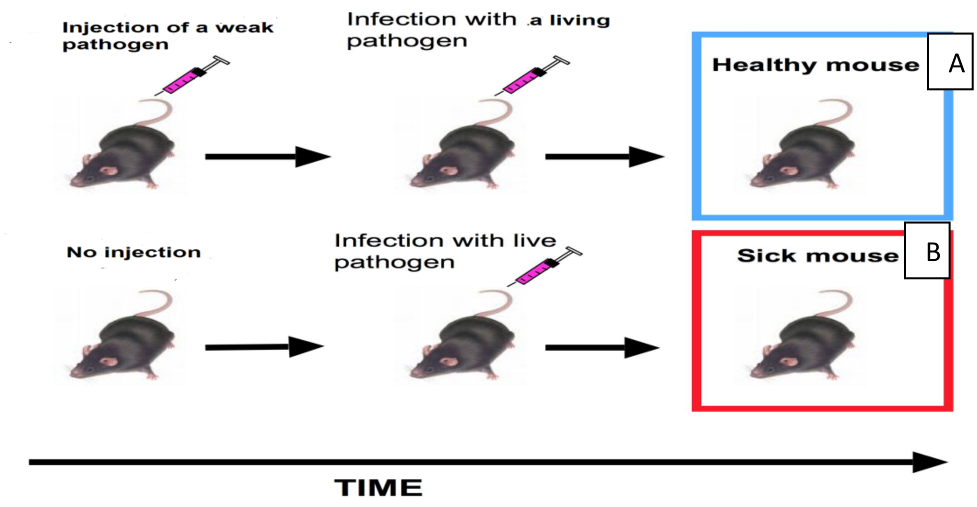
   a. Mouse A accepted the tissue from Mouse B but rejected the tissue from Mouse A.

   b. Mouse A accepted the tissue from Mouse A but rejected the tissue from Mouse B.

   c. Mouse A accepted the tissues from both mice A and B since they all belong to the same species.

   d. Mouse A rejected both tissues from Mouse A and Mouse B.

6. Observe the following diagram then answer the question: (analysis)



   Mouse A remained healthy while Mouse B became sick because:

   a. The immune system of Mouse A is stronger than that of Mouse B

   b. The immune system of Mouse A produced antibodies against the weak pathogen that helped it fight the living pathogen.

   c. The weak pathogen helped the immune system fight other pathogens.

   d. The immune system of Mouse A produced antibodies that help it fight any living pathogen that infects the body.

7. SARS is a respiratory disease caused by a virus. Use the data table to decide which statement below is true: (evaluation)

SARS Cases (2002-2003)		
Country	**number of cases**	**number of deaths**
Canada	251	43
China	5327	349
Taiwan	346	37
Singapore	238	33
United States	29	0

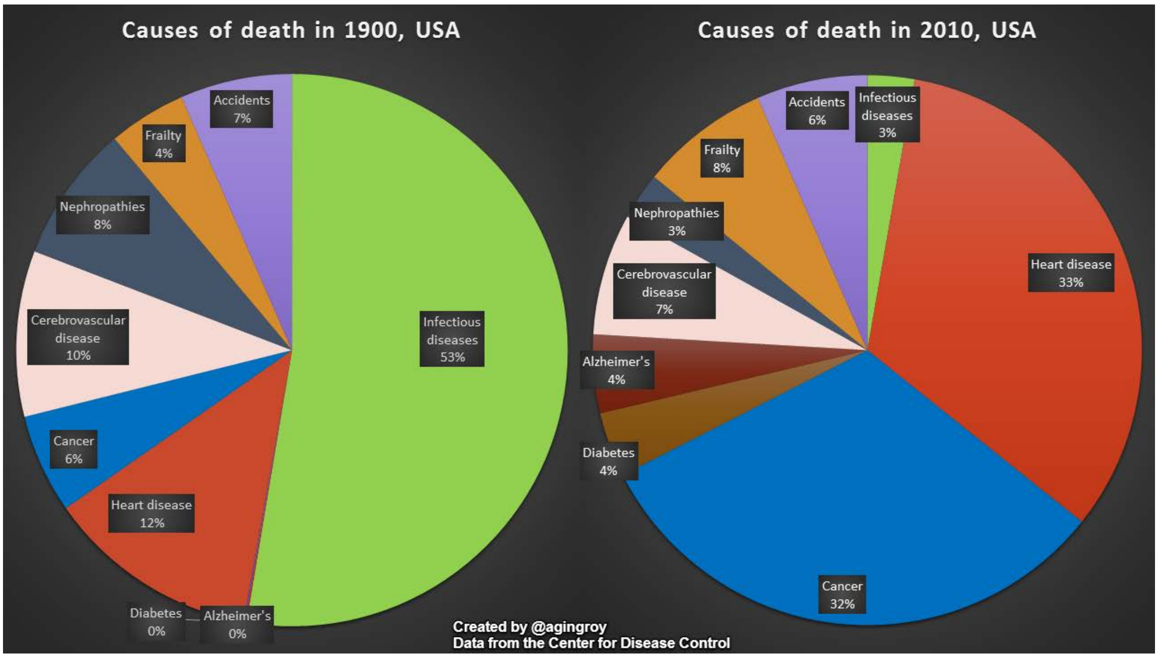
a. Most of the people who got SARS died

b. SARS is a contagious disease since nearby countries have more affected individuals

c. The SARS virus is hard to diagnose but easy to treat

d. There is a vaccine against SARS that decreases the risk of being infected with the virus

8. The following diagram compares the causes of death in the USA in 1900 and 2010: (synthesis)



Which of the following statements best explains the decrease in the number of deaths from infectious diseases?

a. Less people died from infectious diseases because the number of pathogens decreased

b. Less people died from infectious diseases because we developed ways to fight infectious diseases.

c. Less people died from infectious diseases because pathogens are less harmful today than they were before

d. Less people died from infectious diseases because over generations, children will not be infected with the pathogens that infected their ancestors

9. Suzy visits the park during spring. After some time, she starts sneezing and her eyes water. Her mother believes that Suzy is having an allergic reaction. An allergy can be best described as: (applying)

   a. Sneezing, itching, watery eyes, and sore throat

   b. An overreaction of the immune system to a foreign substance

   c. A cold during spring months

   d. A reaction to the influenza virus during spring months

10. Allergens trigger an allergic reaction in some people. It causes a runny nose, watering eyes, or a red skin rash. All of the following are examples of allergens except: (comprehension)

   a. Pollen

   b. Dust

   c. Virus

   d. Nuts

11. After receiving a vaccine for chickenpox, children will not be severely infected when the chickenpox virus invades the body because: (analysis)

   a. The vaccine contains white blood cells that fight the disease.

   b. The vaccine contains a weak chickenpox virus that the body identifies and develops antibodies against it.

   c. The vaccine contains antibodies that fight the virus when it infects the body.

   d. The vaccine contains a different virus that helps the body fight the chickenpox virus.

Exercise 2 (knowledge and comprehension levels)

Indicate whether the following statements are true or false. Correct the false statements.

1. Human pathogens cannot be spread through contact with a sick person or object in the environment including other living things. False, can be spread
2. Most pathogens can be seen only with a microscope. True
3. HIV is a virus that can survive briefly outside the human body in fluids including blood. False, it is only transmitted through blood or semen
4. An antibiotic is a chemical that can kill disease-causing bacteria. True
5. An allergy is an infectious disease because it is not caused by pathogen such as viruses and bacteria. False, caused by a harmless allergen

Exercise 3:

Answer the following questions:

1. Describe the ways in which the body makes it difficult for a pathogen to reach parts of the body where it can cause disease. Physical barriers.
2. For some people, cat hair causes an allergic reaction. However, many people are infected with the chickenpox virus. Compare the causes of these diseases and determine the ways in which you body protects you from them.

Allergic reaction	Chicken pox
Caused by allergen leads to an exaggerated immune response to get rid of the allergen	Caused by virus White blood cells (T and B lymphocytes) fight the virus

3. List three ways in which the HIV virus can be transmitted from one person to another. Blood, semen, needle injection…

Appendix II

Immunology Chapter Tests

Chapter Test 1

Question I: Write down the word that best replaces the given definitions:

1) Binding of an antibody to its corresponding antigen
2) Liquid containing dead leukocytes
3) Leukocyte which completes its maturation in the thymus
4) Molecules secreted into the serum

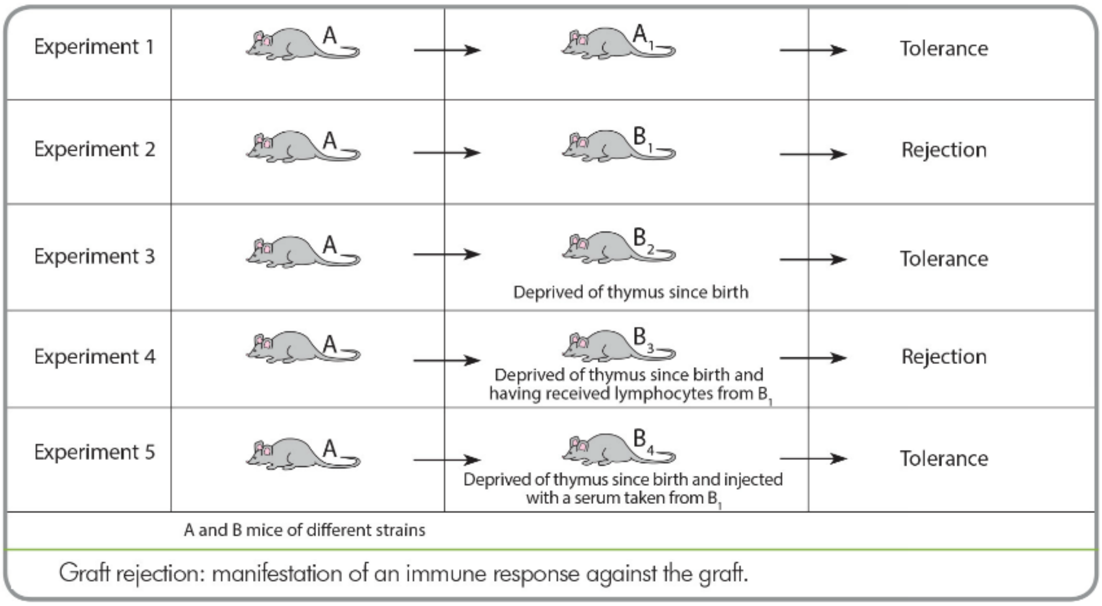
Question II: Answer the following questions briefly:

1) List the two types of specific immune response.
2) Indicate the natural barriers of the body.
3) What are the possible results of phagocytosis?
4) Describe the mode of action of T lymphocytes.
5) What are the five signs of an inflammatory reaction?
6) Indicate 3 differences between B and T lymphocytes.

Question III: Answer by true or false. Correct the false statements:

1) T-lymphocytes have an immediate, non-specific immune response.
2) Erythrocytes and lymphocytes are two types of phagocytes.
3) Cells infected by a virus are targeted by B lymphocytes.
4) The production of antibodies by T lymphocytes characterizes a cell-mediated immune response.
5) Microorganisms are recognized by molecules on their surface called antibodies.

Question IV:



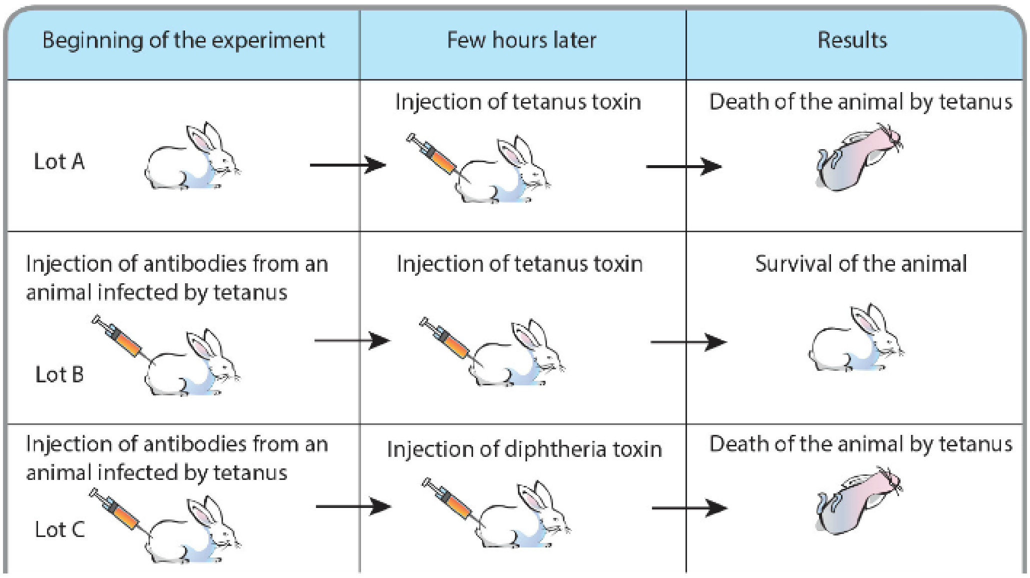
1) Analyze the above experiments.
2) Interpret experiments 2 and 3. Draw out a conclusion.
3) Determine which immune cells are responsible for graft rejection.

Chapter Test 2

I. Answer the below questions briefly:

1) What is an allergy? Describe its mechanism.
2) What is the cause of innate immunodeficiency and acquired immunodeficiency?
3) Describe the role of T4 (Helper T-Lymphocyte).
4) What does the term ‘HIV positive’ mean? What test is performed to determine if a person is HIV positive or not?

II. Consider the below experiments conducted on three lots of rabbits to determine the characteristics of an immune response:



1) Analyze the experiments carried out in the above experiments.
2) What is the importance of the experiment performed on Lot A?
3) Draw out a conclusion concerning the immune response observed in the above experiments.

III. The below table shows the quantity of antigens and antibodies in blood samples taken from a person infected with pathogenic bacteria.

Time (days)	**0**	**2**	**4**	**6**	**8**	**10**	**12**	**14**	**16**
Quantity of antigens in the blood (a.u.)	3	3	4	3.5	2.5	1.9	1	0	0
Quantity of antibodies in the blood (a.u.)	0	0	0	0.2	0.5	1	1.5	4	6

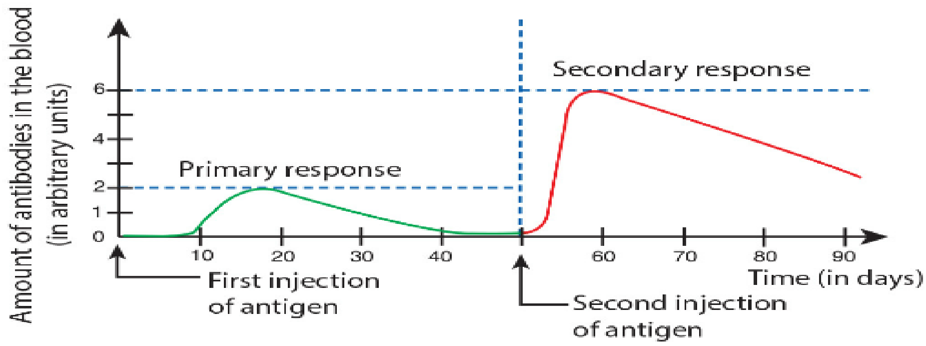
1) Plot on the same graph the variation of the quantity of antigens (curve 1) and the variation in the quantity of antibodies (curve 2) as a function of time.

Scale: x-axis: 1 cm ⟶ 2 days

y-axis: 1 cm ⟶ 0.5 a.u.

2) Specify:
   a. The day when the infection was maximal.
   b. The day when this person became seropositive.
3) Show that a relationship exists between the quantity of the antigens and antibodies in the blood.
4) Name the cells responsible for the shown immune response.

IV. The below graph illustrates the evolution of the amount of antibodies upon two successive injections of the same antigen:



Evolution of the amount of antibody after two successive injections of the same antigen.

1) Analyze the above graph.
2) Draw out the characteristics of the secondary response.

Chapter Test 3

I- **Blood groups are determined by antigens on the erythrocytes and specific antibodies in the plasma accompanying these antigens.**

a- How many types of antigens are there? Name them.
b- How many types of antibodies are there? Name them.

II- **After a blood transfusion, the erythrocytes of the donor should not agglutinate with the plasma of the receiver. From this acknowledgement, put a tick in the case of agglutination.**

Donor / Recipient	A	B	AB	O
A				
B				
AB				
O				

III- **We collected blood from different individuals, and the samples were subjected to centrifugation in order to separate the different blood components. Then, we mixed two different drops: The first one taken from the upper phase and the second drop taken from the lower phase from different samples. The results obtained are illustrated below:**

First Drop (taken from the upper phase)	A	B	O
Blood Mixture Result	Agglutination	No agglutination	Agglutination
Second Drop (taken from the lower phase)	?	?	?

Knowing the blood group of the first drop, name the corresponding group of the second drop in each mixture. Justify.

IV- **To determine the blood group of two individuals, we use serum tests containing known antibodies. We mix each time one blood drop of each individual with one drop of serum tests. The results are illustrated below:**

<u>Individual 1:</u>

The blood drop agglutinated with serum anti-B and serum anti-A anti-B

<u>Individual 2:</u>

The blood drop didn't agglutinate with any serum-test.

1- Define agglutination.
2- Determine the **blood** group of each individual and justify the answer.

V- Indicate the difference between pathogens and non-pathogenic microorganisms.

VI- The table below shows the evolution of infection by Koch Bacillus with time.

	Lungs	**Blood**	**Other organs(bones and kidneys)**
Before contamination	-	-	-
1 month later	++	-	-
2 years later	++	++	++

Describe the evolution of the infection with Koch Bacillus.

Appendix III

Experimental Group Lesson Plans

Session 1 Chapter 1: "Self" and "Non-Self"

Purpose

This lesson introduces students to "self" and "non-self" markers through learning about organ transplant and tissue rejection.

Science Content and Major Concepts

Students differentiate self from non-self markers and examine grafting**.** Also, they indicate examples of self and non-self antigens.

Instructional Objectives

Students should be able to:

- Apply their knowledge on grafting and immune system reactions
- Explain why graft rejection occurs upon transferring a tissue or an organ from one individual to another
- Relate the chances of success of a graft to the similarity of HLA molecules of the donor and the recipient

Entrance Abilities

This is the first lesson in the unit (immune response) and the students are not expected to have prior knowledge about it.

Material and Equipment

Prepared Worksheet

Textbook

Instructional Activities

Set Induction. At the beginning of the session, the teacher informs the students that they will start a new unit: The Immune System. She will ask the students how we get sick and then feel better. She then explains the role of the immune system in fighting “foreign” bodies that enter but not our own body cells. The role is written on the board.

Other Instructional Activities. After the introduction, the teacher will distribute a worksheet about organ transplant **(Appendix IV)**. They are required to read the information in the sheet and answer the first three questions individually in which they deduce that tissue acceptance occurs only when the donor and the recipient are the same individual or identical twins The teacher will then lead a whole classroom discussion in which the students finally define the terms “self” and “non-self” and give examples of each. Then, they solve part 4 on the worksheet in which they identify certain organs or items as self or non-self. After that, the teacher will further explain that every individual has unique markers on the surface of his body cells called “antigens” or HLA markers. They read about HLA markers in the book and answer a question in the book in which they rank cells by decreasing order of HLA molecule similarity.

Closure and Review. The students summarize the difference between self and no-self markers.

Session 2 Chapter 1: “Self” and “Non-Self”

Purpose

Students will make decisions about whether or not they agree or disagree with certain criteria of organ donation. They argue with or against each one and present evidence to support their position.

Science Content and Major Concepts

Students will examine the advantages and risks of organ transplant including the ethical debate surrounding this issue.

Instructional Objectives

Students should be able to:

- Apply their knowledge on grafting and immune system reactions
- Explain why graft rejection occurs upon transferring a tissue or an organ from one individual to another
- Relate the chances of success of a graft to the similarity of HLA molecules of the donor and the recipient

Entrance Abilities

Students should be acquainted with the meaning of grafting, organ transplant, and graft rejection.

Material and Equipment

Worksheet: Organ Donation

Type of Activity: Individual and pair work

Instructional Activities

Set Induction. At the beginning of the session, the teacher reviews the concepts learned in the previous session regarding the difference between self and non-self markers. Also, students are reminded of the meaning of graft rejection and why it occurs. Then, the teacher collects students' opinions and ideas about organ transplant by asking questions such as: 'In your opinion, is there anything wrong with organ transplant?' 'Should everyone be required to be an organ donor?' 'How do you convince someone to become an organ donor?'

Instructional Activities. Students are given a worksheet (organ donation) to complete individually and then in pairs. The aim is to determine which criteria are most important for determining which recipient deserves most an organ transplant. Students defend their opinions on the criteria they believe are most important and provide an explanation for the least important ones. In pairs, students discuss their ideas with their peer, defending their ideas and refuting any conflicting belief.

Assessment of Instructional Objectives

In this lesson, the students' understanding of a claim and supporting evidence will be informally assessed during the classroom activity. The students' understanding of argumentation will be further assessed during the following sessions.

Session three: Introducing Argumentation and Toulmin's Model

Purpose

This lesson will introduce the students to argumentation. They will explore the meaning of argumentation and its various components based on Toulmin's model. The lesson will allow the students to identify the components of a scientific argument, develop their own arguments, and argue against different views.

Science Content and Major Concepts

The students will be introduced to Toulmin's Model of Argumentation and its various components (Appendix IV).

Instructional Objectives

By the end of the lesson, the students will be able to:

- Define argumentation
- Identify the components of argumentation based on Toulmin's model
- Develop their argumentation skills

Entrance Abilities

The lesson does not require any pre-requisite abilities necessary to attain its objectives, because it is not directly related to the content of the unit. The lesson focuses on a topic that is related to the students' daily living.

Materials and Equipment

Prepared handouts

Instructional Activities

Set induction. The teacher will first implement a short exercise as a brainstorming activity. In this exercise, the students will reflect on their different perceptions of argumentation. They will first solve the exercise (worksheet is in Appendix IV) individually and then discuss their answers with a partner identifying any points of agreement/disagreement before a whole classroom discussion is raised. During the classroom discussion, the teacher will pinpoint the common perception based on the students' responses. She will then define argumentation and relate it to the field of science.

Other instructional activities. The teacher will then explicitly introduce Toulmin's argumentation model through a short exercise. The students will be asked to construct a concise well-written argument in an attempt to answer the following question: "Do you think that smoking in public places should be banned?" In their response, the students must make sure to state their choice and support it with as many reasons as possible. The students will first work individually and construct their own arguments. They will then discuss their answers with a partner in order to evaluate the adequacy of each other's argument before a whole classroom discussion is raised. During the classroom discussion, the students will have a chance to share their different points of view. The teacher will also guide the discussion in a way where the various components of Toulmin's argumentation model get revealed. She will illustrate in a structured diagram the discussed argument and will fill in the various components of Toulmin's argumentation model so that the students familiarize themselves with the terms.

Closure and review. The various argumentation components will be summarized, and the students will receive a handout (Appendix IV) that contains information describing each component along with a diagram of Toulmin's model.

Assessment of Instructional Objectives

In this lesson, the students' understanding of argumentation and its components will be informally assessed during the classroom discussion. The students' understanding of argumentation will be further assessed during the following sessions.

Session 4 Self and non-self (Kinds of Pathogens)

Purpose

Students identify the different kinds of pathogens that could invade the body. They compare the nature of these pathogens.

Science Content and Major Concepts

Students will be introduced to the different kinds of pathogens that cause disease in our body because they are recognized as non-self.

Instructional Objectives:

By the end of this session, students should be able to:

1. Identify different pathogens that induce an immune response
2. Differentiate bacteria from viruses
3. Differentiate self from non-self molecules

Entrance abilities

Students should be familiar with the terms self and non-self.

Material and Equipment

Textbook

Worksheet: Viruses

Instructional Activities

Set Induction. The teacher recalls what they learned about self and non-self. They are reminded that in previous sessions, they learned how the body fights any foreign tissue or organ. The students are asked to provide other non-self molecules that the body fights against. Students' responses are written on the board (such as bacteria, viruses,…).

Instructional Activity. Students are introduced to the structure of viruses using an online animation. The purpose is to provide a visual stimulus; to ask the question what type of organism is it. Also, it will engage students in the argument. Students work in pairs to classify each card from the evidence cards under the column they think is correct. The evidence cards sheet is distributed to students. Then, students are given about 10-15 minutes to sort out the cards. The teacher goes around while they are working in their groups in order to explore their reasoning for selecting cards to put in one column over the other. After that, the teacher asks each group to argue with or against the claim that viruses are alive. Students discuss their arguments in pairs and write it with supporting evidence and counter arguments. The teacher could ask questions such as "what information would you use from the cards to prove that this argument is not true?"

Lesson Closure.

The teacher concludes that scientists debate this topic but consider viruses to be not living based on evaluating evidence just like the students did.

Assessment and Evaluation

Student work on the activity will be analyzed in order to determine the level of their arguments and the level of informal reasoning.

Session 5: SNOWMAN ACTIVITY

This activity uses “competing theories” where they provide explanations about a particular phenomenon. The students are asked to predict which snowman – one wearing a coat and another not wearing a coat – would catch a cold in a cold weather. Pupils are presented with two alternative explanations that would support which snowman catches a cold and are asked to evaluate a list of evidence which can support one theory or the other, or both.

Purpose

This exercise aims to generate scientific argument and debate around competing theories of what will happen to two snowmen in a cold weather. It provides an opportunity to develop pupils’ understanding of the scientific concepts and to construct a written argument.

Instructional objectives

At the end of this lesson, students should be able to:

1. Generate an explanation for transmission of disease.
2. Construct their arguments and to revise their arguments based on discussions in the class.

Instructional Activities

Set Induction. Distribute the activity sheet consisting of the concept cartoons. In groups, students to decide which snowman will catch a cold and why. The task is first introduced (about 10 minutes) explaining what they will be expected to do. They will be constructing an argument for both theory and also justifying their choice with reasons. They will need to give at least two reasons to support their point of view.

Other instructional activities. In pairs, students write reasons to support their argument and justify them. Once they have completed this task, the students share their ideas in the groups of four. Then, the improved argument sheet is distributed and students are encouraged to use the evidence sheet to write an improved argument. (15 minutes). The groups present their ideas to the whole class. Argumentation is encouraged by asking they would argue against other students' evidence. If there are significant differences in the reasoning provided across the groups, get the students to realize the difference by asking questions such as "how is this group's ideas different from the previous group?"

Assessment and Evaluation

Students' level of argumentation and level of informal reasoning will be evaluated based on their responses on the activity worksheet.

Chapter 3: Session 6 Allergies

Purpose

Students are introduced to non-infectious diseases called allergens. The aim is to realize that some individuals' immune system overreacts to these harmless allergens and the individuals feel sick.

Science content and major concepts

Allergies are due to an immune response triggered against harmless allergens. It is a specific reaction that causes edema, asthma, sneezing, a rash… Allergens include pollen, dust mites, bee venom, certain food…

Instructional objectives

1. Explain that allergies are exaggerated reactions of the immune system to certain substances in the environment.

2. Identify the symptoms of an allergic reaction and its medications.

Entrance Abilities

Students should be familiar with infectious diseases and the body's reaction against them in order to compare them to non-infectious ones.

Material and equipment

Worksheet (Allergies)

Instructional Activities

Set Induction. The teacher gives a scenario: you and your friends go to the cinema. When you enter, you start sneezing and your throat feels scratchy. The teacher asks them to explain what is happening and why only they were affected not their friends. They should infer that ‘something’ affected their body only so, it does not affect everyone. Also, it could not have been a virus or bacteria because they take time. The teacher explains that these are called allergens. Allergens are defined and examples are given (pollen in the spring) and the way it affects the body is described.

Other instructional activities. The teacher distributes a worksheet (allergies) that describes a scenario from which students should find out, from given data, if they are allergic to strawberry and give evidence for their views.

Another activity about allergens is given. It puts students in a scenario where they have to decide whether or not the ‘Mankushe’ should be banned from school because it contains an allergen that most Lebanese people are allergic to. They work in pairs the in groups to complete a worksheet where they have to make a decision and support it with evidence.

Evaluation and assessment

Students’ responses on the worksheets are used to evaluate their level of arguments and level of informal reasoning.

Chapter 3 Session 7: Immunodeficiency

Purpose

The aim is to learn what immunodeficiencies are and how they are caused. Students learn some examples of immunodeficiencies and focus on AIDS.

Science content and major concepts

Students learn that immunodeficiency is a failure of the immune system to defend the body effectively against infections. Also, they are caused by the absence of malfunctioning of WBC. AIDS is caused by HIV virus which infects T4 lymphocytes and renders the immune system weak.

Instructional objectives

By the end of this lesson, students will be able to:

1. Define immunodeficiency
2. Explain how AIDS is caused by HIV virus
3. Identify the ways by which HIV virus can be transmitted from one person to another
4. Determine the social impact of AIDS on infected individuals and society

Entrance abilities

Students should be familiar with the immune system’s defense against pathogens.

Material and equipment

Textbook

Worksheet (AIDS)

Instructional activities

Set induction. The teacher asks what might happen if we did not have an immune system. Then, she explains that some babies are born without WBCs. Students infer that they should be placed in sterile conditions to prevent their contamination with pathogens. The teacher explains that this is an example of innate immunodeficiency and that an acquired immunodeficiency also exists which is AIDS.

Students are asked to answer questions about a graph showing the evolution of the amount of HIV and T4 Lymphocytes during the three phases of AIDS. What happens to T4 lymphocytes when the person is infected with HIV virus? Show that the amount of HIV virus depends on the amount of T4Lymphocytes? How much time can a person infected with HIV virus live?

Students also read about AIDS in their textbook and infer the importance of HIV test, the cause of appearance of opportunistic diseases, and how an HIV virus is transmitted from one individual to another.

Other instructional activities. Students receive a worksheet about a social issue related to AIDS. They discuss the issue in pairs, make a decision, and support it with justified evidence.

Another activity could be conducted about AIDS where students are given different statements that provide information about AIDS. Students decide in pairs whether they agree or disagree with each statement and provide reasons to support their decision.

Evaluation and assessment

Students' responses on both AIDS activities are analyzed to determine the level of their arguments and informal reasoning skills.

Session 8 Chapter 3: Vaccination and Serotherapy

Purpose

Students learn what vaccination is and why it is important. Also, they learn the difference between vaccination and serotherapy.

Science content and major concepts

Vaccination is a preventive method that is acquired and specific in fighting a virus. It is based on the principle of immune memory and can induce an immune response by inoculating a weakened pathogen in the body. Serotherapy is a curative method that is immediate but not lasting. It consists of transferring a large amount of antibodies specific to a microbe taken from a serum from another individual who has been in contact with the antigen and developed immune cells against it.

Instructional objectives

1. Justify the importance of vaccination as a preventive method that induces an immune response by inoculating a weakened pathogenic antigen
2. Compare the benefits and risks of vaccination.
3. Explain why vaccination is obligatory in Lebanon
4. Compare vaccination and serotherapy.

Entrance abilities

Students should be familiar with the immune response against pathogens including the specific immune responses in order to understand that vaccines work by initiating an immune response against a weakened pathogen.

Material and Equipment

Textbook

Worksheet (The Vaccine War)

Instructional Activities

Set Induction. Students are divided into groups in which each group reads about a scientist and his experiment. They then answer the following questions:

- What was the important finding by this scientist?
- Explain the results obtained.
- How does this discovery help improve our society in our current day?

1796 Edward Jenner

He was an English doctor who successfully cured a child infected with smallpox, a deadly viral disease. Jenner used material from the sore of a person with cowpox, a mild but similar disorder. Although Jenner's procedure was successful, he did not understand why it worked.

1854 Florence Nightingale

This English nurse cared for British soldiers during war. She insisted that the army hospitals be kept clean. By doing this, she saved many soldier's lives. She is considered to be the founder of the modern nursing profession.

1868 Louis Pasteur

In France, Louis Pasteur showed that microorganisms were the cause of disease in silkworms. He reasoned that he could control the spread of disease by killing microorganisms. He also proposed that infectious diseases in humans are caused by microorganisms.

1952 Jonas Salk

In 1952, there were more than 57,000 cases of polio, making it one of the dreaded diseases known at the time. That same year, Jonas Salk, showed that people injected with killed polio viruses did not get the disease.

Scientist	Important finding	Explanation of finding	This discovery helps improve society today since…
1796 Edward Jenner		I believe that Jenner's procedure was successful because…	
1854 Florence Nightingale		I believe that Jenner's procedure saved lives because…	
1868 Louis Pasteur		I agree/disagree with Pasteur that infectious diseases in humans are caused by microorganisms because…	
1952 Jonas Salk		I believe that people injected with killed polio viruses did not get the disease because…	

Students' responses are discussed and they infer that these discoveries include vaccination that saves many lives today as well as sterilization. They read in the textbook about vaccination and how it works. Then, they compare it to serotherapy. This scenario is given to introduce serotherapy: **a person who is not vaccinated against tetanus gets injured while arranging his ancient tools. Should he get a vaccination against tetanus? Justify with evidence.**

In this case, students realize that vaccination takes time for the body to develop immunity against the pathogen and a different solution is needed.

Other instructional activities. After analyzing graphs related to vaccination and serotherapy, students will do an activity in which they argue with or against vaccination after reading about its benefits and risks. (Appendix IV)

Another argumentation activity could be added to this lesson. Students read a case about whether it is effective or not to take a flu vaccine. Students decide which claim they support and provide evidence for their decision. (Appendix IV)

Assessment and Evaluation Students' responses are written and are used to evaluate their level of argumentation and their level of informal reasoning.

Appendix IV

Experimental Group Worksheets

Session 1: "Self" and "Non-Self"

When kidney transplants were beginning in the 1950s, "tissue rejection" often occurred and death was quick when the kidney was transferred from one individual to another. This type of graft (organ transfer) is called allograft. Then, by chance, a twin who was suffering kidney failure received a kidney from his identical twin (isograft), who had two healthy kidneys. Tissue rejection did not occur and both individuals went on to live for many more years.

Answer individually the following questions:

1. What is tissue rejection? How does the body reject an organ?
2. A key concept in tissue transplants is the notion of "self" vs. "non-self." Using the information above, what is the difference between "self" and "non-self" items?
3. Would the body reject a skin transplant that occurs in the same organism? (autograft)
4. Match the following:

Isograft •	• an individual receives a graft of his own skin
Allograft •	• an individual receives a graft from his twin
Autograft •	• an individual receives a graft from another individual

5. Using the concept of "self and non-self," what is the function of the immune system?

6. Using your knowledge of the immune system identify the following items as "self" or "non self"

Organ/item	Self or Non-Self	Organ/item	Self or Non-Self
Your Heart		Artificial knee made of titanium.	
Your Brain		Bacteria found in the large intestine	
A transplanted heart from a distant relative		A transplanted kidney from your identical twin	
Transplanted heart valve that originated in a pig.			

Session 2: Organ Donation

A. Complete the following table in order to determine which criteria are important or not concerning who deserves an organ transplant. Then, provide reasons to support your ideas.

Criteria	Important to Consider	Not Important
Age		
Gender		
Quality of HLA marker match		
Personal Accomplishment of an individual		
Worth to Community		
Lifestyle choices: Smoker, Obese,…		
Intelligence		
Prisoner who committed a crime		

Now choose one of the criteria that you think is the most important one to consider in organ donation. Explain why you believe this criterion is important.

Then, Choose the least important criteria and explain why you believe is not important.

*I believe that the criterion*____________________________ *is most important in organ donation because…*

I believe this criterion _____________________________*is not important in organ donation because…*

B. A main problem of organ donation is that there are not enough organs for everyone who needs them. Give other possibilities to increase organ supply. Suggestions: Animal transplantation, technological solutions…

Session 3: What is Argumentation?

This exercise was developed by the Ideas, Evidence and Argument in Science (IDEAS) Project (Osborne, Erduran, & Simon, 2004b) and will be implemented as a brainstorming activity.

Activity

The following table contains several metaphors for people's perceptions of the term "argumentation".

a- Which of the following metaphors is most similar to the way you think about argumentation?

b- State in the comments column the reasons why you do or do not like each of the mentioned metaphors.

Metaphor: Argumentation is like	**Comments**
Brainstorming	
War	
An explanation	
A dead end	
(Other suggestions/thoughts)	

Session 3 (cont'd): Toulmin Model of Argumentation

Toulmin (1958) explained that effective scientific argumentation consists of the following six components:

- Claim: A statement that a proper believes has the status of a certain truth.
- Data: The evidence used to prove an argument and back it up.

- Warrants: General and implicit statements that link the claim with the evidence. Warrants might be rules or principles that are suggested to justify the links between the evidence and the claim.
- Qualifiers: Statements that limit the claim or statements that specify the conditions under which a claim is true.
- Rebuttals: Counter-arguments or statements that indicate the circumstances when an argument does not hold true.
- Backing: Statements that function as assurances and are meant to justify a certain warrant. In other words, these are statements that do not necessarily prove the claim but do prove that a warrant is true.

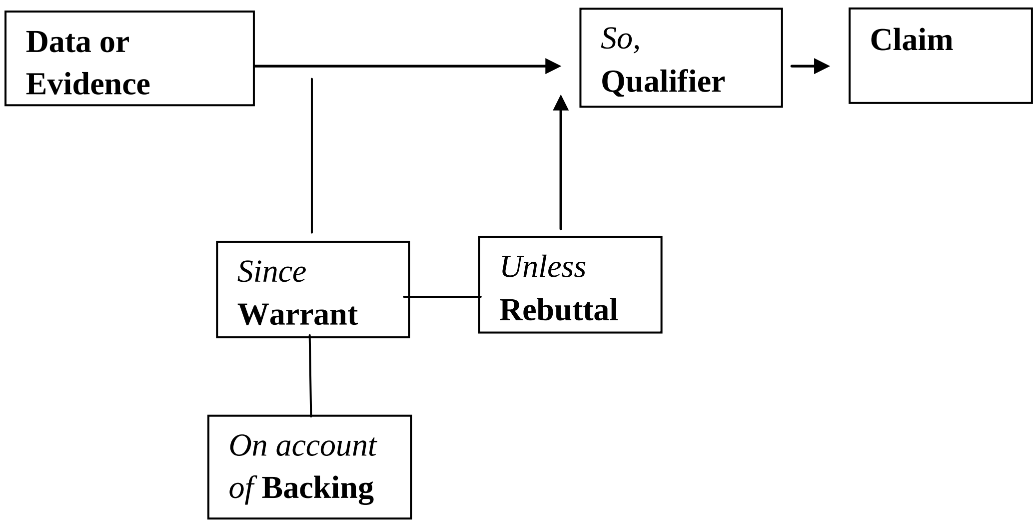


Figure 1. Toulmin’s Argumentation Model (Toulmin, 1958, p.104).

Session 4: Are Viruses alive?

Background: Scientists have chosen certain criteria to determine whether something is alive or not. For instance, roses grow and reproduce, but viruses seem to have a different way of existing. Several facts about viruses have confused scientists and made them wonder whether viruses are living or non-living things. Below are evidence cards. Classify these cards as either evidence supporting the idea that viruses are alive or as evidence supporting the idea that they are not.

Virus Evidence Cards

Viruses Damage our cells and	**Viruses contain DNA**
Viruses are not cells	**Viruses cannot reproduce without a host cell**
Viruses do not need food from	**Viruses confused early**
Viruses do not have a cell	**Viruses do not grow in size**

Viruses live in ponds and puddles	**The immune system identifies and kills cells infected with a**
Viruses can reproduce with the help of host cells.	**Viruses do not move on their own**

Viruses – Alive or Not?

Evidence that suggests *viruses are alive*	**Evidence that suggests *viruses are not***

Which argument do you support? Provide evidence for your claim and counterarguments.

I support the argument that viruses (are/are not) alive. The reasons for my argument

are

____

____

____

____

____

____

____

____

____

____

I do not believe that the argument stating that viruses (are/are not) alive is correct

because

____

____

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____

____

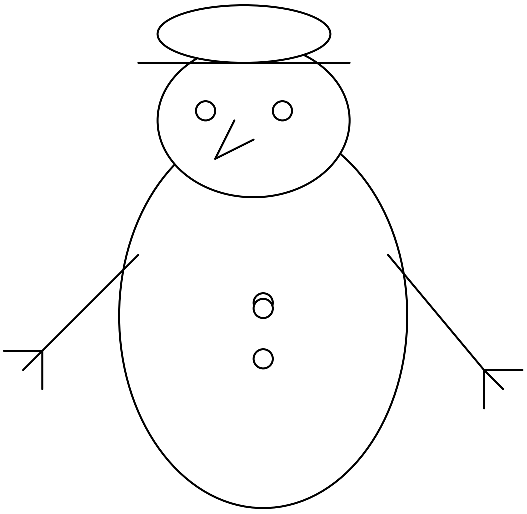
____

____

____

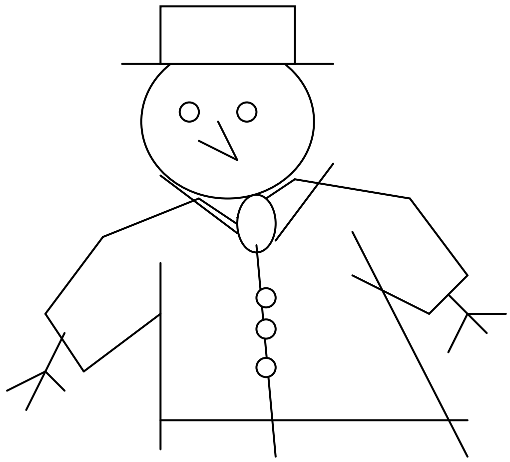
Session 5: Catching a Cold (SNOWMAN activity)

Sami



I think that I will not catch a cold because I need to be infected with the virus in order to be sick.

Tarek



I think I will not catch a cold because my jacket keeps my body warm which keeps my immune system strong to fight disease.

1. Which snowman do you think will catch a cold?

2. Why have you decided this?

3. Do you agree with the science behind Sami's argument?

4. Why?

5. Using the pieces of evidence given to you try to rewrite Tarek's argument on the next diagram so that it is more convincing. (Be careful. Not all information is necessarily useful!)

Our Argument

Our group supports ______ argument. We believe this because:

Tarek's Improved Argument

I think that Tarek will not catch a cold _____ because….

Another reason is that….

One reason why Tarek's argument was wrong in the first place is because….

Finally, I think that….

Session 6 (Allergies)

Two weeks ago, after you ate strawberry shortcake with whipped cream, you broke out in an itchy rash. The ingredients in the dessert were strawberries, sugar, flour, butter, eggs, vanilla, baking powder, salt and cream. Last night, you ate a strawberry tart with whipped cream and again broke out in a rash. The ingredients were strawberries, sugar, cornstarch, milk, eggs, flour, salt, and vanilla.

You think that you may be allergic to strawberries.

Do you have enough evidence to support this conclusion? Why? If not, what additional evidence do you need?

Session 6: Allergies (cont'd)   Should the Lebanese 'Mankushe' and food rich in nuts be banned from schools?

Duration: 50 minutes

Reference:

Irani, C., Maalouly, G., Germanos, M., & Kazma, H. (2011). Food Allergy in Lebanon: Is Sesame Seed the "Middle Eastern" Peanut. *World Allergy Organization Journal*, *4*(1), 1-3. doi:10.1097/wox.0b013e318204b745

Type of Activity: Pair/ Group Discussion

Objectives:

- Explain that allergies are exaggerated reactions of the immune system to certain substances in the environment
- Identify the symptoms of an allergic reaction and its medications

A recent study was conducted in Lebanon to illustrate the common food allergies in the Lebanese population. According to this study, hazelnut and sesame were shown to be severe allergens among Lebanese people. As a result, your school decided to ban food items that contain these ingredients such some kinds of chocolate which contain nuts and the Lebanese 'Mankoushe' which contains sesame along with thyme. Discuss this issue in pairs and then, construct an argument in which you take a stand with or against your school decision. Remember to support your argument with evidence.

Group discussion: After agreeing, in pairs, on a written argument, discuss it with the group next to you. Do you agree with their argument? Why or why not?

Session 7: HIV Breaking the silence

Duration: 50 minutes

Reference:

UNESCO HIV and Health Education Clearinghouse. (n.d.). Retrieved May 18, 2016, from http://hivhealthclearinghouse.unesco.org/

Type of Activity: Pair work, whole class discussion

First Challenge: A teacher tells a colleague that she is HIV positive. This information has spread, and local community members, including parents, are pressuring school administrators to fire the teacher.

In pairs, discuss the above challenge. Use the following statements to help you give the reasons behind your challenge as determined by the group:

- The teacher should/should not be fired because…
- Parents want the teacher to be fired because…
- Other teachers in the school think that…

Second Challenge: Convince school administrators that the teacher has a right to remain employed in the school setting and that discrimination can be harmful to the entire school community.

- I agree/disagree with this objective because…
- Both students and teachers who are infected with HIV should/should not be allowed to work or study at the school because…

Construct an argument that is most effective in responding to these reasons.

REASONS BEHIND THE CHALLENGE	POSSIBLE CONSTRUCTIVE ARGUMENTS

Session 7: (cont'd) Fact Or Myth about AIDS

Read the following statements and, in pairs, decide whether you agree or disagree with each one.

1. I'm too young to get AIDS.
2. I don't think I should hang out with her too because she is HIV positive.
3. I feel nervous using the toilet after someone with HIV has used it because I'm afraid I'll get HIV.
4. Are you kidding? He's so clean and plays sports all the time. He does not have AIDS.
5. I've known her my whole life, she has good manners and there's no way she has AIDS.
6. I don't think she has AIDS. She looks too healthy.

Statements I AGREE with	Statements I DISAGREE with

Now, choose one of the statements that you agree with and another one you disagree with and provide reasons to support your choice.

I agree with the statement………because……

I disagree with the statement….. because……

Session 8: Vaccination Debate

Reference:

The vaccine war: The Growing Debate over Vaccine Safety. (n.d.). Retrieved from: www.pbs.org/frontline/teach

Type of Activity: individual, pair work, and whole class discussion

Read the following discussions between the parents and doctors of children affected by a measles outbreak to open a general discussion of opposing perspectives on vaccination. Compare the medical risks of vaccination to its benefits to the individual and to the community. Then, construct an argument in which you argue for or against vaccination.

Medical Risks of Vaccination	**Benefits of Vaccination**

Argument: I am with/against Vaccination because…

Betty is a parent who recently had her world turned upside down. In February, her daughter was kept in the hospital for three weeks because she had been exposed to the measles.

She explained: “We were very scared, because we didn’t know what that meant. We were also angry, because the measles was brought to our city by a 7-year-old unvaccinated boy who was exposed to the disease while on vacation in Switzerland.”

Betty said that if a parent decides not to vaccinate, they shouldn't take their unvaccinated child to a foreign country where there is a higher incidence of measles and other diseases. And if you do that and you bring your child back sick, don't take that child to public places until you know what's really going on with them. Because of that one child, 70 children had to be quarantined; 11 got the measles; one of those had to be hospitalized. Fortunately, there were no deaths.

Doctors say that the outbreaks are being driven in part by people who are refusing to vaccinate their children. One mother refused to vaccinate her 7-year-old and 3-year-old sons. She says that she researched about vaccination and read that it may cause allergies, increased chances of asthma, increased chances of autoimmune disease, and autism. So, she was scared to vaccinate her children because vaccination may lead to certain diseases.

However, most doctors have indicated that recent research shows that vaccines are not a cause of autism. This is because autism occurs in children who are genetically predisposed to the disease. They add that the vaccines that babies get today are preventing about 33,000 deaths over the course of those babies' lives, preventing 14 million infections, and also saving about $43 billion in San Diego.

On the other hand, other doctors who are aware of the benefits of vaccination believe that sometimes vaccines do more harm than good. They believe that the children who receive no vaccines at all are statistically safe and that the later you give vaccines and the more slowly you give vaccines, the safer you are. This is because vaccines are causing an increase in the incidence of everything from diabetes to multiple sclerosis to other autoimmune diseases. Although these are rare occurrences but they are happening.

Session 8 (cont'd) Vaccination activity

Read the text and answer the questions:

Karen and Mary work at a restaurant. During their work, they read about getting bird flu vaccines. Mary suggests that Karen should get this vaccine. However, Karen said: No way am I going to take another flu shot. I got one last year and I still got sick.

I had fever, headaches, and I felt very tired.

Karen adds: If it doesn't stop you from getting the flu, then what good is the vaccine?

1. Karen and Mary work in a restaurant: How can they help protect the restaurant customers from catching pathogens?

____

____

Explain how a vaccine provides immunity against infection.

____

____

2.Do you agree with Karen's decision not to take a flu vaccine?

I agree with Karen's decision because…

I disagree with Karen's decision because…

Mary tried to convince Karen to get the vaccine.

But Karen added: Last year when I got sick, I ended up going to the doctor and he gave me some antibiotics. I got better the next day. I could just do that. That way, I only take medicine when I am sick instead of every winter.

Mary did not agree again and said: Sorry, but there's a big difference between viral and bacterial infections. The antibiotics helped you feel better because your sinus infection was caused by bacteria. Antibiotics don't help at all for influenza.

3. Can Karen rely on antibiotics if she gets influenza this year? Why or why not?

4. Which claim do you support (Mary's or Karen's)? Provide evidence for your choice.

Appendix V

Control Group Lesson Plans

Session 1 Chapter 1: "Self" and "Non-Self"

Purpose

This lesson will introduce students to "self" and "non-self" markers through learning about organ transplant and tissue rejection.

Science Content and Major Concepts

Students will differentiate self from non-self markers and examine grafting**.** Also, they will indicate examples of self and non-self antigens.

Instructional Objectives

Students should be able to:

- Apply their knowledge on grafting and immune system reactions
- Explain why graft rejection occurs upon transferring a tissue or an organ from one individual to another
- Relate the chances of success of a graft to the similarity of HLA molecules of the donor and the recipient

Entrance Abilities

This is the first lesson in the unit (immune response) and the students are not expected to have prior knowledge about it.

Material and Equipment

Prepared Worksheet

Textbook

Instructional Activities

Set Induction. At the beginning of the session, the teacher informs the students that they will start a new unit: The Immune System. She will ask the students how we get sick and then feel better. She then explains the role of the immune system in fighting “foreign” bodies that enter but not our own body cells. The role is written on the board.

Other Instructional Activities. After the introduction, the teacher will distribute a worksheet about organ transplant **(Appendix VI)**. They are required to read the information in the sheet and answer the first three questions individually in which they deduce that tissue acceptance occurs only when the donor and the recipient are the same individual or identical twins The teacher will then lead a whole classroom discussion in which the students finally define the terms “self” and “non-self” and give examples of each. Then, they solve part 4 on the worksheet in which they identify certain organs or items as self or non-self. After that, the teacher will further explain that every individual has unique markers on the surface of his body cells called “antigens” or HLA markers. They read about HLA markers in the book and answer a question in the book in which they rank cells by decreasing order of HLA molecule similarity.

Closure and Review. The students summarize the difference between self and no-self markers.

Session 2

Chapter 1: "Self" and "Non-Self"

Purpose

Students will determine the importance of organ donation and explain that it is difficult to graft an organ from one individual to another due to the different HLA-markers.

Science Content and Major Concepts

Students will determine the uniqueness of every individual's HLA-markers that helps the immune system identify self from non-self. Also, they understand that the different HLA-markers on each individual make the process of accepting an organ transplant difficult.

Instructional Objectives

Students should be able to:

- Apply their knowledge on grafting and immune system reactions
- Explain why graft rejection occurs upon transferring a tissue or an organ from one individual to another
- Relate the chances of success of a graft to the similarity of HLA molecules of the donor and the recipient

Entrance Abilities

Students should be acquainted with the meaning of grafting, organ transplant, and graft rejection.

Material and Equipment Worksheet: First hand transplant

Type of Activity: Individual and pair work

Instructional Activities

Set Induction. At the beginning of the session, the teacher reviews the concepts learned in the previous session regarding the difference between self and non-self markers. Also, students are reminded of the meaning of graft rejection and why it occurs. Then, the teacher collects students' opinions and ideas about organ transplant by asking questions such as: 'In your opinion, is there anything wrong with organ transplant?' 'Should everyone be required to be an organ donor?' 'How do you convince someone to become an organ donor?'

Instructional Activities. Students are given a worksheet (first hand transplant) to complete individually and then in pairs. The aim is to determine the importance of organ transplant and the difficulty to obtain a successful one. Students read about the first successful hand transplant and explain why it is difficult to always succeed in transplanting organs.

Assessment of Instructional Objectives

In this lesson, the students are assessed informally according to the class discussions and their answers on the worksheet.

Session 3: Identifying pathogens: Cholera

Purpose

This lesson will introduce the students to a pathogen (bacteria) that causes cholera through a real-life scenario about a pandemic disease.

Science Content and Major Concepts

The students will be introduced cholera, a disease caused by a bacterium. They learn that some pathogens are spread through water or air and could be highly contagious.

Instructional Objectives

By the end of the lesson, the students will be able to:

- Define pathogens

- Determine how pathogens are transmitted and cause disease

Entrance Abilities

Students should be familiar with self and non-self molecules in order to determine that bacteria are pathogens that the body's immune system fights because they are non-self.

Materials and Equipment

Cholera Worksheet

Video

Instructional Activities

Set induction. The students watch a video about cholera: the video shows a story about a village which was infected by cholera due to the contaminated water, how it was spread, and treated. Then, they answer related questions on the worksheet.

Other instructional activities. The students read (Cholera worksheet) about how cholera caused thousands of deaths in 2010 and determine how this disease was contained. They answer related questions about the reading and discuss them in pairs.

Closure and review.

The teacher explains that pathogens could be bacteria or others that cause disease because the body identifies them as non-self.

Assessment of Instructional Objectives

In this lesson, the students' understanding of is informally assessed through the worksheet and class discussions.

Session 4

Self and non-self (cont'd)

Kinds of Pathogens

Purpose

Students identify the different kinds of pathogens that could invade the body. They compare the nature of these pathogens.

Science Content and Major Concepts

Students will be introduced to the different kinds of pathogens that cause disease in our body because they are recognized as non-self.

Instructional Objectives:

By the end of this session, students should be able to:

4. Identify different pathogens that induce an immune response

5. Differentiate self from non-self molecules

Entrance abilities

Students should be familiar with the terms self and non-self.

Material and Equipment

Textbook

Worksheet: Clue to infection

Instructional Activities

Set Induction. The teacher recalls what they learned about self and non-self. They are reminded that in previous sessions, they learned how the body fights any foreign tissue or organ. The students are asked to provide other non-self molecules that the body fights against. Students' responses are written on the board (such as bacteria, viruses,…).

Instructional Activity. Students are introduced to the structure of viruses using an online animation. Then, they are given a worksheet about the body's defense against a virus: Hepatitis. In this worksheet, they analyze a graph that shows the variation of temperature as a function of time (weeks) when a person is infected with hepatitis. The purpose is to determine the symptoms of a person infected with hepatitis (mainly change in temperature). They answer the worksheet questions which are later discussed in the class.

Lesson Closure.

They conclude that certain clues or symptoms help us determine an infection.

Assessment and Evaluation

Informal assessment based on students' responses on the worksheet.

Session 5

Chapter 1: Cells and Organs of the Immune System

Purpose

Students identify the organs and cells of the immune system and their function. Also, they determine the natural barriers in the body that act as the first line of defense against pathogens.

Science Content and Major Concepts

Students recognize the role of white blood cells and the organs of the immune system in fighting pathogens. They also identify the structure of WBCs and the location of the organs of the immune system. Students understand the role of the body's natural barriers in preventing pathogens from entering the body.

Instructional Objectives

By the end of this lesson, students will be able to:

1. Identify the body's first line of defense against pathogens
2. Identify the cells and organs of the immune system

Entrance Abilities

Students should be familiar with the meaning of pathogens and their ability to initiate an immune response if they enter the body.

Material and Equipment

Worksheet (Blood Cells)

Instructional Activities

Set Induction. Students are given a worksheet (Blood cells) where they differentiate white blood cells from red blood cells in structure and function. Then, the teacher introduces different kinds of WBCs by showing images.

Then, students are given a worksheet about the different organs of the immune system that they read and identify these organs and their function.

Other Instructional Activities. Students are given a scenario: Imagine you are a pathogen attacking a human body. How would you enter this body? Would you face any barriers or obstacles? Students discuss this issue in pairs. Students' responses are written on the board. Then, they are presented with the body's natural barriers (which they should have predicted in their responses).

Closure and Review. The teacher reviews the main cells and organs of the immune system and their functions as well as the body's first line of defense against pathogens.

Session 6

Chapter 2: (Non-specific Immune Response)

Purpose

Students understand specific and non-specific immune responses by relating its components to a scenario from everyday life.

Science Content and Major Concepts

Students will construct the meanings of immunity and its kinds (specific and non-specific).

Instructional Objectives

By the end of this lesson, students should be able to:

1. Differentiate between specific and non-specific immune systems
2. Identify the organs and cells responsible for initiating a specific or non-specific response.

Entrance abilities

Students can response with no pre-requisite on this activity. But later in the discussion they should be familiar with the meaning of pathogens and immune system in order to relate the scenario to them.

Material and Equipment

Index cards of the scenarios

Instructional abilities

Set Induction. Students are divided in groups of four. The teacher distributes one scenario to each group. Students in each group will read the scenario and determine the action that they would take accordingly. Students discuss the scenarios in groups and provide a written response of their action describing and justifying it.

Other instructional Activities. Students are asked to imagine the house as the human body and the stranger as the pathogens that could invade it. Students discuss the means by which an immune system recognizes pathogens and relate it to the scenarios. In this session, only the first two scenarios are discussed and related to the non-specific immune response. The cells of the non-specific immune response (phagocytes) and their mode of action are presented. The specific immune response is discussed in the next session.

<u>**Scenario I:**</u> **You are home alone and it is 12:30 at night. Your parents are out of town and are not expected back until the following day. You wake up from a deep sleep when you hear a loud noise outside in the street. What are your options and which one would you be most likely to take?**

The sound is nonspecific, and could generate many different responses. The main point that this should be used to illustrate is that the immune system has **primary** and **secondary defenses** as well as **specific** and **nonspecific defenses**. This loud noise in the street could be a potential danger (such as somebody who sitting next to you in class who is visibly sick), but, at this point it probably will generate no significant response from the person in the house (your immune system).

<u>**Scenario II:**</u> **You are home alone and it is 12:30 at night. Your parents are out of town and are not expected back until the following day. You are awakened from a sound sleep when you hear a loud noise downstairs. What are your options and which one would you be most likely to take?**

The sound is once again nonspecific, however, it would most likely generate a different response from the one generated from *scenario I*. The possible responses are many and analogously could be applied to a nonspecific secondary immune response. The potential danger is in the house (body), and the person who was sleeping in the house could respond to this situation in several different ways. The immune system has **phagocytes** and **macrophages**, which are WBCs that can provide non-specific secondary defense against pathogens.

Closure and review

Students differentiate specific from non-specific immune response and relate it to a stranger in the house scenario.

Session 7

Chapter 2: (Specific Immune Response)

Purpose

Students understand specific and non-specific immune responses by relating its components to a scenario from everyday life.

Science Content and Major Concepts

Students will construct the meanings of immunity and its kinds (specific and non-specific).

Instructional Objectives

By the end of this lesson, students should be able to:

1. Differentiate between specific and non-specific immune systems
2. Identify the organs and cells responsible for initiating a specific or non-specific response.

Entrance abilities

Students can response with no pre-requisite on this activity. But later in the discussion they should be familiar with the meaning of pathogens and immune system in order to relate the scenario to them.

Material and Equipment

Index cards of the scenarios

Instructional Activities

Set Induction. The teacher recaps the non-specific immune response and relates it to the stranger in the house scenario. Students are reminded of the cells responsible to act as a result of an unidentified pathogen. Students are told that in this session they will discuss the other scenarios and relate them to the immune response.

Other instructional Activities. Students define a specific immune response by relating it to the stranger in the house scenario and are introduced to the cells of the specific immune response.

Scenario III: You are home alone and it is 12:30 at night. Your parents are out of town and are not expected back until the following day. You wake up from a sound sleep when you hear a window break downstairs. What are your options and which one would you most likely take?

This situation could generate several different responses, and these all should be explored and developed. This scenario, however, could be used to develop an understanding for an **inflammatory response** generated from a foreign object penetrating the surface of the skin. The broken window (**skin**) could cause the person sleeping to call the police (**phagocytes**) who will respond and remove the potential threat (**pathogen/bacteria**).

Scenario IV: You are home alone and it is 12:30 at night. Your parents are out of town and are not expected back until the following day. You wake from a sound sleep when you hear somebody downstairs. What are your options and which one would you take?

This situation could also generate several different responses; however, these all can be used to generate an understanding for **specific secondary defense mechanisms** in the immune system. The role of **pathogens**, **antigens**, **B lymphocytes**, **antibodies**, and **T lymphocytes** should be developed and explained.

Closure and review

Students differentiate specific from non-specific immune response and relate it to a stranger in the house scenario.

Session 8: SARS

Purpose

Students examine the transmission of a virus that had disrupted the lives of thousands of people and caused many deaths.

Entrance abilities

Students should be familiar with how viruses infect the body and cause disease.

Science Content

Students learn about a pandemic virus, how it was spread and affected the lives of many people.

Material and Equipment

Worksheet (SARS)

Instructional Objectives

Students should be able to:

- Explain how diseases are transmitted
- State the means by which we can prevent this spreading of disease.

Instructional Activities

Set Induction. Students are handed a worksheet to read and complete questions about a virus that had killed many people.

Other instructional activities. Students then suggest a plan that includes the role of the government, parents, schools (teachers and students) in case this virus spreads again and infects many people. They are also asked to compare the plan to control a virus to that suggested to control a bacteria (discussed in previous sessions).

Assessment and Evaluation

Informal assessment of student work

Session 9: Malaria

In this activity, students further examine the spread of diseases; specifically the spread of malaria.

Purpose

This exercise aims to examine the spread of malaria, how it causes infection, and how it could be stopped.

Instructional objectives

At the end of this lesson, students should be able to:

Generate an explanation for transmission of disease.

Instructional Activities

Set Induction. Distribute the activity sheet that introduces malaria (its causes, transmission, and treatment). Students work in pairs to answer the questions on the worksheet.

Other instructional activities. Students' responses are discussed in class. Students use their understanding of the activity and relate it to a real-life example in which they explain the reasons why shallow pools are drained from time to time.

Assessment and Evaluation

Informal assessment of student work on the activity.

Chapter 3: Session 10

Allergies

Purpose

Students are introduced to non-infectious diseases called allergens. The aim is to realize that some individuals' immune system overreacts to these harmless allergens and the individuals feel sick.

Science content and major concepts

Allergies are due to an immune response triggered against harmless allergens. It is a specific reaction that causes edema, asthma, sneezing, a rash… Allergens include pollen, dust mites, bee venom, certain food…

Instructional objectives

3. Explain that allergies are exaggerated reactions of the immune system to certain substances in the environment.

4. Identify the symptoms of an allergic reaction and its medications.

Entrance Abilities

Students should be familiar with infectious diseases and the body's reaction against them in order to compare them to non-infectious ones.

Material and equipment

Worksheet (Allergies)

Instructional Activities

Set Induction. The teacher gives a scenario: you and your friends go to the cinema. When you enter, you start sneezing and your throat feels scratchy. The teacher asks them to explain what is happening and why only they were affected not their friends. They should infer that 'something' affected their body only so, it does not affect everyone. Also, it could not have been a virus or bacteria because they take time. The teacher explains that these are called allergens. Allergens are defined and examples are given (pollen in the spring) and the way it affects the body is described.

Other instructional activities. The teacher distributes a worksheet (allergies) that describes a scenario where an individual is in contact with an allergen (poison Ivy) that causes a skin rash. Then, students identify the symptoms and the causes of this rash indicating whether Poison Ivy is an allergen or a pathogen. Finally, students' responses are discussed and a solution is provided to help cure this infection.

Evaluation and assessment

Students' responses on the worksheets are used to evaluate their level of arguments and level of informal reasoning.

Chapter 3: Session 11

Immunodeficiency

Purpose

The aim is to learn what immuodeficiencies are and how they are caused. Students learn some examples of immunodeficiencies and focus on AIDS.

Science content and major concepts

Students learn that immunodeficiency is a failure of the immune system to defend the body effectively against infections. Also, they are caused by the absence of malfunctioning of WBC. AIDS is caused by HIV virus which infects T4 lymphocytes and renders the immune system weak.

Instructional objectives

By the end of this lesson, students will be able to:

5. Define immunodeficiency
6. Explain how AIDS is caused by HIV virus
7. Identify the ways by which HIV virus can be transmitted from one person to another
8. Determine the social impact of AIDS on infected individuals and society

Entrance abilities

Students should be familiar with the immune system's defense against pathogens.

Material and equipment

Textbook

Worksheet (AIDS)

Instructional activities

The teacher asks what might happen if we did not have an immune system. Then, she explains that some babies are born without WBCs. Students infer that they should be placed in sterile conditions to prevent their contamination with pathogens. The teacher explains that this is an example of innate immunodeficiency and that an acquired immunodeficiency also exists which is AIDS.

Students are asked to answer questions about a graph showing the evolution of the amount of HIV and T4 Lymphocytes during the three phases of AIDS. What happens to T4 lymphocytes when the person is infected with HIV virus? Show that the amount of HIV virus depends on the amount of T4Lymphocytes? How much time can a person infected with HIV virus live?

Students also read about AIDS in their textbook and infer the importance of HIV test, the cause of appearance of opportunistic diseases, and how an HIV virus is transmitted from one individual to another.

Chapter 3: Session 12

Vaccination and Serotherapy

Purpose

Students learn what vaccination is and why it is important. Also, they learn the difference between vaccination and serotherapy.

Science content and major concepts

Vaccination is a preventive method that is acquired and specific in fighting a virus. It is based on the principle of immune memory and can induce an immune response by inoculating a weakened pathogen in the body. Serotherapy is a curative method that is immediate but not lasting. It consists of transferring a large amount of antibodies specific to a microbe taken from a serum from another individual who has been in contact with the antigen and developed immune cells against it.

Instructional objectives

5. Justify the importance of vaccination as a preventive method that induces an immune response by inoculating a weakened pathogenic antigen

6. Compare vaccination and serotherapy.

Entrance abilities

Students should be familiar with the immune response against pathogens including the specific immune responses in order to understand that vaccines work by initiating an immune response against a weakened pathogen.

Material and Equipment

Textbook

Worksheets (Testing a vaccine) and (Edward Jenner)

Instructional Activities

Set Induction. Students (in pairs) read about vaccination in the worksheet (testing a vaccine) and deduce the function and importance of vaccination. (Appendix VI). Then, they analyze two graphs and deduce which vaccination (graph 1 or graph 2) is more effective. The purpose is for students to relate the effectiveness of a vaccine to the number of white blood cells produced in an immune response.

Other instructional activities. They read in the textbook about vaccination and how it works. They answer the questions in the book.

Moreover, students read about the discovery of vaccination by Edward Jenner (Appendix VI). The purpose of this activity is not only to understand how vaccination works and why it is important but also to realize the steps of a scientific method that begins with observations and asking questions to posing a theory and testing it.

Assessment and evaluation

Informal assessment of students' work on the activities.

Session 13: Specific cell-mediated immune response

Purpose

Students determine the role of T-lymphocytes in a specific immune response.

Entrance abilities

Students should be familiar with pathogens and specific immune response

Science Content

Students learn that a T-lymphocyte is activated upon contact with pathogen.

Material and Equipment

Worksheet (Specific Immune Response)

Instructional Objectives

Students should be able to:

- Explain how T cells are activated
- Determine the characteristics and role of an activated T cell.

Instructional Activities

Set Induction. Students are handed a worksheet to read and complete questions about through a cartoon diagram.

Other instructional activities. Students then suggest that a T cell can be more severe or effective in killing sometimes.

Assessment and Evaluation: Informal assessment of student work.

Appendix VI

Control Group Worksheets

Session 1: "Self" and "Non-Self"

When kidney transplants were beginning in the 1950s, "tissue rejection" often occurred and death was quick when the kidney was transferred from one individual to another. This type of graft (organ transfer) is called allograft. Then, by chance, a twin who was suffering kidney failure received a kidney from his identical twin (isograft), who had two healthy kidneys. Tissue rejection did not occur and both individuals went on to live for many more years.

Answer individually the following questions:

7. What is tissue rejection? How does the body reject an organ?

8. A key concept in tissue transplants is the notion of "self" vs. "non-self." Using the information above, what is the difference between "self" and "non-self" items?

9. Would the body reject a skin transplant that occurs in the same organism? (autograft)

10. Match the following:

Isograft •	• an individual receives a graft of his own skin
Allograft •	• an individual receives a graft from his twin
Autograft •	• an individual receives a graft from another individual

11. Using the concept of “self and non-self,” what is the function of the immune system?

12. Using your knowledge of the immune system identify the following items as “self” or “non self”

Organ/item	Self or Non-Self	Organ/item	Self or Non-Self
Your Heart		Artificial knee made of titanium.	
Your Brain		Bacteria found in the large intestine	
A transplanted heart from a distant relative		A transplanted kidney from your identical twin	
Transplanted heart valve that originated in a pig.			

Worksheet: First Hand Transplant (Session 2)

Hand transplant: A New Hope

Many accident victims in the world lose a limb and suffer all their life form this tragedy. Today, for these people, a new hope has emerged since the first hand allograft has been performed.

Doctors have known, for many years now, how to tie up again an accidentally amputated limb, such as a finger or a hand. They can also transplant a heart, a kidney, or a liver from one individual to another. So, why can't they transplant a hand?

The reason is that the transplantation of a limb is much more difficult than that of an organ. The skin is the natural barrier of the body and is extremely rich with white blood cells. It is therefore much more aggressive than any organ upon the introduction of foreign elements, including allografts.

To avoid rejection, the immune system is "put to sleep" with the help of certain drugs. This, of course, is very risky: when the body defenses are weakened the patient is prone to all sorts of infections. But doctors learns to make the immune system not too strong (risk of rejection), nor too weak (risk of infections). This has made possible many hand transplants.

Answer the following:

1. Explain the reasons that make it difficult to transplant a limb?
2. How were scientists able to make a limb transplant possible?
3. Indicate the advantages of such a transplant on individuals and the society?

Session 3: Worksheet: Cholera

Watch the video and answer the following:

1. What was the problem discussed in the video?

____

____

2. How was it caused?

____

____

3. How was it solved?

____

____

On October 19, 2010, ten months after the January 2010 earthquake in Haiti many people in Haiti started getting sick: watery diarrhea and less water in their body. Later, it was known that this sickness is Cholera. Cholera s an illness **caused by an infection** of the intestine with the bacterium *Vibrio cholerae*.

- **An estimated 3-5 million cases and over 100,000 deaths** occur each year around the world.
- **The cholera bacterium is usually found in water or food** sources that came in touch with feces (poop) from a person infected
- with cholera.

- **Cholera is most likely to be found and spread in places with not enough clean water and poor** hygiene.
- **Since October 2010, over 470,000 Haitians have been sickened by cholera** and nearly 7,000 have died.
- **The Haitian government** is trying to help make the number of cholera cases less and improve water cleanliness in the country.
- We now know that people can avoid cholera infection by making sure their water supplies are clean. Unfortunately, in poor countries where only 35% of the population has access to clean water, cholera epidemics continue.

1. Is Cholera caused by a bacteria or a virus? What is it called?

___

2. How does a person with Cholera feel?

___

3. Where is this disease usually found?

___

4. Do you think it is contagious (Can someone with Cholera give the disease to someone else)?

___

5. Suggest a plan to help control the spread of Cholera and explain the role of the government and citizens (at work, schools, homes) in this process.

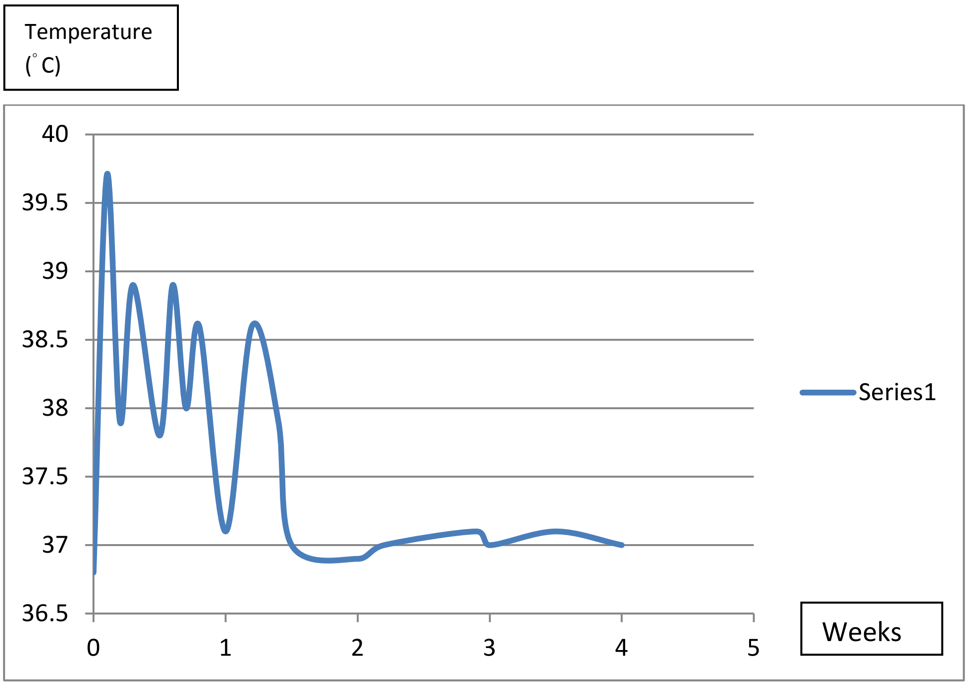
___

Session 4

Clue to infection

Hepatitis is a disease caused by a virus that infects the liver. The graph below shows the fever pattern in a person with hepatitis. Symptoms last a minimum of several weeks. (Remember that normal body temperature is 37°C)

Fever and infectious Hepatitis



1. What was the person's body temperature before the first fever spike during the first week?

2. During the first week of infection, what was the person's highest temperature?

3. During the first week of infection, what was the greatest change in the person's body temperature?

4. Describe how this person's temperature changed during the course of the disease.

5. If you were a doctor and suspected your patient had infectious hepatitis, would you rule out the disease if the patient had a near-normal temperature? Explain.

Session 5

Blood Cells

Read the following story about blood cells. Then, follow the instructions.

Red blood cells (RBCs) look like tiny flattened Basketballs. Their red color comes from a substance in cells called hemoglobin. Hemoglobin picks up oxygen in the lungs and carries it to all cells of the body. Sometimes RBCs move alone in the blood. At other times they travel in rows that look like stacks of coins. RBCs are made inside bones. Unlike most cells, a RBC has no nucleus. One milliliter of blood has between 4 million and 6 million RBCs. If all RBCs from an adults' body are placed side by side, they would go around the Earth four times.

White blood cells (WBCs) look different from RBCs and do different work; they surround and destroy invading bacteria. WBCs are large and contain nuclei. They have irregular shapes. Some are made in the same bones as the RBCs. Others are made in special glands. Some WBCs live only a few days. In one milliliter of blood, there are between 5,000 and 10,000 WBCs. When bacteria enter a person's body, the number increases.

1. Complete the following table by comparing RBCs and WBCs:

Characteristic	RBCs	WBCs
Size		
Number		
nucleus		
Function		
Shape		

2. Based on the description of RBCs and WBCs, predict the shape of each and draw it below.

RBC	WBC

3. Why does the number of WBCs increase when bacteria enter the body?

____

____

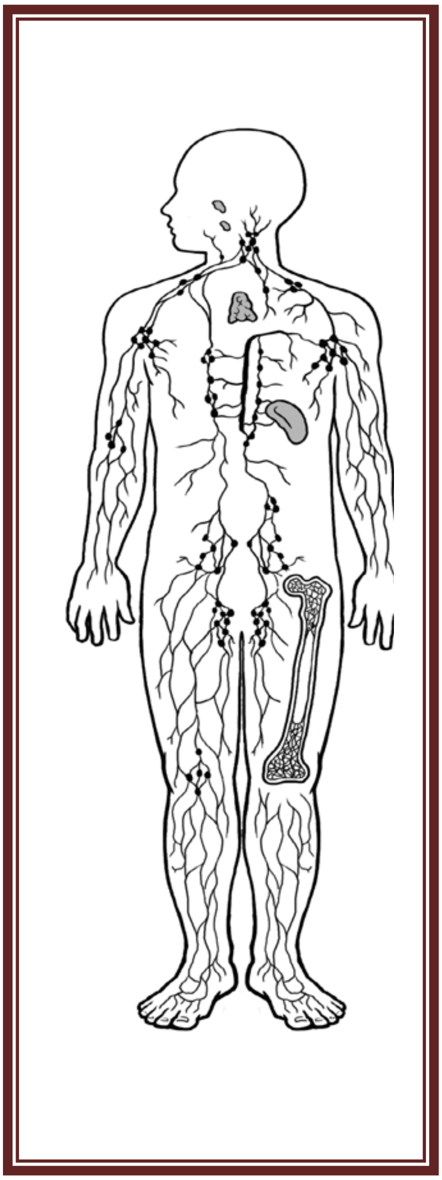
____

____

Session 5: Organs of the immune system

The immune system is a network of cells, tissues and organs that defend the body against harmful

Toxins and microorganisms.



1. red bone marrow: spongy tissue of the bone that produces cells of the immune system including lymphocytes and macrophages. Lymphocytes recognize antigens (harmful foreign bodies), and macrophages engulf and destroy antigens.

2. lymphatic system: network of lymph nodes and lymph vessels that store and transport disease fighting immune cells.

3. thymus: organ of the immune system that is responsible for the maturation of a special kind of white blood cell called T-lymphocytes or T-cells. T-cells detect and destroy infected cells in the body.

4. spleen: lymphoid organ that contains disease fighting WBC and filters the blood by destroying old blood cells and removing small particles.

5. pharyngeal tonsils (adenoids): lymphoid tissue located at the back of the nasal cavity thought to be the first line of defense against inhaled pathogens (harmful microorganisms) .

Session 6

Index Cards

Scenario 1

You are home alone and it is 12:30 at night. Your parents are out of town and are not expected back until the following day. You wake up from a deep sleep when you hear a loud noise outside in the street. What are your options and which one would you be most likely to take?

Scenario II

You are home alone and it is 12:30 at night. Your parents are out of town and are not expected back until the following day. You are awakened from a sound sleep when you hear a loud noise downstairs. What are your options and which one would you be most likely to take?

Scenario III

You are home alone and it is 12:30 at night. Your parents are out of town and are not expected back until the following day. You wake up from a sound sleep when you hear a window break downstairs.
What are your options and which one would you most likely take?

Scenario IV

You are home alone and it is 12:30 at night. Your parents are out of town and are not expected back until the following day. You wake from a sound sleep when you hear somebody downstairs. What are your options and which one would you take?

Session 7: SARS

Ten years ago, the world was in panic over an outbreak of a mysterious illness - SARS. The virus killed hundreds - and infected thousands more - but its impact would have been far more devastating had it not been for the bravery of a handful of doctors and nurses.

Within days, nearly 40 people at the hospital had fallen ill, including a number of the staff.

It was highly contagious, and often deadly. More than 8,000 people around the world were infected, and more than 770 died. People with this disease feel as if they have a common flu: respiratory problems, fever, sneezing, and coughing.

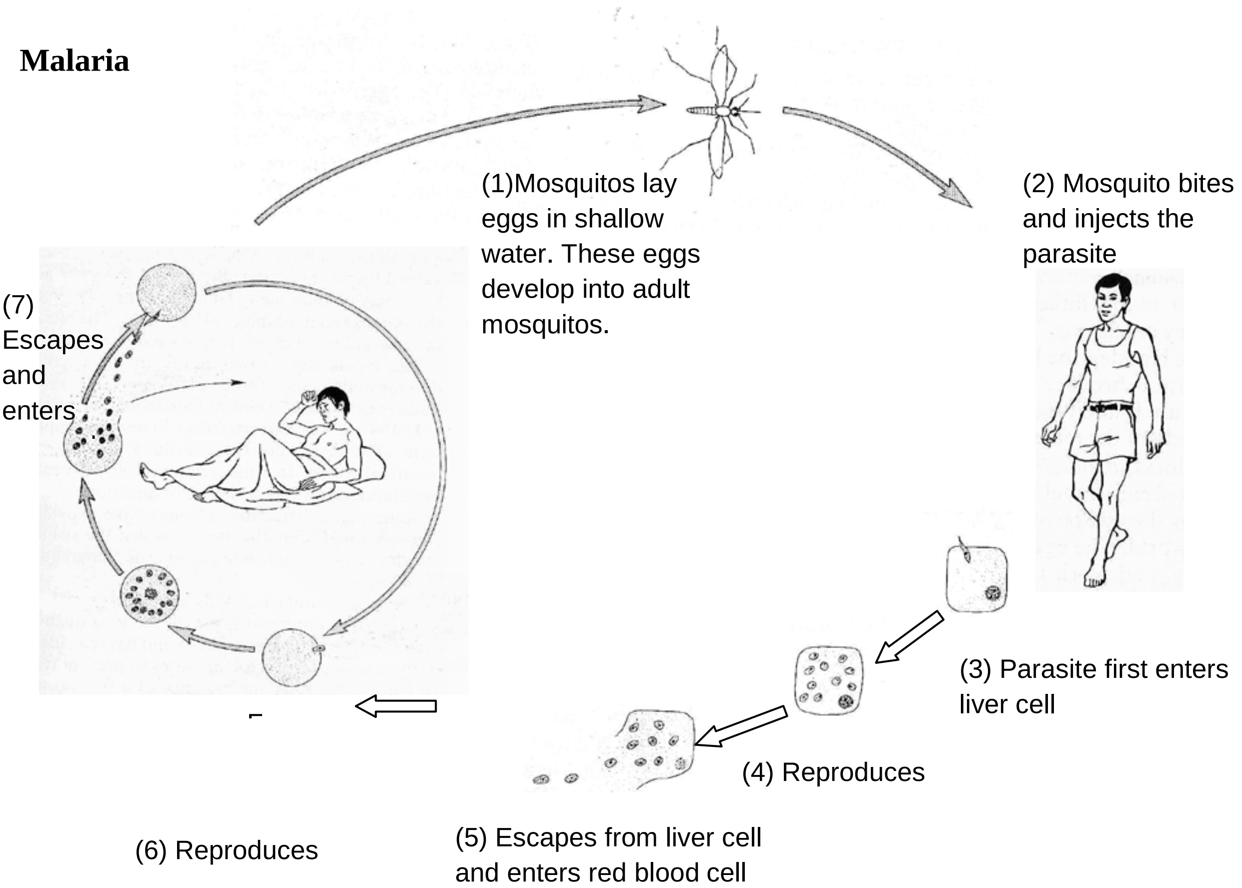
SARS is caused by a virus called (SARS-CoV). It was first identified in April 2003. The family of this virus has been found in many different animal species including birds and mammals. SARS-CoV is thought to have passed from animals to humans through close contact, butchering or eating undercooked meat in China.

1. Is SARS caused by a virus or bacteria?
2. How does a person infected with SARS feel?
3. Why did people panic because of this disease?
4. Suggest a plan in order to control the spread of this virus if it spreads again indicating the role of the government, schools, hospitals, and families. Compare this plan to that suggested during the cholera infection.

Session 8: Stopping Malaria

Malaria is an infectious disease caused by the protest Plasmodium. This pathogen is transmitted from one person too another by the bite of the female mosquito. The disease infects more than 150 million people a year and kills between 1.5 and 3 million people. Although malaria is treatable, it occurs in parts of the world where effective treatments are largely unavailable. For this reason, the battle against the spread of malaria has focused on prevention. The diagram below provides information about the spread of malaria and the life cycle of the female mosquito.

Malaria



Transmission and life cycle of Plasmodium

1. Diseases can be spread in many ways. In which of these ways is malaria spread?
2. Where does the female mosquito lay eggs?
3. How does a person get malaria?
4. Sometimes shallow pools in an area are drained to help prevent malaria. Why is this strategy effective?
5. If mosquitoes could be prevented from biting humans, the disease would die out. What are other ways to prevent the spread of malaria?

Session 9 (Allergies)

I- Read the text then answer the questions:

Paul must take great care to avoid *poison ivy* all his life. Poison Ivy is a plant that can cause a skin rash when they touch your skin. The rash is red, uncomfortable, and itchy.

The oil in this plant is the allergen that causes this rash. The rash usually appears 8 to 48 hours after Paul's contact with the plant. The rash will continue to develop in new areas over several days. The rash is not contagious. He cannot catch or spread a rash after it appears, even if you touch someone else.

1. What are the symptoms of Poison Ivy allergy?

____

____

2. Why does the rash appear? Why does it need several hours?

____

____

3. Is Poison ivy sensitivity caused by a pathogen? Why or Why not?

____

____

4. Name a solution to help Paul face his Poison Ivy sensitivity?

____

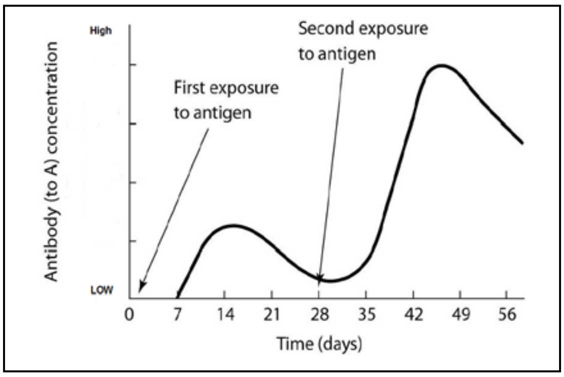
____

Session 10

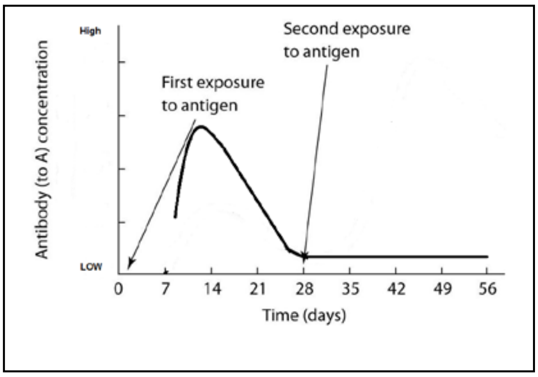
Testing a Vaccine

Vaccines have been developed to protect people against many infectious diseases. Years ago, the only way to discover whether a vaccine worked against a certain disease was to expose a group of people who were vaccinated to a pathogen that caused the disease. This was dangerous because if the vaccine didn't work, the people or animals might get the disease.

Today, many vaccines are made using only part of the pathogen. When injected, this part, called the antigen, stimulates the body to form antibodies. Using lab techniques, scientists can measure the concentration of antibodies. Later, the antigen can be injected again and the concentration of antibodies measured once more. When a vaccine is made, scientists first make several vaccinations of it. Then, they test the variations to determine which one is the best. The graphs below show possible results of a test of two variations of a vaccine.



Person A



Person B

1. In both cases, what happened to the person's antibody level after the vaccine was first injected?
2. Which person had most likely already been exposed to the pathogen? Explain.
3. Which version of the vaccine seems to be more effective? Explain.

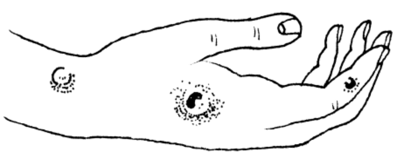
Session 11 (Vaccination)

Edward Jenner

Smallpox was a very serious disease which caused huge spots filled with pus to appear all over the body. In the 18th century nearly everyone caught the disease and 25% of victims died. Those who lived had terrible scars left by the spots, especially on their faces.

As a young man, Edward Jenner (1749–1823) was given smallpox on purpose. The idea was that by giving it to people when they were young, fit and healthy they would survive better than if they caught it when they were older. This was a very dangerous thing to do and many people died. Jenner survived but later in his life, he set about trying to stop this practice.

Jenner noticed that girls who looked after cows rarely caught smallpox. He came up with a theory that if you gave people a disease caught from cows, called cowpox, they would be protected from smallpox. Many people thought he was mad and some even thought that anyone who was given cowpox would turn into a cow.



Cowpox spots on the hand of Sarah Nelmes.

He tested his theory in 1796, when a milk maid called Sarah Nelmes caught cowpox. He asked an eight-year-old boy, called James Phipps, to come to his house, where he squeezed pus from a cowpox spot on Sarah’s hand into a cut on James’ arm. The boy caught cowpox. Eight weeks after this, he squeezed pus from a smallpox spot into another cut on

James' arm. The boy did not get smallpox. This was the first vaccine (although Jenner knew nothing of microbes). The word 'vaccine' comes from the Latin for cow – *vacca*. Thanks to immunization, smallpox no longer exists in the world (although some of the viruses are kept in laboratories for research).

1. Indicate the reason behind giving Jenner smallpox as a young man?
2. Describe the symptoms that Jenner might have suffered.
3. What was Jenner's theory?
4. What observations did he make to come up with this theory?
5. What is a vaccine?
6. Explain why Jenner had to carry out an experiment to test his idea?
7. What did Jenner have to take into account when choosing a suitable person for his experiment?
8. Do you think Jenner could be sure that his vaccine had worked? Explain your answer.
9. How could Jenner have changed his experiment to make his results more reliable?

Activity 12 Cartoon activity: Specific immune response

T-cells are white blood cells that help the immune system fight invading microorganisms. The following figures show 2 types of T-cells found in the body.

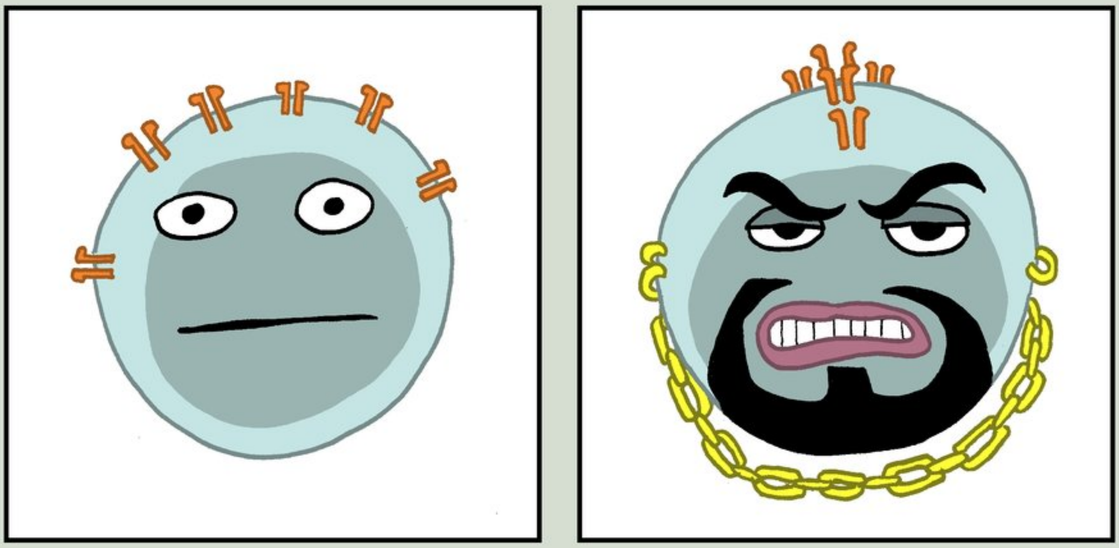


Figure 1. The T cell. *mounts an immune response against non-self antigens.*

Figure 2. Mr T cell. *pitties the fool who expresses a non-self antigen.*

1. Compare the T-cell to Mr. T cell.
2. Which T-cell is more efficient in fighting germs? Why?
3. What do you think is the job of the less efficient T-cell?

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