ARGUMENTATION IN THE SCIENCE CLASSROOM.

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ABSTRACT

Students need to know how new knowledge is generated and validated by scientists as well as the important theories, laws, and concepts of the different disciplines in order to understand science as a way of knowing. Students must also develop the abilities needed to construct and support scientific claims through argumentation and to evaluate or challenge the claims or arguments developed by others (Douglas and Victor, 2007).

One of the challenges of educational research is the design of instructional units and innovative strategies and their evaluation through case studies (Jiménez and Bustamante Díaz, 2003). In this perspective, the objectives of teaching science, such as the learning of concepts and models or the development of attitudes and skills, are part of the adoption of a scientific culture, transforming science class into a community where knowledge is used and produced.

This research seeks to contribute to the practice of communicative skills of written argumentation in cellular processes through three main functions: a communicative function that serves as a tool to teach, assess and make knowledge public; a social function that acts as a mediator of interpersonal relations, agreements and collaborative projects; and an epistemic function that serves as an intellectual tool for learning. It follows a teaching strategy where the arguments of students are analyzed according to Toulmin's theory (1972), before and after an intervention.

INTRODUCTION

Science should be seen as a social construction that results from inquiry processes, like experimentation, communication and public scrutiny that lead to discussions where controversies must be solved to reach consensus. In most schools, science is commonly portrayed from a "positivist perspective" as a subject in which there are "right or wrong" answers and where data lead uncontroversially to agreed conclusions (Erduran and Jiménez 2007). As a consequence, science is seen as a finished subject that must be learned and memorized as literally as possible.

Students and teachers should be aware that scientific ideas do not necessarily resemble common sense nor are always evident, but are rather the products of one of the most important cognitive and social activities of humanity. Thus, the cognitive-linguistic ability to argue, that links phenomena, models, evidence and explanations, must play a central role in sciences classes. It is necessary to design a context in which students face resolution of genuine problems, in tasks that are relevant to their lives. Likewise, it is necessary to understand how to build the explanations in the classroom, and explore the processes through which meaning is constructed in science classes.

This proposal seeks to contribute to an educational transformation that is seen as a key process to respond to the new needs of a knowledge society, and to stop the processes of social disintegration through the promotion of communicative skills that enable students a greater and better participation in society. At present, society needs critical people, with training based on responsibility and ethical values. All technological and scientific advances should be discussed so that they do not represent a risk for society (Arana, 2005).

Scientists use arguments to establish theories, models and explanations of the natural world. Contemporary philosophy of science perspectives emphasize that science is not only the accumulation of evidence of the way the world works. Science includes the construction of theories explaining the way in which the world should be. Thus, science progresses from disputes, conflicts and arguments (Erduran and Jiménez, 2007).

The use of online learning environments, as Knowledge Forum, allows students to create, modify and share ideas and arguments with one another. It engages students in proposing, supporting, evaluating and refining their ideas. This type of collaboration extends beyond simply sharing or combining ideas; it requires students to engage in a process of dialogical argumentation (Douglas and Victor, 2007).

METHOD

The methodology used in this research is qualitative. It is based on case studies. This method constitutes a design particularly suitable for the analysis of situations with certain intensity, in a short period of time. It is characterized by paying special attention to issues that can be specifically recognized through cases. It favors qualitative content analysis because it tries to identify the way in which students increase their argumentative skills, by analyzing their argumentative texts before and after an intervention. The analysis is carried out from the written production done by students.

This work is also based on pedagogical principles proposed by Marlene Scardamalia (2002), which include the statement of pertinent questions that focus students in a topic of their interest. In this case, the students' focus was if they agreed or disagreed with the culture of in vitro cells. Some other principles followed in this work were the importance of using different sources of information to allow students to support their claims based on theoretical evidence (constructive use of authoritative sources); the Improvement of ideas, to deepen the themes and correct mistakes achieving common goals and solving problems and concerns as a group. The group benefits from the ideas of all members, prompting students to improve the quality of the contributions. All contributions from students were discussed as a group; this helped them achieve and consolidate their knowledge. Students added new ideas and discarded those that did not fill their expectations. With the use of the promising ideas tool from the Knowledge Forum platform, students chose data that helped them support their claims and discarded those that did not fill their expectations.

The model used for evaluating the students' texts was the one proposed by Stephen Toulmin (1972). He proposed the following criteria for analyzing argumentative texts:

a. Claim: A claim is a statement that must be ratified and is intended to be accepted by another person. To make a claim, it should be demonstrated by data. The data are the basis of real persuasion which consists of facts. It is the 'truth' on which the claim is based. These data may also include proof of expertise and the basic premises on which the rest of the argument is based.
b. Support: are the data that give additional support to the argument in response to different questions.
c. Qualifier (or modal qualifier): indicates the force that data must have to support the claim. They include words like 'more', 'usually', 'always' or 'often'. In this way, the arguments can range between strong statements, fairly discrete or quite uncertain.

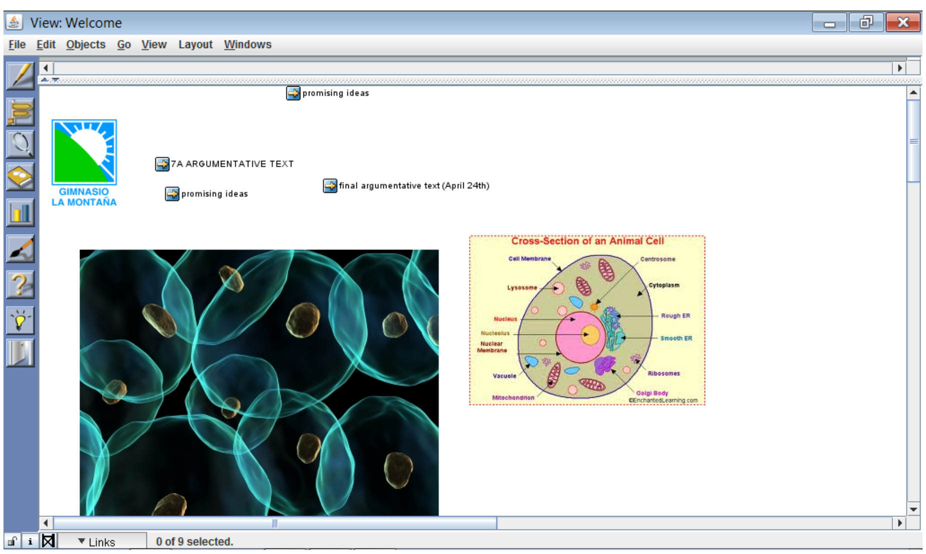
The following table was designed to analyze the students' texts:

Criteria	**DESCRIPTION**			
Grade	5	4	3	2
Claim	Easily identifiable and clearly connected with the title.	It can be a bit confusing. The title does not have a clear connection with the thesis or is not so interesting.	It contains many vague terms. It is necessary to structure the document in a better way. The thesis and the title are not clearly connected with the text.	Difficult to identify; it is not connected clearly with the title.
Support	Evident, understandable, adapted for the thesis. Excellent transitions from point to point. The paragraphs support the topic solidly.	It is clear and appropriate, though occasionally it can stroll. It can have some weak paragraphs that support the topic.	Little clear. Some paragraphs do not relate to the topic.	It is not clear, because the thesis is weak or non-existent.
Use of evidence	It uses primary sources of information to reinforce every point with an example at least. The examples support the mini-thesis. It demonstrates a deep	It uses examples in most of the text. Often, the examples can be inadequate. It shows a solid comprehension of the ideas of the topic and evaluates it	Examples are used for supporting some points. Often, evidence is absent or is used in an inadequate form. It demonstrates a general understanding of the	It uses little evidence or the examples are weak. Evidence seems not to support any

	understanding of the ideas of the topic and critically evaluates and answers these ideas in an analytical and persuasive way.	critically, showing ideas in an analytical and persuasive way.	ideas of the assigned topic and only occasionally evaluates critically these ideas in an analytical and persuasive way.	declaration. It demonstrates little understanding of ideas in the topic.
Structure and use of qualifiers	The structure possesses an excellent grammar. It does not have spelling mistakes. It fulfills the requirements of the format.	Grammatical structure is good; style, punctuation and quotes are often used correctly. It has some (minor) spelling mistakes. It fulfills the requirements of the format.	It has phrase structure problems; it has some punctuation and spelling mistakes. It fulfills the requirements of the format.	It shows important grammatical and spelling mistakes. It does not adjust to the requirements of the format.

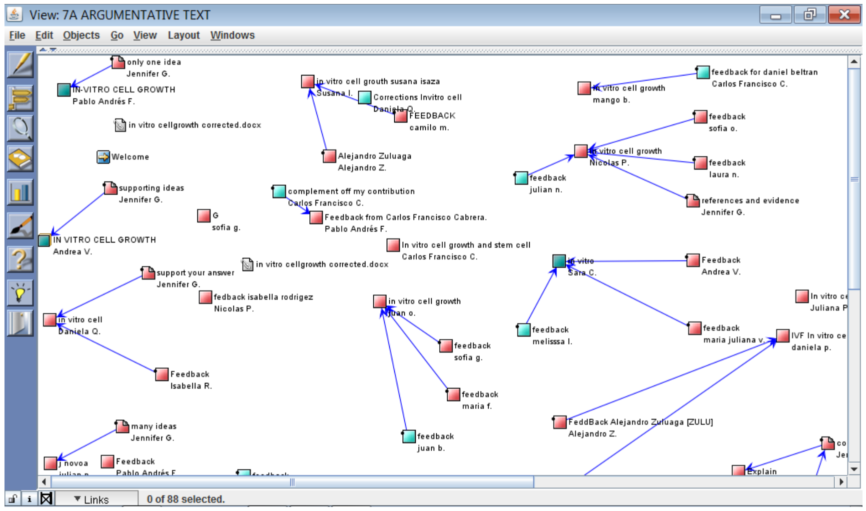
The study was done with 14 seventh grade students, 6 boys and 8 girls. It was developed in Biology class during four months. The sequence of activities was divided by steps as follows:

Step 1: Students chose the topic that they wanted to discuss. The topic had to be related to cellular processes to fulfill the year objectives. They got an introductory class to show them how to use the Knowledge Forum platform, to register and to decorate the home page.

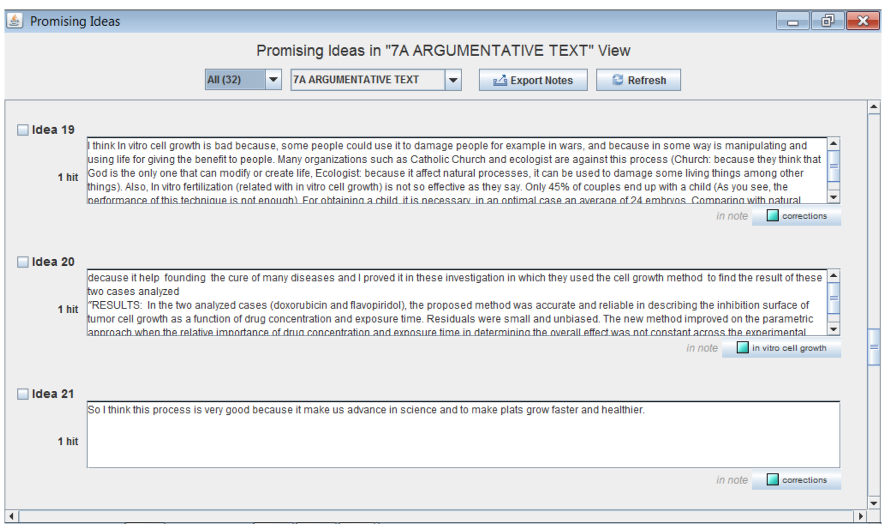


Step 2: Without any previous explanation, the students were asked to write an argumentative text about the culture of cells in vitro. Once the students were familiar with the goal of the activity, they were given time to develop their tentative arguments.

Step 3: The teacher explained the parts of an argumentative text, the purpose of writing this type of documents and the way the text should be organized. Then, students were asked to read one of their classmates' texts and give them feedback to help them correct the text. Students corrected their texts taking into account the contributions made by their peers.



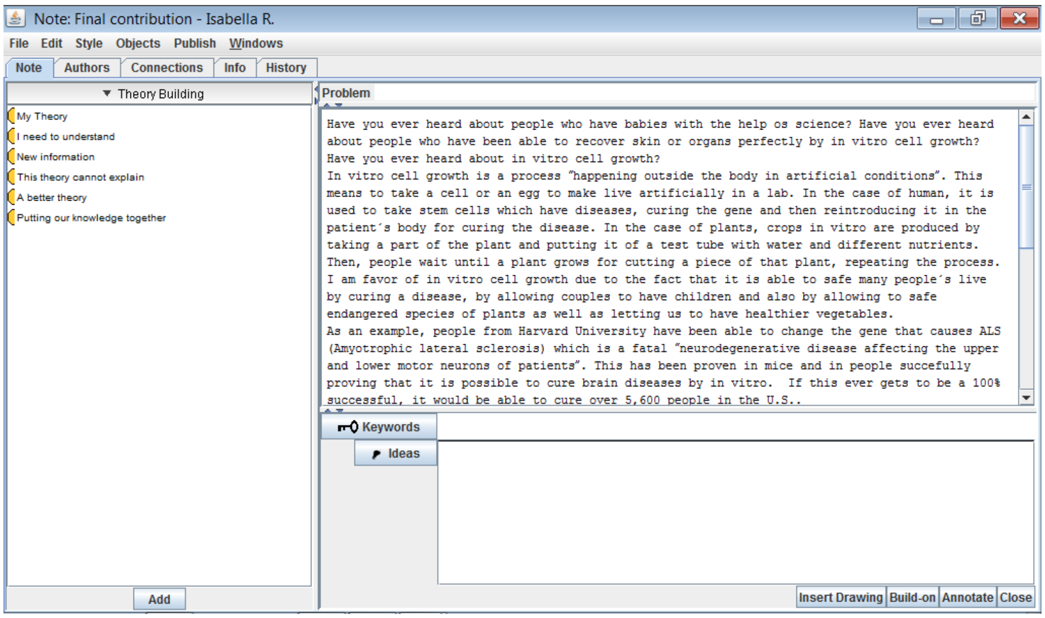
Step 4: The teacher explained how to use the promising ideas tool and told students to choose the evidence that supported or rejected the use of in vitro cell growth. After selecting the promising ideas, students looked for more data that helped them support their evidence and included them as contributions.



Step 5: Students watched a National Geographic channel documentary about new advances in making in vitro organs. The purpose of the video was to give students more evidence about the uses of these methodologies.

Step 6: Class discussion: students were divided into two groups. Three students were chosen as judges of the discussion. One of the groups was supposed to be against in vitro cell culture and the other one was in favor. The objective of the discussion was to persuade the judges of their claim. At this point, they were supposed to be directed to evaluate their claim in light of all the evidence, rationales, and other claims that they had seen. The teacher directed the students' attention to the various aspects needed in a sufficient claim to evaluate how well the evidence and other reasons are connected to the claim. The students were prompted to fully evaluate the persuasive nature of their own argument as well as those of the other groups.

Step 7: Students wrote their final argumentative text supporting or rejecting the use of in vitro cell cultures.



RESULTS

Each of the students' text was analyzed using Toulmin's criteria. The following table was designed to evaluate student's production.

Points	Level of argumentation
22-25	**Excellent**
19-21	**Good**
16-18	**Average**
13-15	**Low**
10-12	**Very low**

The first text written by students was written in Knowledge Forum and showed the following results:

STUDENTS / CRITERION	CLAIM	SUPPORT	EVIDENCE	ANÁLYSIS	STRUCTURE
001	2	3	3	2	2
002	2	2	2	2	2
003	2	2	2	2	2
004	2	2	2	3	2
005	2	2	2	2	2
006	2	2	2	2	2
007	2	2	2	2	2
008	3	2	2	2	2
009	2	3	2	2	3
010	2	2	2	2	2
011	4	3	3	2	3
012	4	3	3	2	3
013	4	3	3	2	3
014	2	2	2	2	2

The level of argumentation that students had at the beginning of the study is shown in the following table:

No	Name / CRITERIA	C	S	E	A	S	TOTAL POINTS	ARGUMENTATION LEVEL
1	**001**	2	3	3	2	2	12	Very low
2	002	2	2	2	2	2	10	Very low
3	003	2	2	2	2	2	10	Very low
4	004	2	2	2	3	2	11	Very low
5	005	2	2	2	2	2	10	Very low
6	006	2	2	2	2	2	10	Very low
7	007	2	2	2	2	2	10	Very low
8	008	3	2	2	2	2	11	Very low
9	009	2	3	2	2	3	12	Very low
10	010	2	2	2	2	2	10	Very low
11	011	4	3	3	2	3	15	Low
12	012	4	3	3	2	3	15	Low
13	013	4	3	3	2	3	15	Low
14	014	2	2	2	2	2	10	Very low

The following table shows the results of the final argumentative texts done by the same group of students:

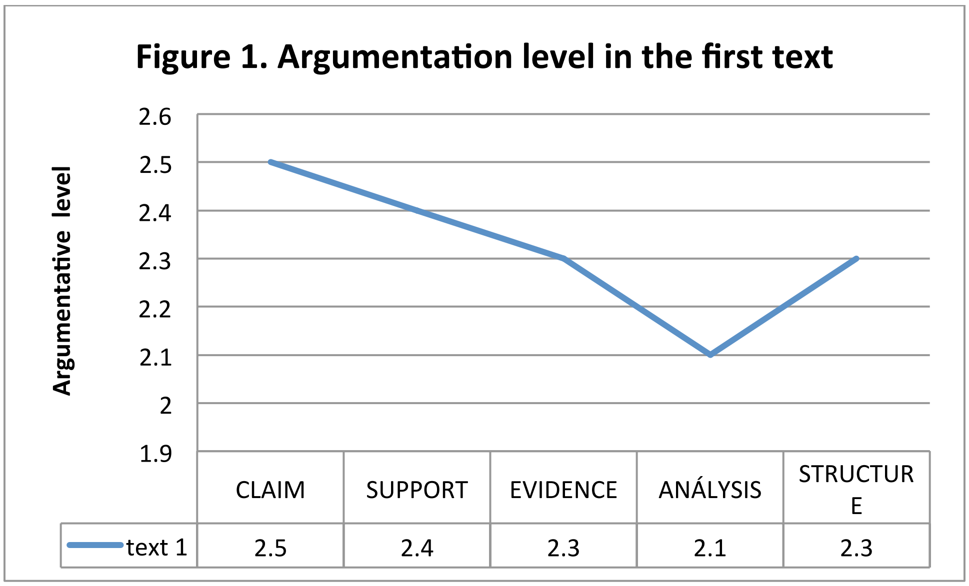
CRITERIA / NAME	CLAIM	SUPPORT	EVIDENCES	ANALYSIS	STRUCTURE
001	5	4	5	5	3
002	2	2	2	2	2
003	5	2	4	5	4
004	3	4	4	4	3
005	3	3	3	3	3
006	5	4	5	4	3
007	5	5	5	5	4
008	5	5	4	5	4
009	5	5	5	5	5
010	5	5	5	5	4
011	5	5	5	5	5
012	5	4	4	4	4
013	5	5	5	5	5
014	5	5	3	3	4

The level of argumentation that students had at the beginning of the study is shown in the following table:

No	CRITERIA / Name	C	S	E	A	S	TOTAL POINTS	ARGUMENTATION LEVEL
1	**001**	5	4	5	5	3	22	Excellent
2	**002**	2	2	2	2	2	10	Very low
3	**003**	5	2	4	5	4	20	Good
4	**004**	3	4	4	4	3	18	Average
5	**005**	3	3	3	3	3	15	Low
6	**006**	5	4	5	4	3	21	Good
7	**007**	5	5	5	5	4	24	Excellent
8	**008**	5	5	4	5	4	23	Excellent
9	**009**	5	5	5	5	5	25	Excellent
10	**010**	5	5	5	5	4	24	Excellent
11	**011**	5	5	5	5	5	25	Excellent
12	**012**	5	4	4	4	4	21	Good
13	**013**	5	5	5	5	5	25	Excellent
14	**014**	5	5	3	3	4	20	Good

DISCUSSION

The results provide a comparative measure of the argumentation occurring before and after applying a teaching strategy. At the beginning of the course, students evidenced a very low level of argumentative skills. As shown in figure 1, the claim was scored with an average of 2.5. The organization of the text to support the claim was scored with an average of 2.4; the use of evidences 2.3; the analysis 2.1 and the structure of their text 2.3.



After applying the strategy, most of the students increased their argumentative skills. They used theoretical evidences to support their claim. Their texts were organized and followed a sequence. Students showed a great improvement in stating a thesis or claim. The average level was 4.5 from a maximum of 5 points. When comparing the initial text with the final one, their first text didn't show a position against or in favor of the culture of in vitro cell growth. In their final text, all of the students showed a clear position and used them as their initial premise.

As shown in figure 2, students also improved the way in which they used evidence to support their claims. In the first text, most of them used empirical evidence; they didn't have enough references and they didn't show knowledge of the concepts involved in the topic. In their last text, they used different sources of information and used them as theoretical evidence. The texts demonstrated knowledge of the concepts needed to explain, describe and support their point of view. Students did not improve so much in the use of English; they made some spelling and grammar mistakes that affected the comprehensibility of their productions. They improved in the use of scientific terms, but they still need to work in their writing skill, which is expected from a group of English-as-a-foreign-language learners. In their first text, they were scored with an average 2.3 and in the last one, 3.8.

During the class discussion, students used their and their peers' contributions to persuade the class judges. They read and selected those contributions that allowed them to support and to refute the claims. They demonstrated knowledge of the concepts by using scientific vocabulary and complex explanations to explain their points of view. This exercise allowed them to understand the importance of the use of theoretical evidence when arguing.

The Knowledge Forum platform allowed students to read their classmates contributions. It helped them use other people's arguments to build their own. They had the opportunity to evaluate the contributions done by their classmates and to give recommendations about the way an argumentative text should be written. This opportunity helped them understand the mechanics and parts of an argument. In each of the contributions, there is a clear improvement of the way they write. This platform also helped them select those ideas that needed to be studied in depth. It was easy for the teacher to follow students' development throughout the process and to identify engagement of students had towards the activity.

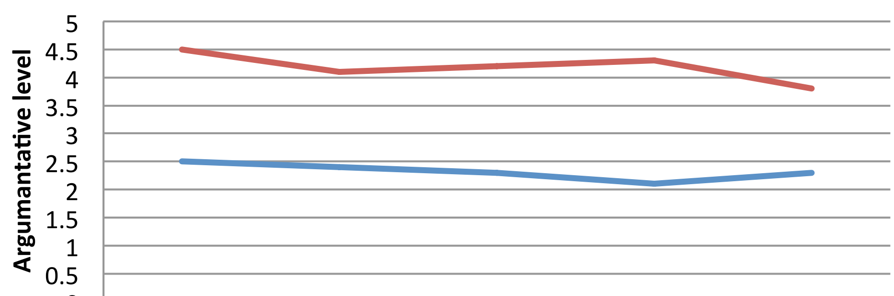


Figure 2. Argumentation level in the first and last texts

	CLAIM	SUPPORT	EVIDENCE	ANÁLYSIS	STRUCTURE
text 1	2.5	2.4	2.3	2.1	2.3
text 2	4.5	4.1	4.2	4.3	3.8

CONCLUSION

The use of argumentative models in science education, allow students to improve their cognitive and linguistic skills. It focuses on important learning outcomes that are often neglected in the science classroom. Students' engagement in scientific argumentation helped them develop a better understanding of the role of argument and evidence in science. It also helped them improve their communication and writing skills, and strengthened their critical thinking skills and their ability to collaborate with others.

Teachers need to take students beyond their initial reactions and claims not as a means of changing those views, but as a means for encouraging critical reflection. The use of technological environments, such as the Knowledge Forum, demonstrated a potential to successfully scaffold students in argumentation, supporting them in the internalization of argumentative skills.

Designing learning environments that help support argumentation in the science classroom is not always an easy task. Argumentation provides some potential contributions such as the externalization of cognitive processes, the development of critical thinking and supports the development of epistemic criteria. It also contributes to learners' scientific education as well as their education as citizens.

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Design-Based Research Aimed at Increasingly Deepening Levels of Knowledge Building

INTELLECTUAL ENGAGEMENT: Beyond social and instructional engagement to engagement that is the source of intellectual excitement and passion for students and teachers, with voluntary engagement pervading student experience.

SUSTAINED WORK WITH IDEAS: Beyond inquiry methods that support question asking and idea generation to methods that support continual idea improvement leading to deeper understanding and competence.

INCLUSIVE KNOWLEDGE SOCIETY: Beyond viewing knowledge as an open, sharable resource to viewing knowledge as improvable and public, with a positive role in knowledge creation for everyone.

KNOWLEDGE BUILDING PARTNERSHIPS: Beyond knowledge-sharing, including respect for diverse contributions, to mutual support of knowledge building innovation across sites and levels.

Development Program to Create Increasingly Powerful Open and Free Resources to Optimize Knowledge Building

TECHNOLOGY FOR KNOWLEDGE CREATION: Beyond software and open educational resources (OERs) to support inquiry and project-based learning to software that embeds OERs in collaborative knowledge building and is optimized for knowledge creation.

REFERENCES

ARANA, M. (2005). La educación científico-tecnológica desde los estudios de ciencia, tecnología, sociedad e innovación. Tabula Rasa. Bogotá - Colombia, No.3: 293-313, enero-diciembre de 2005 ISSN 1794-2489. Retrieved from: http://www.revistatabularasa.org/numero_tres/aranaNo.3.pdf, 28/10/2011

Douglas, C. Y Victor, S. (2007). Scaffolding Scientific Argumentation Between Multiple Students in Online Learning Environments to Support the Development of 21st Century Skills. Arizona State University, United States.

Erduran, S., Jiménez, M, P. (2007). Argumentation in Science Education. Perspectives from Classroom-Based Research. Science & Technology Education Library. Volume 35. Retrieved from: http://www.springerlink.com/content/978-1-4020-6669-6#section=138889&page=1, 15/09/2011.

Jiménez, M. Y Díaz De Bustamante, J (2003). Discurso de aula y argumentación en la clase de ciencias: cuestiones teóricas y metodológicas. Enseñanza de las ciencias. Vol. 21. N° 3. Pág. 359 a 370. Retrieved from: http://ensciencias.uab.es/revistes/21-3/359-370.pdf

Sampson, V. y Gerbino, F (2010). Two instructional models that teachers can use to promote & support scientific argumentation in the biology classroom. The American biology teacher. Vol. 72. N° 7. Pág. 427-431. Retrieved from: http://findarticles.com/p/articles/mi_6958/is_7_72/ai_n56534116/

Scardamalia, M. (2002). Collective cognitive responsibility for the advancement of knowledge. In B. Smith (Ed.), Liberal education in the knowledge society (pp. 67-98). Chicago: Open Court. Retrieved from http://ikit.org/fulltext/inpressCollectiveCog.pdf.

Scardamalia, M., & Bereiter, C. (2007). Knowledge Building. Theory, pedagogy and Technology. In K. Sawyer (Ed.), The Cambridge Handbook of the Learning Sciences (pp. 97-115). Cambridge, UK: Cambridge University Press.

Toulmin, S. (1958). The uses of Argument. Nueva York: Cambridge University Press.

Toulmin, S. (1972). Human understanding. The collective use and evolution of concepts. Vol 1. Princeton N.Y. Princeton University Press.

Zhang, J., Scardamalia, M., Reeve, R., & Messina, R. (2009). Designs for Collective Cognitive Responsibility in Knowledge-Building Communities. Journal of the Learning Sciences, 18(1), 7-44. Retrieved from http://www.informaworld.com/10.1080/1050840080258167