

Examining the practical aspects of implementing the living cell topic as a longitudinal axis in junior - high schools

Rachel Cohen, PhD Thesis, July 2009

Abstract

The cell is the smallest unit of structure and function in all living organisms. The multi-cellular organisms' function derives from the existence of fundamental processes occurring inside the cells. Therefore, it is important and essential to understand that the cell constitutes a unit of structure and function, in order to understand the function of living creatures and macroscopic biological phenomena occurring in them. Studies in biology education have indicated difficulties in pupils' perceptions of the living cell and in their ability to link phenomena in the multi-cellular organism to cellular processes. These studies have been conducted among high school and college students, university science majors and science teachers.

In Israel in 1996, it was decided that the cell should be studied as a "longitudinal axis" integrated in all the biological contents taught in the framework of science and technology studies in junior high schools. On the one hand, it appears that this directive is well suited to building reciprocal relations between the various biological levels of organization (macro-micro). On the other hand, this directive changes the mode and timing of teaching the topic of the living cell in junior high school, since until announcement of the new curriculum, the living cell had been studied in Israel in the 9th grade.

In the framework of this doctoral thesis we have examined the expression of the assimilation of the change in teaching the living cell as a "longitudinal axis" in junior high school and the various aspects of its implementation. One of the main goals of this research was to identify and investigate the significance of perceiving the approach of the cell as a "longitudinal axis" among various partners in the curricular process, including the scientific community, text books, official national exams, science teachers and pupils.

Examining how the assimilation of the change is expressed in teaching the living cell as a "longitudinal axis" in junior high school among all the above-mentioned partners in the curricular process provides, for the first time, a basis for understanding the partners tendency towards a traditional approach to teaching the living cell, thereby preventing the assimilation of the curricular change.

The traditional approach to teaching the living cell mainly focuses on cellular aspects and, therefore, it is not suited to up-to-date approaches in the field which call for forming macro-micro links. In light of the research findings, an intervention program (in-service training course) was developed and

conducted, which provides a theoretical and practical basis for assimilating the change and dealing with one of its limiting factors, pedagogical-content knowledge (PCK). In this way it is likely to improve the expression of the new approach to teaching the living cell as a "longitudinal axis" during the years of junior high school.

That being the case, this research had several goals:

A. To characterize and analyze the expression of the approach to the living cell as a "longitudinal axis" among the various relevant partners for assimilating the curricular change, namely in the different phases of the curriculum. This stage is the diagnostic stage of studying and analyzing the existing situation. We asked: Is there a difference in the expression of perceptions connected to the approach of teaching the living cell as a "longitudinal axis" between the various relevant partners in assimilating the curricular change?

B. To formulate, develop and manage an intervention program for the professional development of teachers which takes into account the research findings regarding characterization of the expression of the "longitudinal axis" approach to teaching the living cell in the various phases of the curriculum, based on research literature in the realm of teachers' in-service training. This stage in the research is the intervention stage, and the research question was: Which structure of in-service training for teachers' professional development is best suited to assimilation of the curricular change and how do teachers evaluate the training course?

C. To examine the effect of the intervention program and evaluate its effectiveness in terms of the change that has occurred in the PCK of the teachers participating in the program and their teaching of the living cell topic. The research question was: How has the in-service training course affected the teachers' PCK and the way they incorporate the living cell as a "longitudinal axis" in teaching other biological topics?

In order to satisfy the first goal, three scientists, who are policy makers and curriculum writers, were interviewed; official national exams (from 2001-2005) and six textbooks were analyzed. In addition, six teachers who graduated a three-year training course were interviewed; and questionnaires and teachers' discussions in focus groups were analyzed. In order to satisfy the second goal, the intervention program was characterized. Evaluation of the intervention program (in-service training course) was based on an analysis of questionnaires and recordings of the focus group discussions of the participating teachers, as well as exploratory interviews with three of the teachers two years after they had attended the course. In order to satisfy the third goal and ascertain the effect of the intervention program (in-service

training course) on the teachers' PCK on the topic of the living cell and their method of teaching it, the questionnaires and recordings of the focus group discussions of the participating teachers were analyzed, as were the exploratory interviews with three of the teachers two years after they had attended the course.

It was found that the policy making scientists were unanimous concerning the meaning of the new directive that "the cell will be studied as a longitudinal axis" but disagreed as to the timing of its execution. The designated curriculum represents the approach held by the majority of scientists. However, it turned out that teaching of the living cell by the teachers was different from the intention of the scientists and from the explicit directive given in the curriculum. Moreover, duality was found among teachers, in terms of their perception of the importance of teaching the topic versus their method of teaching it, as well as in a comparison between their way of teaching it and the way the topic of particles is taught in chemistry. We revealed that while junior high school teachers emphasized the reciprocal macro-micro relations in chemistry they seldom did so in biology.

The "longitudinal axis" approach to the cell topic was expressed in its low incidence on exams, in which most of the macro-micro questions were at the cognitive level of knowledge. Furthermore, it was evident that the number of questions examined during the five years (2001-2005) in biology ($n=187$) was larger than the number of questions ($n=134$) in chemistry. However, an inverse proportion was found between the number of questions requiring macro-micro linkage in biology ($n=36$) and those in chemistry ($n=38$). This fact indicates that a difference exists between evaluating the pupils on biology topics in comparison to chemistry topics on official national exams. That is, pupils are expected to express more macro-micro contexts in chemistry than in biology.

A distinction was also found among various textbooks dealing with the same topic, in terms of the scope of biological contents, variety of living species which might invite the integration of the topic of the living cell and demonstrate formation of macro-micro relations in biological phenomena within them. In addition, the rate of illustrations and pictures of cells which could emphasize these macro-micro connections in six books designed for 7th and 8th grade, which were published after the new curriculum came out, was also found to be relatively low. In general, it was found in all the books that the cellular structure is emphasized more than the processes occurring within the cells. Our findings indicate that the level of organization most pronounced, in four of the six textbooks examined, is the macroscopic level. Moreover, in most of the books it was found that in forming macro-micro relations, the cells were mentioned in the context of macroscopic phenomena but without any description of the structures and processes occurring within them. The books

which did form these macro-micro relations were mainly brought as examples that have no connection and continuation of the contents taught in biology in junior high school.

In addition, it was found that the junior high school pupils in Israel have difficulty in forming links between various levels of biological organization; namely between a macroscopic phenomenon and its cellular explanation. Based on our findings, we believe that pupils display inadequate performance and a superficial understanding of the topic, not only because of the cell's being an abstract and complex topic, but also as a result of its being presented in the traditional approach by various curricular parties. In this study we revealed a lack of coherency in the message expressed in the approach to teaching the living cell as a "longitudinal axis", despite the change proposed in this teaching method in the curriculum which was published in 1996. The traditional approach to teaching the living cell concentrates on cellular aspects; therefore, it is not suited to the up-to-date approaches to knowledge in the realm of forming macro-micro relations.

In light of the characterization of the aforementioned curricular processes, it seems that the teachers should have undergone a substantive and deep change in their perception of teaching the living cell, and from analysis of the textbooks it is evident that they should have functioned as curricular developers. What is more, it is apparent that no pressure is put on the teachers to change their way of teaching the living cell, considering the fact that on the official national exams there was not a great deal of representation of the directive that the cell be taught as a "longitudinal axis".

Following that, an intervention program for professional development (in-service training course) was developed for teachers, which refers to the course's various elements and stages of the holistic model (cognitive and affective aspects and the element of PCK). It is evident that the teachers' course in this format is applicable and its strength lies in its methodology and its emphasis on replication and inquiry with the teachers' cooperation. Teachers' reporting reveals that they judged the course as relevant to them and as contributing to their professional development. Professional development is perceived by the teachers as training in which they have learned competencies and skills for improving the teaching of the living cell and encouraging them to conduct reflective and critical thinking on the pedagogy of their teaching. The teachers found most of the course's activities to be relevant and beneficial in helping them understand operationally the curriculum directive to teach the cell as a "longitudinal axis". From the questionnaires, interviews and focus groups it is evident that the course contributed to a shift in the teachers' beliefs, knowledge and behavior. It also constituted a turning point in their professional development and caused a perceptual change in their goals, teaching methods and evaluation of the topic

of the living cell. They reported a change in beliefs and knowledge in each of the elements of PCK. That is, regarding orientation towards the topic of the living cell, being familiar with the curriculum on the topic (the directive, teaching goals, textbooks and teaching aids for the living cell and evaluation of the topic).

In conclusion, we suggest that when implementation of a curricular change is required, it is worthwhile examining the coherency and synergy between the elements involved in assimilating the change and acting to narrow the gap between them. Furthermore, when teachers are asked to execute a substantial-meaningful change, there is value in wisely building an in-service training course that includes cognitive and affective ingredients on the basis of PCK elements and involving the teachers in advancing their professionalism in such a course.

The present research study was conducted according to a qualitative paradigm, which seeks to extend the body of existing knowledge in the formulation of curriculum, teachers' acquisition of PCK and their professional development in teaching the topic of the living cell. From a theoretical research standpoint, this study contributes to developing a tool for analyzing the understanding of forming macro-micro relations in biology and characterizing the teachers' PCK in this area. In addition, the study makes a practical contribution, in that it demonstrates a suitable framework for assimilating curricular change in the teaching of the living cell in junior high school and for providing professional development training for teachers. The study is also important in contributing to educational policy (for planning curricula and developing textbooks) and teacher training. The study suggests further research directions, such as closely following the change process taking place among teachers over a long period of time, after having participated in training courses built on the model proposed herein.