High Order Learning Skills in Science Studies: Development of an Instructional Model, and Research on Implementation and Students' Learning

A Dissertation Submitted for the Degree of Doctor of Philosophy

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Abstract of thesis

High order skills instruction such as thinking and learning skills, inquiry and problem solving skills, are considered as an integral part of a good science education. In this thesis, we review different approaches to the teaching of skills and present our model for the instruction of high order skills in relation to these approaches. The model emphasizes explicit and spiral instruction of skills integrated with contents, and a continuous demand for their implementation in various contexts and performance tasks. On the basis of this model, we developed a modular instructional program "Scientific Communication" for the acquisition of High-Order Learning Skills (HOLS) for the junior high school (JHS) level. More specifically, the program focuses mainly on the following HOLS: information retrieval, scientific reading, listening and observing, scientific writing, information representation, and knowledge presentation. The program supports the application of the model in the science and technology curriculum.

The aim of our study was to determine how science teachers implement this complex and demanding model of instruction and how does the instructional program effect students' performances.

The first part of the study addresses the following questions: what are the instructional methods and strategies science teachers use for teaching "Scientific Communication" skills, and to what extent? How does the instruction of "Scientific Communication" contribute to the professional development of teachers?

The results show that science teachers succeeded to cope with the instructional model. The teachers who participated in the study (N=49) understood the rationale of the program and implemented "Scientific Communication" activities in the subject “Science and Technology”. Most of them claimed that they integrate the skills with content learning, and carry out a spiral implementation. They usually plan the instruction as teamwork with their colleagues in school. Teachers used the modular and flexible nature of the program to integrate various activities in a spiral way with scientific contents throughout the three years of JHS. The results show that during the course of HOLS instruction, the teachers realized that the skills differ in the level of their complexity and therefore distributed the instruction of certain skills accordingly in the different grade levels. The teachers who participated in the study customized the program and conducted a variety of sequences and patterns of instruction. Moreover, qualitative analysis of interviews with the teachers revealed that they had developed professionally. They improved their perceptions about the acquisition of HOLS, their understanding of the instructional model, their quality of teaching “Scientific Communication”, and their interaction with the educational system.

Another part of the study examined the influence of the HOLS instruction on students’ views and achievements in JHS science studies. There is a hidden assumption that the acquisition of skills takes place spontaneously as a consequence of the different learning activities in class. We wanted to examine this assumption and to explore the impact of formal instruction of skills on students' achievements in the context of a complex assessment task. Furthermore, in designing the study we differentiated between two main components of our instructional model and the program "Scientific Communication": (1) structured instruction of learning skills, and (2) opportunities to demonstrate the mastery of skills through performance tasks.

In this longitudinal study (7th-8th grades), 447 Students took part. The sample included two main groups: The comparison group (N=58) who did not experience any formal instruction of learning skills. The intervention group (SC group, N=389) who experienced HOLS attainment as part of the subject “Science and Technology”. This group was further divided into three subgroups: One group of students experienced both components of "Scientific Communication": the structured instruction of learning skills and the performance tasks. The second group experienced the structured instruction of learning skills, but not the performance tasks. The third group carried out only the performance tasks.

The results revealed that students who learned “Scientific Communication” were aware of their own acquisition of skills. They could indicate what skills

they had acquired and how it contributes to their “Science and Technology” studies. Moreover, they could describe in detail actions they would take while implementing learning skills in learning tasks. The results of students who did not learn “Scientific Communication” were much lower.

Students’ performances in HOLS were evaluated in the context of a complex assessment task "Update Report". Our findings show that without planned intervention, the spontaneous attainment of learning skills occurs, but only to a limited extent. The achievements of students who experienced neither structured instruction of learning skills nor had opportunities to practice them through performance tasks, scored significantly lower in the complex assessment task than all other students, in all categories that were measured: (a) knowledge, (b) performance of learning skills, (c) products and outcomes, and also in the final score. In contrast, students who experienced at least one of the components of the program scored higher in all these categories: those who experienced performance tasks only, achieved scores similar to those who had experienced only structured instruction of skills. We conclude that students that completed the short performance tasks gained practice and knowledge that helped them to cope with the complex assessment task. In other words, the performance tasks provided opportunities for learning (assessment for learning) and thus enhanced students' achievements and learning skills to the level of those who experienced structured instruction of the same skills.

However, students who had experienced both components of the program had the best achievements in all the categories mentioned above. These findings demonstrate a synergistic effect in which the combination of structured instruction of skills and the participation in performance tasks upgraded students’ learning skills.

The explicit instruction of HOLS integrated into scientific contents, and the opportunities to implement the skills in different contexts and various performance tasks is important and in fact crucial in improving students' mastery of HOLS. We also showed that teachers can cope with this instructional model and program of skills instruction, they customize the program according to their needs, and develop their proficiency.

The proposed model of HOLS instruction can be applied to the instruction of other high order skills like thinking skills, as well as inquiry and problem-solving skills. This general model has the potential to enable teachers and educators to promote skills acquisition. Thus, its application can lead to realizing the central goal of science education: literate students possessing scientific knowledge.