

# Ways to Incorporate Key Competencies in the Science Curriculum

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**Abstract:** This study explored ways to implement a competencies-based curriculum in schools by reviewing exemplary cases that have introduced Key Competencies (KCs) in the school science curriculum. Since the OECD redefined key competencies as ‘what people should know and do in order to lead a successful life in a well-functioning society’, many countries have emphasized the use of a competencies-based curriculum. Foreign and domestic classroom cases, which have used a competencies-based curriculum in science teaching, were collected and analyzed. Through open-ended interviews with teachers and principals, we investigated changes of teachers’ professional knowledge and practice that were evident as a result of the implementation of competencies-based curriculum in science class. Foreign science teachers suggested ways to relate competencies-based curriculum and science curriculum including maintaining a balance between competencies-based curriculum and content-based curriculum. They also integrated KCs into all subject-based curriculums, gave priority to KCs over subject matter knowledge, and developed KCs through teaching science contents that students wanted to learn. On the other hand, Korean science teachers suggested reconstructing competencies-based curriculum by extracting common attributes from the existing subject areas. They also made KCs realized through content teaching, and developed various KCs within science contexts. Implications of the competencies-based curriculum for science teaching and learning were discussed at the end.

**Keywords:** key competencies, curriculum reform, competencies-based curriculum, curriculum reconstruction

## Introduction

One of the keywords in every nation’s recent educational policy is Key Competencies (KCs). Considering national competitiveness originating from educational competitiveness, educational policy has been driven to identify KCs and realize them through school education. Within this context some leading countries have developed competencies-based curriculum, and discussed ways to relate KCs and subject matter areas. Regardless of these efforts and interests, there has been little discussion on how schools should change and how teachers should be prepared. Without incorporating KCs into content-centered curriculum, KCs have drifted as slogan.

In light of the national level curriculum, many countries have reformed national level curriculum by incorporating KCs based on the OECD DeSeCo (Definition and Selection of Key Competencies)

project (OECD, 2003, 2006). Countries including New Zealand, England and France have officially accommodated KCs to the national curriculum. Based on KCs developed by OECD (2003), each country developed her own version of KCs by identifying what young people should know and be able to do in order to lead a successful life in a well-functioning society (Boyd and Watson, 2006; Yoon et al., 2007; Lee et al., 2009; So et al., 2010). In these countries, the necessities as well as specific components of KCs are mentioned in the general part of their national curriculum, which leads and controls subject level curriculums.

Curriculum policy in these countries, however, allows schools and teachers to have significant autonomy in interpreting the meaning of KCs and finding ways to coordinate KCs with their curricular programs at the school level (Hong et al., 2010; Park et al., 2010). Within this context, Korea has also made theoretical and political efforts to reexamine existing curriculum in terms of KCs since 2000 (Lee et al., 2009; Choi et al., 2009). In case of Korea, KCs are mentioned at the introduction level in the 2009 revised national

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curriculum where KCs are proposed at the ‘name and hope’ level. Various components of KCs are mentioned and proclaimed in the 2011 as well as the 2009 revised Korean national curricula. For example, the 2009 national curriculum at the high school level states that students should possess lifelong learning competencies and career development based on knowledge and skills of various fields and mature self-consciousness (MEST, 2011). At the middle school level, the national curriculum specified that “students should develop creative thinking ability based on basic competencies and problem-solving skills necessary in their everyday life.” In the 2011 revised national curriculum, KCs such as growing as a well-rounded person, basic skills, creativity, communication skills, and so on are implied. In sum, the 2011 revised national curriculum did not use the term of key competencies, it mentioned the components of KCs directly and indirectly in each section of the curriculum document. In particular, the science curriculum emphasized repeatedly such KCs as creativity, communication skills, problem solving skills, ICT skills, cooperation with others, and so on.

Regarding the trends of teaching and learning, there are various ways to connect competencies- and content-based curriculum. In some cases, schools and teachers developed for former by completely reconstructing the latter. In other cases, teachers partially reconstructed existing content-based curriculum by incorporating KCs. With the emphasis on KCs, teaching and learning puts more emphasis on differentiated and customized learning, more creative teaching methods, inquiry learning, etc. The focus of teaching and learning also changed from transmitting didactic knowledge to developing students’ KCs. Other changes in light of teaching and learning include an increased use of cross-curricular practices and integrative curriculum, increased participation opportunities of students in instructional decision making, an increased use of democratic and participatory teaching strategies, etc (Boyd and Watson, 2006). With the emphasis of KCs, student assessment requires a new approach to evaluating students’

learning processes and outcomes. Like other curriculum reforms, competencies-based curriculum could not be successfully implemented without new ways of evaluating students’ learning. Most teachers in this study used such assessment methods as performance assessment, observation notes and journals, portfolios, etc. After all, to effectively implement competencies-based curriculum, teachers need more expertise in teaching and learning methods and assessments, which requires communication and discussion among teachers to coordinate and raise each student’s competency level.

However, there has been little discussion on practical implementation of competencies-based curriculum in schools. In particular there have been a few researches on how to integrate KCs into subject matter areas. Under these conditions, we investigated ways to incorporate and integrate KCs into science curriculum. The purpose of this study is to explore implementation of competencies-based curriculum in schools by reviewing exemplary cases that have introduced KCs in the school-level science curriculum. In order to obtain this purpose, we examined the background of introducing KCs in science curriculum, the meaning and necessity of competencies-based curriculum in science teaching, and ways to connect KCs with science curriculum. Lastly, we discussed some implications of competencies-based curriculum for science teaching and learning.

## Methods

This research has been conducted as part of a larger study which investigated curriculum reform to improve students’ KCs. In the larger study, we investigated ways to introduce competencies-based curriculum into content-based curriculum. Through case study, we explored how ‘early adopters’ of the KCs framework interpreted and implemented competencies-based curriculum in their schools. Cases include one a Korean case and three foreign cases including New Zealand, Britain, and French. These domestic and foreign cases have embedded KCs into their school

**Table 1.** Background information of the participants

Countries	Participants	
New Zealand	Ministry of Education <School A> <School B> <School C>	Education Officer (G) Principal (D), Science teacher (J) Social studies teacher (F) Principal (L), Science teacher (M)
Britain Foreign School French Foreign School Korean International School Research consultants (Korean science teachers)	Principal (H), Science teacher (A), English teacher (C) Science teacher (P) Science teacher (R) W, Y, Z	

level curriculum. For each case, we conducted classroom observation and teacher interviews, which were recorded. With videotaped lessons, we analyzed teaching characteristics of each lesson with three experienced science teachers. Like other classroom research, we also utilized video-based discussions (Van Esa and Sherinb, 2008) where teachers watched videotaped lessons and analyzed the characteristics of the classroom practice through probing questions. Videotaped lessons provide teachers' learning community with sharable materials and curriculum (Fullan and Hargreaves, 2002). We triangulated these video-based discussions with open-ended interviews with teachers. The participants of this study are shown in Table 1. Each foreign school features one or two science teachers and we observed and interviewed a representative science teacher in each school.

However in this study we will focus on changes in teaching practices with the influence of competencies-based curriculum. We explored what changes to teachers' professional knowledge and practice were evident as a result of the incorporation of competencies-based curriculum. To answer this research question, we mainly used teacher interview data and teachers' conferences where they discussed about their changes with the introduction of the KCs. Most of the results in this research centered on science teaching and science teachers of foreign and Korean cases, which also has limitations in terms of generalizing these results to other cases such as other subjects and other countries.

## Results and discussion

Main results of this study include ways to relate competencies-based curriculum and the science curriculum where we also examined the meaning and necessity of KCs in science education. We presented the findings into two parts: Foreign and Korean cases.

### Foreign cases

Science teachers in our foreign cases emphasized KCs because these KCs are helpful for students. Emphasizing the usefulness and necessity of KCs in students' life, Britain teachers explained that they try to maintain the balance between science content and KCs. Some science teachers contended that "since not all students are to become scientists", they should learn KCs through all subjects (Teacher M). In addition, New Zealand teachers contended that "KCs have been well known to everybody over more than 100 years and have been recently specified as competencies-based curriculum" (Teacher L). Considering their importance in students' life, teachers should always teach KCs although they are not specified in the curriculum (Teacher L). Teachers argued that "regardless of one's life style, KCs such as lifelong learning or self-regulation are necessary", and therefore KCs should be developed throughout schooling (Teacher H).

With the rapid development of knowledge-based society, it's time to develop students' KCs to prepare young people for future society and work environment,

by getting away from conventional factual knowledge learning (Teacher G). In New Zealand, when KCs were introduced to the curriculum for the first time, teachers were overwhelmed with adding more contents into already overcrowded curriculum. After trial processes for integrating the KCs into content curriculum, New Zealand government has persuaded teachers to teach KCs while they teach subject matters by changing teaching and learning methods. Foreign science teachers suggested ways to relate competencies-based curriculum and science curriculum as follows:

① Britain teachers contended that although it is not easy, it is important to maintain a balance between the competencies-based curriculum and content-based curriculum.

Regarding desirable relationship between the competencies-based curriculum and science curriculum, Britain science teachers contended that “competencies-based curriculum is almost similar to science curriculum since science curriculum also prescribes inquiry skills, which is similar to the KCs” (Teacher A). That is, in science teaching and learning, students should conduct lab activities and write up lab reports using math skills, presentation skills, collaboration skills, independent learning skills, and so on (Park, 2010), so that competencies-based curriculum and science curriculum should go hand in hand.

C: Teachers should decide the order of priority. It is hardly possible to teach only science contents. First, teachers should respect students since KCs are mostly individual learning processes. We need to make sure that students could enjoy their own learning rather than structuring their learning too much.

On the one hand, some science teachers argued that students need to learn basic background knowledge in science first to be autonomous and self-regulative learners. In other words, “what is important is teaching KCs, not covering lots of content knowledge” (Teacher C). Teachers, therefore, should seriously worry about “what to teach” rather than “how much content to teach”. Since it is impossible to teach

science content only, teachers should make students “enjoy learning, learn independently, and reflect on their own learning processes.”

② Science learning outcomes and KCs should be arranged in a row since every subject is grounded in KCs.

New Zealand teachers explained that “since KCs could be developed over a long period of time, teachers are trying to integrate KCs into all lessons”. From the lesson planning, teachers keep KCs in their mind and put everything under the KC umbrella. For example, regardless of subject areas, if teachers want to develop students’ self management competency they embed that in every curricular and extracurricular activity. If students had enough experience in self management skills but lack ‘relating to others’ skills, teachers collaboratively design various group activities whereby students could learn teamwork and ways of sharing with others.

D: We teach key skills such as self management and relating to others through group activities and other activities. After all we focus on different key skills depending on the unit. Although we do not evaluate key skills, we design and deal with key skills from the planning stage.

French teachers explained that “KCs are completely integrated into all subject-based curriculums since KCs are really melted into everyday curriculum.” That is, “KCs are embedded in everyday teaching without the teacher’s deliberately specifying what KCs she is dealing with, just like our enjoying music without telling what musical instruments are played” (Teacher P).

③ KCs should take priority over subject matter knowledge.

New Zealand teachers argued that KCs such as self management and problem solving are the top priority in teaching, and learning science content knowledge would be a bonus. When planning science lessons, “I always keep the KCs in my mind, and depending on which KCs to focus on in that lesson, teaching

activities vary” (Teacher F). For example, “If I want to focus on ‘participation and contribution’, I design group activities, and I plan other activities if the focus is on thinking skills” (Teacher F). Some New Zealand science teachers provide Website address where students could visit and learn basic science concepts and principles, so that they devote classroom teaching to “utilizing what students learned on the Website” (Teacher J). Teachers contended that “we don’t want waste our lessons on teaching science contents in front of the students”. Through this way of teaching, teachers argued, students will be better problem solvers with open-ended problems and gain better scores in the standardized test. French science teachers also contended that “students could find scientific knowledge here and there easily; however, they need KCs to utilize that knowledge” (Teacher P). Through developing KCs in students, teachers emphasized, “teachers should teach students how to self-study and act” (Teacher P).

J: I always emphasize how to use science and math. I encourage students to learn math concepts and algorithm through computers or Websites for themselves, and I let them utilize what they learned in my lessons. I introduce video-lessons and tutorials that students can use for their self-study, and then I devote my lessons to showing how to utilize students' content knowledge.

P: KCs take precedence of science curriculum. Everybody can find scientific knowledge easily with new technology. What is important is students' self regulation, thinking skills and ways of act. KCs are all about how students self-study and act. In science lessons, students should develop open-minded attitude, self-confidence, self-regulative learning skill, and so on. It is important to teach these KCs rather than basic scientific knowledge.

④ KCs are teaching science contents that students want to learn.

French science teachers contended that content areas in the curriculum are what are prescribed at the national curriculum, whereas KCs are what should be developed in students. The focus of KCs is to

emphasize “students’ self-directive learning with their own responsibility” (Teacher P). Teachers, therefore, should “encourage students to self-study and research what they are interested in and to interact with other students” (Teacher P). After all, teachers should decide what to teach based on what students want to learn, not what the teacher wants to teach. Teachers should accommodate what to teach and how to teach based on students’ interest and concerns.

P: KCs are what teachers should develop in students. With a competencies-based curriculum, teachers should try to teach what students want to learn. Textbooks are only one framework and teachers should decide what to teach in a real classroom. They should regulate what to teach and how to teach based on students' interest.

### Korean cases

Current science education in Korea lacks KCs and focuses on drilling and memorizing only fragmentary knowledge, which results in students’ not knowing the fun of science and where to use what they learned (Teacher Z). Science teachers contended that Korean science education focuses on “things you don’t need to know when you look back after grown up”, and makes “students memorize what they can find in a book” (Teacher W). Science teachers argued that “existing science education reached uppermost limit and this system needs a change in one form or another” (Teacher Z).

As an alternative to the current system, science teachers suggested that “by combining KCs with science contents, teachers should make transferable science lessons where students can communicate and utilize what they learned in other places.” Korean science teachers contended that students with KCs can understand and find answers beyond the manual rather than performing their task mechanically. Since the future society demands different KCs with the frequent transition of jobs, students need KCs different from what are necessary in these days (Teacher Z). In other words, in the future society students rarely use subject-specific knowledge and they need KCs such as

communication, problem solving, and so on, which is why the national curriculum needs to focus on KCs. Korean science teachers argued that “if KCs are specified in the national curriculum, science teachers could focus on the KCs legitimately in their science teaching.” Korean science teachers discussed about ways to relate competencies-based curriculum and science curriculum as follows:

① Korean science teachers argued major goals of teaching science are to teach existing science concepts and attitudes, with KCs accompanied.

Science teachers identified existing science education as the mainstream accompanied by KCs. Korean science teachers thought KCs are subordinate to the science content teaching. For example, teachers contended, science teachers should teach such KCs as communication skills and problem solving skills through “communicating about electric resistance or semiconductor in a specific science teaching context.”

W: I think I want to teach students scientific concepts correctly, accompanied with communication skills and attitudes. If KCs are annexed, students could better understand science contents.

Y: In addition to teaching science contents, science teachers should develop students' communication skills. To do that we need to reduce the existing science contents in the science curriculum. It's not compromising or sacrificing science contents. As a science teacher, I want to give up content coverage rather than giving up KCs. Science teachers need to make transferable science lessons by teaching KCs.

Korean science teachers contended that “after reducing overcrowded science contents in the curriculum, we need to incorporate KCs into science curriculum and to enable students to learn such key skills as scientific thinking skills through competencies-based science curriculum. Since such KCs as problem solving skills and communication skills can be displayed in specific contexts, science teachers should teach KCs within a science teaching context (Teacher W). After developing various KCs within science contexts, students are expected to transfer these KCs to other contexts.

② Science teachers argued it could be an issue to teach only KCs without the support of scientific knowledge or theory.

In all subjects KCs should be developed based on specific subject areas. In particular, teachers contended, “since it is impossible to communicate in the void of any knowledge base, we need scientific knowledge base even for the competencies-based curriculum” (Teacher Z). Desirable final products could be derived based on background knowledge of related subject areas.

After all, ways of relating KCs and science curriculum come down to how to relate KCs and science content. Science teachers argued that KCs such as problem solving or communication skills are “not general attributes, but meaningful under specific background knowledge and contexts”. Students equipped with “scientific core contents and KCs could delve into what they are interested in for themselves” beyond classroom learning (Teacher W). Science teachers contended that “curriculum is after all a collection of minimum transferable knowledge; therefore, science curriculum should be developed through researching the minimum amount of scientific knowledge to be delivered” (Teacher Z). Since “emphasizing KCs is not compromising or giving up scientific knowledge, the status of scientific knowledge in the competencies-based curriculum is to make students search what they need for themselves in the 21st knowledge-based society. In a real KC-focused teaching, science teachers should develop students' motivation and ability to delve into other scientific topics and contents of their own interest.

Z: It's impossible to communicate without any background knowledge. Background knowledge is building bricks for the house of scientific reasoning and communication. Students could write reports on momentum conservation only after they understand the concept of momentum conservation, where scientific knowledge is necessary to communicate with others.

W: Creativity couldn't be developed without knowledge or theoretical background. Is it ever possible to develop

students with great creativity in the absence of theoretical knowledge? Creative ideas can be produced based on what we know. The more we have background knowledge, the better our chances to produce creative ideas.

③ We need to reconstruct a competencies-based curriculum by extracting common attributes from existing subjects.

Curriculum goals should be set in the form of KCs by extracting common attributes from several subject areas. For example, existing subject areas including science, math, and so on can be utilized as a means to develop KCs such as creativity. On the other hand, we need to reduce existing knowledge structures of subjects. Since it is impossible to teach all KCs as well as all science contents, science contents in the curriculum should be reduced to secure the place for KCs.

Y: KCs emphasize developing strategic people or people who can meet the needs of the age. If KCs are becoming the main goals, existing subject areas will be integrated into KCs. That is, the common properties of existing subjects will be extracted and integrated into key competency goals. For example, the common goals of math, science and other subjects will be specified as goals of KCs.

W: For example, previous knowledge and subject areas would be means to develop KCs such as creativity. Since the goal is to develop creativity, relevant parts from the existing subject areas are brought out and utilized. That is, to develop such KCs as creativity, teachers should utilize creativity in science and creativity in math, and so on.

“Since KCs are necessary to become an excellent scientist, science teachers should embed KCs in science teaching” although KCs are not articulated in the science curriculum (Teacher Z). In addition, Korean science teachers emphasized, “if KCs are specified in the science curriculum, science teachers could legitimately conduct competencies-based science teaching”. Regarding content-specific teaching and learning, with the integration of KCs into the subject teaching, Korean science teachers suggested more

emphasis on individual students’ needs and demands in curriculum reconstruction and teaching, utilizing multi-grade or non-grade classrooms, activating team teaching, expanding learning situations beyond textbook contents, etc. Suggestions as to managing competencies-based curriculum include more systematic supports for teachers to interpret and integrate the KCs, and increased awareness of the KCs in the society.

## Conclusions

In this concluding section, we will discuss about some implications of competencies-based curriculum for science teaching and learning.

Firstly, specific methods of curriculum integration should be determined at the school level based on the teacher’s professional autonomy (Gess-Newsome and Lederman, 1999; Darling-Hammond et al., 2009). According to the national and foreign cases, there are various ways to connect KCs and science education, and a continuum of curriculum integration can be found. In some cases, schools and teachers developed competencies-based curriculum by completely reconstructing content-based curriculum. In other cases, teachers partially reconstructed existing content-based curriculum by incorporating KCs. For example, in science teaching, topic-centered curriculum has emerged with the influence of the competencies-based curriculum (NRC, 2007). That is, to develop cross-curricular competencies, some aspects of subjects relevant to the learning context are integrated. This type of integration is to make students learn KCs involved in the processes of learning and utilizing scientific knowledge rather than science content itself. In this type of curriculum integration, teachers use science as materials and opportunities to teach cross-curricular competencies. Another type of integration of KCs into the science curriculum is to develop KCs through science learning. That is, teachers can reconstruct the existing science subjects in a form appropriate to developing KCs in which science subject knowledge is used as teaching materials. After all, regardless of the types of curriculum integration,

the national-level curriculum should be less specified, and classroom-level curriculum should be reconstructed and specified by teachers with professionalism (KICE, 2009; Luke and McArdle, 2009). Schools and teachers should have significant autonomy in interpreting the meaning of KCs and finding ways to coordinate core competences with their curricular programs.

Secondly, KCs should be realized through subject teaching. Korean as well as foreign science teachers contended that competencies-based curriculum “unaccompanied by the scientific knowledge or theory” would be problematic. That is, in all subject areas including science, competencies-based curriculum should be implemented based on a specific subject area. For example, KCs such as creativity or problem solving skills should be developed through science teaching since they could best be developed based on scientific knowledge. In summary, science teachers argued that KCs should be taught to students through subject teaching since KCs without any knowledge base is impossible.

Thirdly, KCs are teaching subject contents that students want to learn. That is, teachers should provide students with more opportunities to co-construct classroom-level curriculum. This approach would increase the potential to provide students with ownership over their learning and opportunities to develop and demonstrate the KCs. Teachers contended that the focus of KCs is to make students more responsible and self-regulative for their own learning and research, and therefore teachers should encourage students to self-study what they are interested in. After all, science teachers contended that, teachers should adjust what and how of their teaching based on students’ interests.

Fourthly, we should reduce science contents to incorporate KCs into the curriculum. Science teachers contended that, “we could teach more science contents more rapidly simply delivering contents or information; however, if we want to integrate KCs, we need to reduce science contents. In France, with the repeated revisions of the national curriculum, the contents of the national science curriculum have been reduced

gradually, which increases the teacher’s autonomy to reconstruct what to teach at the classroom level. French science teachers argued that “it only takes 4-5 months to cover the textbook contents or the given program, and thus teachers have enough time to conduct project- or discussion-based teaching, interactive activities, and so on.” As the science contents prescribed in the national curriculum are gradually decreasing, it demands more teacher professionalism in determining what to fill in the rest of the classroom-level curriculum (Niemi, 2005; Wenger, 1998).

Lastly, we should construct the curriculum and the textbook more flexibly to develop KCs. For example, to enable competencies-based education, science textbooks should provide alternative experiments for a given topic rather than designating only one experiment. In addition, rather than presenting a textbook solution, various solutions and thoughts should be acknowledged so that students could think various possibilities. After all, science teachers contended that the achievement standards should be more opened by incorporating KCs rather than prescribing the achievement standards focused mainly on the scientific concepts. The curriculum should be less crowded and designated so that teachers adjust what and how to teach to their students.

After all, the competencies-based curriculum is more of process-oriented rather than outcome-oriented, which encourages students to fully experience a teaching and learning process itself regardless of the outcome.

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