

A Study on Evaluation of the Development and Implementation of Context-based Chemistry Curriculum: A Case Study on Salters Advanced Chemistry

Yukinori UTSUMI^{*1}

This paper aims to identify the factors of success in the development of Salters Advanced Chemistry(SAC) for students aged 17-18 in England and Wales through evaluating the curriculum development and implementation by using the model of curriculum representations described by Van den Akker (1998).

The research evidence indicates three things. First, the Ideal Curriculum has been reflected in the other five curricula, ranging from the Formal Curriculum to the Attained Curriculum, so SAC could well have been developed and implemented successfully with the coherency of six curricula as intended. Second, teachers have been involved in the development, dissemination of context-based chemistry curriculum and in-service program of support for teachers, so as a result of involving teachers in these stages, their professional growth has been facilitated. Third, the in-service program has provided the opportunity to move towards value congruence between developers and teachers, in that teachers have gained the knowledge and skills needed to teach and have developed their professional growth.

Key words: context-based chemistry curriculum, curriculum representations, development and implementation, professional development

1. Introduction

Salters Advanced Chemistry (SAC) for students aged 17-18 was developed in the early 1990s and has been introduced in England and Wales (Bennett, et al., 2006). SAC is a curriculum which adopts context-based approaches in science teaching where contexts and applications of science are used as the starting point for the development of scientific ideas (Bennett, et al., 2006). Draft material for all the components of the course was discussed and developed at a series of planning and writing workshops held over 4 years (1988-1992) involving the developers, funders, science educators, scientists, teachers, and representatives of the Examination Board, which would ultimately set the examinations for the course (Bennett, et al., 2006).

The model of curriculum which is categorized in detail, needs to be used in order to analyze the curriculum development more precisely by focusing on teachers and students. There is a comprehensive model of curriculum representations described by Van den Akker (1998) (in short, VdA model). It differentiates between six, progressively more concrete, formats of the science curriculum as presented in Table 1 (Van den Akker, 1998).

^{*1} Faculty of Education, Gifu University

Table 1. The model of curriculum representations described by Van den Akker (VdA model)
(Van den Akker, 1998)

<ul style="list-style-type: none"> ● The Ideal Curriculum The <i>Ideal Curriculum</i> represents the original vision, basic philosophy, rationale, or mission underlying the curriculum. ● The Formal Curriculum The <i>Formal Curriculum</i> where the vision is elaborated in a curriculum documentation. ● The Perceived Curriculum The <i>Perceived Curriculum</i> describes the curriculum as perceived by its users, especially teachers. ● The Operational Curriculum The <i>Operational Curriculum</i> describes the actual instructional process in the classroom. ● The Experiential Curriculum The <i>Experiential Curriculum</i> describes the actual learning experiences of the students. ● The Attained Curriculum The <i>Attained Curriculum</i> describes the resulting learning outcomes of the students.

Utsumi, et al. (2010a) researched the materials and approaches for Chemistry in SAC. Utsumi, et al. (2010b) researched the process and model of curriculum development of SAC. However, the evaluation of development and implementation of SAC has not been researched yet. Bennett, et al. (2005a) assessed the extent of the fit between any proposed model and what happened in practice by using the VdA model and examined the extent to which the model is helpful in characterizing SAC. They haven't evaluated it from the point of view of the impact of the Ideal Curriculum on the other five curricula. It is helpful in a specific new curriculum development to solve problems confronting the education.

This paper aims to review the work of Bennett, et al. (2005a) and identify the factors of success in the development of SAC through evaluating the curriculum development and implementation by using the VdA model, focused on teachers and students.

2. Curriculum and its development of SAC

2.1. An overview of SAC

The SAC course has three components. The Chemical Storylines book, the Chemical Ideas book and the folder of the Activities and Teachers Guide. Figure 1 represents the structure of these components in SAC.

SAC adopts a context-based approach which uses contexts and applications of science as the starting points for developing scientific understanding. It is expected by adopting this approach that students' motivation to learn is enhanced and that they foster their interest with further study in the subject (Bennett, et al., 2005a; Burton, et al., 1995).

Context-based courses are characterized by the use of contexts as starting points. It means that students' learning starts with a story of Chemical Storylines. They learn scientific ideas with Chemical Ideas to understand its contexts and the laboratory work. The Chemical Storylines provides the "backbone" of the course, introducing the context within which chemical ideas and skills are developed, and indicating where students need to be directed to next, either the Chemical Ideas book or to activities from the Activities folder. The Chemical Ideas book systematically draws together the chemical principles from the individual units and the different parts of the course.

How are students engaged in their learning? In the unit 'The Oceans' of the Chemical Storylines, firstly, students learn in contexts relevant to the dynamic events and phenomena related to broad

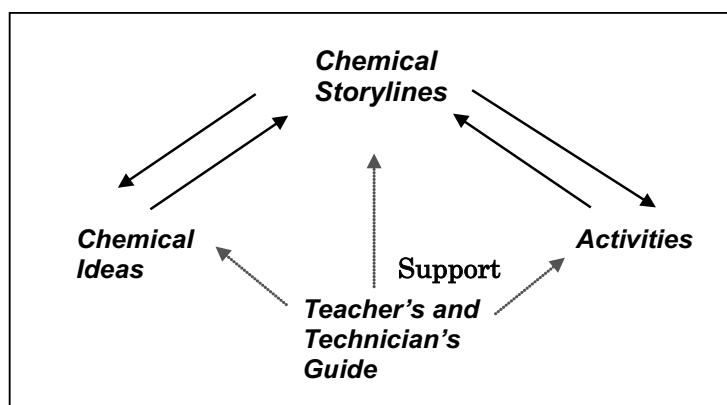


Figure 1. Structure of the units used in the course
(Burton, et al., 1995. Modified by Author.)
Note. Solid lines indicate flows of materials used.

oceans, such as, the cycle of materials, circulation and climatic impact, etc. Next, students learn scientific ideas, such as solution, entropy and equilibrium, etc. using the Chemical Ideas to understand these contexts. Finally, they carry out experiments and observation, for example, on polarity of solvent and solubility, enthalpy change of vaporization of water, pH measurement of hydrochloric acid and acetic acid, pH measurement of some buffer solutions with Activities (Burton, et al., 2000a; Burton, et al., 2000b; Burton, et al., 2000c).

2.2. Curriculum development of SAC

Six Salters courses which adopt context-based approaches have been developed¹⁾. SAC is one of their most successful courses (Bennett, et al., 2006). These courses are developed in stages in Table 2.

3. Analysis of curriculum development of SAC using VdA model

Analyzing the curriculum development and implementation in SAC using VdA model presented in Table 1, this chapter describes the extent to which the Ideal Curriculum has reflected the other five curricula.

3.1. Analysis of a curriculum development of SAC

3.1.1. The Ideal Curriculum

The Ideal Curriculum represents the original vision underlying the curriculum. The origin of SAC was “Salters approach”, which adopted the following two fundamental design criteria in the

Table 2 The stages in the development of a typical Salters curriculum
(Bennett, et al., 2005b)

Year	Stage
1	Planning and consulting; starting to write resources for year 1 of trial
2	Writing resources for year 1; designing and validating assessment framework
3	Year 1 of trial; writing resources for year 2
4	Year 2 of trial; revising year 1 resources for publication
5	Publication of year 1 resources; revising year 2 resources for publication
6	Publication of year 2 resources; full-scale implementation

development of course materials (Campbell, et al., 1994).

【Fundamental Design Criteria i】

The ideas and concepts selected, and the contexts within which they are studied, should enhance young people's appreciation of how chemistry:

- contributes to their lives or the lives of others around the world; or
- helps them to acquire a better understanding of the natural environment.

Campbell, et al. (1994) concluded that this first design criteria should enhance young people's appreciation of chemistry. Additionally, the second design criteria is intended to be interesting and accessible to a wide range of students (Campbell, et al., 1994).

【Fundamental Design Criteria ii】

- The course should include a wide range of activities in which students can actively engage.

These two design criteria are designed very widely. One strength of adopting design criteria that were very broad in nature was that, in the early stages, they provided general direction without the need to specify outcomes at a very detailed level. The content decisions emerged during the development, rather than being specified as the first step (Bennett, et al., 2006). As a result, the adoption of a wide range of design criteria in SAC didn't depend on a particular theory of learning, so the curriculum development of SAC had not been subject to any restrictions and a lot of flexibility could be provided in it. Therefore, SAC could be developed to overcome the curricular problems in chemistry education (Utsumi, et al., 2010b).

3.1.2. The Formal Curriculum

The Formal Curriculum is the vision which is elaborated in a curriculum documentation. It contains the specification and teaching materials to be produced. Scientific ideas are introduced on a 'need to know' basis with materials as presented by Figure 1. In other words, they are needed to help develop understanding of features of the particular context being studied (Bennett, et al., 2005a).

The concept of chemical equilibrium provides a good example of this. It is not introduced and developed in one unit, but rather revisited for development through five units. This approach is known as the "drip-feed" approach, which clearly has implications for the way in which students' understanding of scientific ideas is developed (Bennett, et al., 2005a).

3.1.3. The Perceived Curriculum

The Perceived Curriculum describes the curriculum as perceived by its users, especially teachers. It requires changes in classroom practice to change the curriculum which has been adopted. Teachers must have the knowledge and skills needed to implement the new curriculum (Bennett, et al., 2005b). Therefore, attendance at the training workshops is optional, but the large majority of schools adopting the course send at least one teacher to be trained often the Head of the appropriate science department. Many schools continue to send new teachers for Salters training long after the project has been implemented in the school (Bennett, et al., 2005b). Teachers have gained new knowledge and skills needed to practice their lessons to perceive the Perceived Curriculum through these in-service workshops.

3.1.4. The Operational Curriculum

The Operational Curriculum describes the actual instructional process in the classroom. Utsumi

(2012) points out the two features of lessons from observation of SAC as follows;

- Teachers use the materials in accordance with maps of the unit in Chemical Storylines and add original material to them in their lessons.
- Chemical Storylines provides the backbone of the course introducing the interesting contexts. Chemical Ideas which explains major chemical principles and Activities including laboratory work, etc. are used to understand the Storyline in lessons.

In SAC, the contents of learning are so closely directed by Chemical Storylines (Kind, et al., 2005), so teachers are required to teach chemistry in faithful accordance with maps of the unit. However, SAC has the flexibility that allows teachers to add original material in their lessons, so it gives teachers a significant degree of autonomy over their teaching (Utsumi, 2012).

3.1.5. The Experiential Curriculum

The Experiential Curriculum describes the actual learning experiences of the students. It views the Operational Curriculum from their experience in the classroom and from their perception. As to students' attitude (Barber, 2001; Key, 1998)²⁾, Barber found that students' interest and motivation was maintained at a higher level across the 2-year course in SAC than in the more conventional course. This higher level of interest in SAC appeared to be reflected in greater numbers of Salters students going on to study chemistry or chemistry-related courses at university (Bennett, et al., 2006). The students following SAC, expressed higher levels of interest in the course and commented positively on the wide range of activities, such as small-group discussions, Internet searches, role plays, and project work. They expressed more concern than students on the more conventional course about their abilities to cope with revision and tests (Bennett, et al., 2006). Key(1998) looked at how students' perceptions of the chemical industry varied during the 2 years of SAC course in England. Students who gained this first-hand experience demonstrated greater insight into the role of the chemical industry and an increased appreciation of its importance compared with those learning about the chemical industry in other ways (Bennett, et al., 2006).

3.1.6. The Attained Curriculum

The Attained Curriculum describes the resulting learning outcomes of the students. Context-based courses introduce scientific ideas on a "need to know" basis to help explain and enrich understanding of features of the particular context being studied. This "drip feed" or "spiral curriculum" approach clearly has implications for the development of students' understanding of scientific ideas (Bennett, et al., 2006). Two studies (Barker, 1996; Banks, 1997)²⁾ have yielded evidence on students' understanding of chemical ideas. Barker undertook a large-scale, comparative, longitudinal study. Statistical analysis of matched responses found no significant differences in levels of understanding between both student groups. In the case of the topics of chemical bonding and thermodynamics, the context-based approach appeared to produce slightly better results in students' understanding. In a smaller-scale study, Banks found that the context-based approach to teaching ideas about chemical equilibrium appeared more effective than the conventional approach (Bennett, et al., 2006).

3.2. The impact of the Ideal Curriculum on five other curricula

3.2.1. The impact of the Ideal Curriculum on the Formal Curriculum

The dialogue that took place at the workshops provided a very important means of establishing the priorities of each group and identifying a course structure that enabled the aspirations of the developers for their Ideal Curriculum to be reflected in a workable way in the Formal Curriculum (Bennett, et al.,

2006). In other words, in the Formal Curriculum; the production of specification and materials, a series of planning, designing and writing seems to reflect the Ideal Curriculum which the developers aspire to.

3.2.2. The impact of the Ideal Curriculum on the Perceived Curriculum

The teachers believed that their course gave as good a foundation for further study as more conventional courses. They also reported that their experiences were significantly influenced by in-service support provided for the course, and saw this as central to building their confidence and hence to the success of the course. Taken together, these findings provide strong evidence of a good match between the Ideal Curriculum as originally conceived, and the Perceived Curriculum; one as perceived by those teaching it (Bennett, et al., 2006). The Perceived Curriculum reflects the Ideal Curriculum by perceiving the Formal Curriculum through the in-service program of support.

3.2.3. The impact of the Ideal Curriculum on the Operational Curriculum

In the Operational Curriculum, teachers implement the program based on the specifications and teaching materials which have been produced from the Ideal Curriculum. Teachers who don't attend the workshop implement the program by disseminating the content which they received, while taking part in the in-service program of support. Therefore, teachers can practice the program which reflects the Ideal Curriculum. Additionally, teaching materials would be used as intended, because the contents of learning are closely directed by Chemical Storylines in SAC.

3.2.4. The impact of the Ideal Curriculum on the Experiential Curriculum

Two studies (Barber, 2001; Key, 1998) support a considerable quantity of anecdotal data that indicate SAC is successful in stimulating and retaining students' interest in the subject in lessons, and influencing decisions to go on to study chemistry at university level. Thus, the Experiential Curriculum is very much in keeping with the aspirations of the developers as envisaged in the Ideal Curriculum (Bennett, et al., 2006).

3.2.5. The impact of the Ideal Curriculum on the Attained Curriculum

Because students taking SAC take a different Ideal Curriculum to those following more conventional courses, direct comparisons of achievement are not possible. However, context-based courses introduce scientific ideas on a "need to know" basis to help explain and enrich understanding of features of the particular context being studied (Bennett, et al., 2006). The better grades of Salters students in their advanced-level examination demonstrate the close link between the Formal and the Attained Curriculum (Bennett, et al., 2006). The Attained Curriculum seems to reflect the Ideal Curriculum through the Formal Curriculum.

4. Discussion

This paper set out to identify the factors of success in the development of SAC, and the teachers' role in the curriculum development and its model from the point of view of the teachers' involvement and their continuing professional development.

4.1. Continuing professional development in the curriculum development

A series of planning, designing and writing of curriculum materials enabled the aspirations of the developers for their Ideal Curriculum to be reflected in a workable way, in the Formal Curriculum. This could be implemented by involving the developers, funders, science educators, scientists and teachers

(Bennett, et al., 2006). As teachers involved in the development worked as instructors in training workshops and promoted dissemination of SAC, the Ideal Curriculum has been jelled in the Operational Curriculum by perceiving the Formal Curriculum. Teachers involved in the development of SAC played an important role in each step in the curriculum development and enhanced their continuing professional development through the curriculum development and its dissemination. Teachers who took part in the in-service workshop developed value congruence with the curriculum developers and gained new knowledge and skills of the context-based approach. As a result, they could receive teacher' continuing professional development and dispel their concerns of teaching SAC. This continuing professional development could be regarded as an important factor to success of the curriculum development.

4.2. Involvement with teachers in the curriculum development and its model

Teachers rarely use curriculum materials as intended by their developers (Elliott, 1994), and practitioners were not even always aware that they violated the developers' intentions (e.g. Reinmann-Rothmeier and Mandl, 1999). This indicates that it is essential to pay attention to the process of implementing the curriculum as well as stages of producing materials in curriculum development.

Fullan and Stiegelbauer (1991) simplify the change process by distinguishing three sub-processes in which an innovation is made to work (or not) in order to produce outcomes; implementation, continuation and outcomes. Altrichter (2005) suggested the “adaptive- evolutionary approach” presented in Figure 2 to solve the implementation problem. It accepts that the innovation as it has been devised will be modified in the course of its implementation. The processes that eventually lead up to and end with the decision to take up a specific innovation proposal has been called initiation phase (also mobilization or adoption). The “adaptive-evolutionary approach” accepts that the innovation as it has been devised will be modified in the course of its implementation (Altrichter, 2005). In the curriculum development of SAC, the “adaptive-evolutionary approach” has been adopted and has been modified to the curriculum by involving teachers and focusing on deficiencies in materials in implementation as well as in curriculum development.

Bulte, et al. (2006) stress the need to reduce the incongruence between ideal and what is implemented in curriculum development³. The Ideal Curriculum reflects the other five curricula by adopting teachers' ideas and making a modification to them in the process of curriculum development. Therefore, the consistency among these six curricula could well have been sustained to an acceptable level.

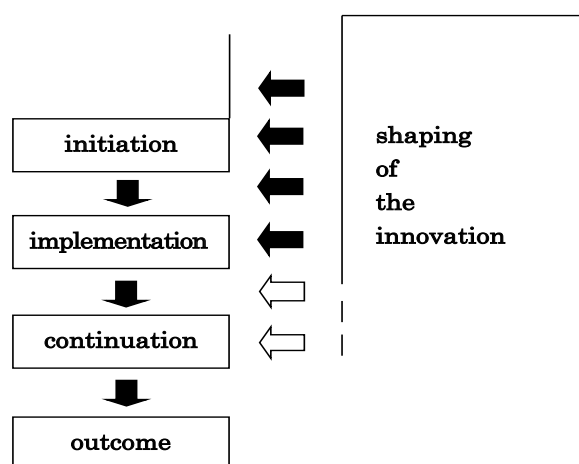


Figure 2. Curriculum making in the “adaptive-evolutionary approach”
(Altrichter, 2005)

5. Conclusions

This paper aimed to identify the factors of success in the development of SAC. Though it cannot always explain appropriately what happened, especially in the Experiential and the Attained Curriculum by using the model of curriculum representations described by Van den Akker, the findings indicate that the consistency among these six curricula could well have been sustained to an acceptable level in that the Ideal Curriculum reflects the other five curricula, and additionally, that teachers involved in curriculum development, dissemination and in-service program of support for teachers contributed to the success of the course as its background.

Acknowledgements

The author wishes to express his gratitude to Professor Tetsuo Isozaki (Graduate School of Education, Hiroshima University) for his helpful comments on an earlier draft of this article.

Note

- 1) Salters courses which adopt context-based curricula are as follows (Bennett, et al., 2006);
 - Chemistry: the Salters Approach (for students aged 14-16, developed in the mid 1980s);
 - Science: the Salters Approach (for students aged 14-16, developed in the late 1980s);
 - Salters Science Focus (for students aged 11-14, developed in the early 1990s);
 - Salters Advanced Chemistry (for students aged 17-18, developed in the early 1990s);
 - Salters Horners Advanced Physics (for students aged 17-18, developed in the mid to late 1990s);
 - Salters Nuffield Advanced Biology (for students aged 17-18, developed in the early 2000s).
- 2) Research studies, both at master's level and doctoral level at the University of York, UK exist on aspects of the use of courses in the Salters family as follows;

Banks, P. (1997) Students' Understanding of Chemical Equilibrium, Unpublished MA thesis, University of York, UK.

Barber, M. (2001) A Comparison of NEAB and Salters A-level Chemistry: Student Views and Achievements, Unpublished MA thesis, University of York, UK.

Barker, V., and Millar, R. (1996) Differences between Salters' and Traditional A-level Chemistry Students' Understanding of Basic Chemical Ideas, Science Education Research Paper 96/05, York, University of York, UK.

Key, M.-B. (1998) Student' Perceptions of Chemical Industry: Influences of Course Syllabi, Teachers, First Hand Experience, Unpublished PhD thesis, University of York, UK.
- 3) A curriculum design process takes place in several cycles according to Bulte, et al. (2006). They point out the importance of the incongruence between Ideal and the Operational, Experiential, and Attained Curricula.

References

- Altrichter, H. (2005) Curriculum Implementation - Limiting and Facilitating Factors, In Nentwing, P. and Waddington, D. (Ed.), *Make It Relevant: Context Based Learning of Science*, Waxmann, 35-62.
- Bennett, J., Gräselb, C., Parchmann, I. and Waddington, D. (2005a) Context-based and Conventional Approaches to Teaching Chemistry: Comparing Teachers' Views, *International Journal of Science Education*, 27(13), 1521-154.
- Bennett, J., Holman, J., Lubben, F., Nicolson, P. and Otter, C. (2005b) Science in Context: The Salters

- Approach, In Nentwing, P. and Waddington, D. (Ed.), *Make It Relevant: Context Based Learning of Science*, Waxmann, 121-153.
- Bennett, J. and Lubben, F. (2006) Context-based Chemistry: The Salters Approach, *International Journal of Science Education*, 28(9), 999-1015.
- Bulte, A.M.W., Westbroek, B. H., O. De Jong, and Pilot, A. (2006) A Research Approach to Designing Chemistry Education Using Authentic Practices as Contexts, *International Journal of Science Education*, 28(9), 1063-1086.
- Burton, G., Holman, J.S., Pilling, G. and Waddington, D. (1995) Salters Advanced Chemistry: A Revolution in Pre-college Chemistry, *Journal of Chemical Education*, 72(3), 227-229.
- Burton, G., Holman, J., Pilling, G., Lazonby, J. and Waddington, D. (2000a) *Salters' Advanced Chemistry: Chemical Storylines*, 2nd ed. Oxford: Heinemann.
- Burton, G., Holman, J., Pilling, G., Lazonby, J. and Waddington, D. (2000b) *Salters' Advanced Chemistry: Chemical Ideas*, 2nd ed. Oxford: Heinemann.
- Burton, G., Holman, J., Pilling, G., Lazonby, J. and Waddington, D. (2000c) *Salters' Advanced Chemistry: Activities and Assessment Pack*, 2nd ed. Oxford: Heinemann.
- Campbell, B., Lazonby, J., Millar, R., Nicolson, P., Ramsden, J. and Waddington, D. (1994) Science: The Salters Approach - A Case Study of the Process of Large Scale Curriculum Development, *Science Education*, 78(5), 415-447.
- Elliott, J. (1994) The Teacher's Role in Curriculum Development an Unresolved Issue in English Attempts at Curriculum Reform, *Curriculum Studies*, 2 (1), 43-69.
- Fullan, M. and Stiegelbauer, S. (1991) *The New Meaning of Educational Change*, London: Cassel.
- Kind, V. and Taber, K. (2005) *New Perspectives on Science Education, Science: Teaching and School Subjects 11-19*, Routledge, 62-91.
- Reinmann-Rothmeier, G. and Mandl, H. (1999) Implementation Konstruktivistischer Lernumgebungen - Revolutionärer Wandel oder Evolutionäre Veränderung? In H. Renkl, (Hrsg.), *Lernen und leben aus der Welt im Kopf*, 61-78, Neuwied: Luchterhand.
- Utsumi, Y. (2012) A Study on the Development of Context-based Chemistry Curriculum: From the Viewpoints of Salters Advanced Chemistry in England and Wales, Unpublished PhD thesis, Hiroshima University. in Japanese
- Utsumi, Y. and Isozaki, T. (2010a) A Study on Teaching Materials and Approaches for Chemistry in Salters Advanced Chemistry, *Journal of Research in Science Education*, 51(1), 13-21. in Japanese
- Utsumi, Y. and Isozaki, T. (2010b) A Study on Curriculum Development of Salters Advanced Chemistry: Its Process and Model of Curriculum Development, *Journal of Science Education in Japan*, 34(4), 339-351. in Japanese
- Van den Akker, J. (1998) The Science Curriculum: Between Ideals and Outcomes. In Frazer, B. and Tobin, K. (Eds.), *International handbook of Science Education* (Vol. 1), Dordrecht, The Netherlands: Kluwer, 421-447.