A systematic review of the use of small-group discussions in science teaching with students aged 11-18, and the effect of different stimuli (print materials, practical work, ICT, video/film) on students' understanding of evidence

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Review summary

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Contextual information

This document contains the Summary of an EPPI-Centre review conducted by the Review Group for Science at the Department of Educational Studies, University of York. The EPPI-Centre is part of the Social Science Research Unit, Institute of Education, University of London.

The full technical report was published in January 2005 and can be found in the EPPI-Centre's Research Evidence in Education Library at http://eppi.ioe.ac.uk/reel/T

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There are no conflicts of interest for the core team of RG members. Other members of the RG (John Holman, Robin Millar) are involved in the development of *21st Century Science*, a course currently in its pilot phase which will be advocating the use of small-group discussions. A number of members of the RG (Judith Bennett, Bob Campbell, John Holman, Robin Millar) were involved in the development of the *Salters* courses (*Science: the Salters Approach*, *Science Focus*, *Salters Advanced Chemistry*, *Salters Horners Advanced Physics*), all of which advocated the use of small-group discussions as one of a range of student-centred approaches in teaching.

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Background

This review builds on the work of an earlier systematic review (Bennett *et al.*, 2004) by continuing to focus on aspects of small-group discussions in science teaching. Small-group discussions have been strongly advocated as an important teaching approach in school science for a number of years, partly arising from a more general movement towards student-centred learning, and partly as a means of drawing on recommendations from social constructivist research, where it is seen as very important to provide students with an opportunity to articulate and reflect on their own ideas about scientific phenomena.

Several factors have come together recently to contribute to the current high levels of interest. These include the following:

- moves towards making changes in the school science curricula of a number of countries such that courses have an increased emphasis on the development of *scientific literacy*
- the most recent version of the National Curriculum for Science in England and Wales requiring that school students be explicitly taught about *ideas and evidence*
- the current interest in formative assessment as a key aspect of teaching
- a more general drive to improve students' *literacy skills*, formalised into the National Literacy Strategy in England and Wales (Department for Education and Employment (DfEE), 1998)

The systematic mapping of the area undertaken in the initial review revealed a wide range of relevant studies and facilitated the potential to explore a number of different aspects of the use of small-group discussion work in science teaching.

Aims

The review has two principal aims:

- to identify the ways in which small-group discussions are currently used in science lessons
- to look at the effects of small-group discussions on students' understanding of science ideas and attitudes to science

Review questions

The main review research question is as follows:

How are small-group discussions used in science teaching with students aged 11-18, and what are their effects on students' understanding in science or attitude to science?

The term 'understanding' encompasses science concepts, ideas about the nature of science and the methods of science. The term 'attitude' includes attitude towards science, attitude towards school science, motivation to learn, interest in science activities and career intentions.

The earlier review by the Review Group (Bennett *et al.*, 2004) led to a systematic map of research activity in the area and an in-depth review of studies addressing the question: *What is the evidence from evaluative studies of the effect of small-group discussions on students' understanding of evidence in science?*

Based on an update of the systematic map, the review reported here includes an in-depth review of studies addressing the question:

What is the evidence from evaluative studies of the effect of using different stimuli (print materials, practical work, ICT, video/film) in small-group discussions on students' understanding of evidence in science?

This particular research question was chosen because little research has been carried out into this aspect of small-group discussions and because there has been no attempt to put the evidence together.

For the purposes of this review, 'understanding of evidence' was defined as the understanding 'related to the collection, validation, representation and interpretation of evidence' (Gott and Duggan, 1996, p 793); that is, the ability to co-ordinate observations (primary or secondary data) with theory (models or concepts).

Methods

The review methods used are those developed by the Evidence for Policy and Practice Information and Co-ordinating Centre (EPPI-Centre) for systematic reviews of educational research literature. Such a review has four main phases:

Searching and screening: developing criteria by which studies are to be included in, or excluded from the review, searching (through electronic databases and by hand) for studies which appear to meet these criteria, and then screening the studies to see if they meet the inclusion criteria

Keywording and generating the systematic map: coding each of the included studies against a pre-agreed list of characteristics which is then used to generate a systematic map of the area where studies are grouped according to their chief characteristics

In-depth review and data extraction: summarising and evaluating the contents of studies according to pre-agreed categories

Synthesis: providing an overview of the quality and relevance across the studies in the in-depth review and combining the weighted findings of the collective studies

Results

The studies identified through the searching and screening processes established that three different stimuli (printed materials, computers and practical work) were being used in diverse ways in promoting discussions about scientific evidence with small groups of students. Aspects of the use of scientific evidence being investigated also varied: examples include seeking relevant information, identifying gaps in knowledge, evaluating, predicting, hypothesising, recognising anomalies, and testing, formulating and revising models or hypotheses. Similarly, measurements of the nature of the discussion or argumentation differed and included challenging, opposing, justifying, explaining, conceding and agreeing. Some papers also included measures of the metacognitive development of students about their understanding of the use of scientific evidence.

Ninety-four studies met the inclusion criteria developed for the overall research review. These studies were keyworded and formed the basis of the systematic map.

The map revealed a number of characteristics of research on small-group discussions that has been published in the English language, as summarised below.

- The majority of the studies report work that has taken place in the USA, the UK and Canada, although studies from many (13) other countries were included.

- Small-group discussions were used with all ages of student in the secondary age range.

- Most studies were carried out with mixed ability and mixed gender classes.

- The majority of work focused on small-group discussions in relation to students' understanding.

- The most common stimuli used to promote discussion were prepared curriculum materials, followed by practical work and then computer software.

- A diversity of measures was used to assess effects on understanding and attitude.

- Very little research has been done on small-group discussions in relation to the teaching of chemistry.

- Typical small-group discussions involved groups of three to four students emerging from friendship ties; they had a duration of at least 30 minutes.

- Typical small-group discussions had individual sense-making as their main aim (as opposed to, for example, leading to a group presentation).

- The most common research strategy was that of case study.

- Twenty-eight studies had experimental designs, of which 12 are RCTs.

- The most popular techniques for gathering data were observation, videotapes and audiotapes of discussions, interviews, questionnaires and test results.

Ten studies were included in the in-depth review which focused on the effect of using different stimuli on students' understanding of the use of evidence in small-group discussions. Following the application of the EPPI-Centre methods for assessing studies, seven were considered to be appropriately focused and of sufficient standard to form the basis for a synthesis of their findings.

The foci of the studies considered for the synthesis of this in-depth review vary somewhat. Therefore many of the findings have, on purpose, been cast in tentative terms because of their narrow evidence base.

The two findings that emerged most strongly from this review are as follows:

- Small-group discussion, focused on understanding the use of evidence, regardless of the prompt stimulus, is enhanced and focused by giving students some form of guidance on how to use that stimulus effectively. This guidance can be prior training in argumentation that provides instruction on how to use evidence or can be built into the structure or sequence of stimulus-based task.

- Second, a successful stimulus for students working in small groups to enhance their understanding of evidence has two elements. One requires students to generate their individual prediction, model or hypothesis which they then debate in their small group (internally driven conflict or debate). The second element requires them to test, compare, revise or develop that jointly with further data provided (externally driven conflict or debate).

Other findings of interest are given below:

- Prior knowledge can sometimes limit the understanding of evidence and its function. This can, for example, be the use of incorrect or inadequate factual knowledge or an idiosyncratic or inconsistent use of evidence to develop a hypothesis or test a model.

- Rich stimuli, such as those that provide complex and open-ended engagement, enhance opportunities for developing understanding of evidence.

Conclusions

Strengths of the review

The review has a number of strengths:

- The review focus is highly topical. The Review Group has already been contacted by potential users interested in the findings. Further evidence of the topicality comes from the range of countries in which studies have been undertaken and from the dramatic rise in relevant published papers since 1992.

- The review has served to establish that there is consistency in the research approaches that those working in the area feel are appropriate to researching practice related to the use of small-group discussions. Such approaches make use of quantitative data, but also draw extensively on qualitative data in the form of students' written responses, interviews and audiotapes of dialogue during discussions.

- End-users of the review findings have been closely involved at all stages of the review.

- Quality-assurance results are high for all stages of the review.

Limitations of the review

The review has two main limitations:

- There was a scarcity of studies that focused on the stimulus as a discrete independent variable, which resulted in very little work emerging which related specifically to the in-depth review question. Of the ten studies that had an overall weighting of medium-high or medium, only in seven was the stimulus the variable that was being evaluated. As a result, only these seven studies were judged to be of reasonable weight with respect to the review question.

- Although the studies in the in-depth review share a number of similar characteristics at the broad level, there are considerable differences at the detailed level. For example, there is considerable variety in the nature and purpose of the discussion tasks, in the data collected, and in the interpretation of the terms 'evidence' and 'understanding of evidence'. Thus, teasing out the findings which specifically relate to small-group discussions and to particular stimuli was not easy, and a number of the findings appeared to be very specific to the particular study from which they emerged rather than suggestive of any overall patterns.

Implications for policy

The Review Group is cautious about commenting on implications of the review for policy for the reasons given in the preceding section on 'Limitations'.

The review has *not* yielded any evidence that inclusion of any specific stimulus for small-group discussions adversely affects students' understanding of the nature of evidence. However, it should also be noted that there is a scarcity of high quality research evidence in the area on which the in-depth review focused.

Where small-group discussions are advocated as a teaching approach, it is important to support this with guidance on running such discussions in a way which will increase the effectiveness of students' learning. Such guidance should include advice to students on how to use materials for the purposes of discussion, as well as the stimulus materials themselves.

Implications for practice

The Review Group is cautious about commenting on implications of the review for practice for the reasons given in the preceding section on 'Limitations'.

The review has indicated that there is a diversity of ways in which the term 'understanding of evidence' is being interpreted. One implication for practice is therefore that teachers should be aware of this lack of clarity.

A further implication is that the success of small-group discussion, whatever the stimulus, depends in part on the students receiving some guidance on how to carry out or structure their discussions. That guidance might be written instruction, cues built into computer software or verbal support from teachers.

Presenting a task that offers opportunities for students to generated both their own input (e.g. own predictions, hypotheses, internal debate/conflict) and requirement to use that in conjunction with the stimulus provided by the teacher whether written, computer software or practical work (external debate/conflict) can be beneficial.

Tasks which are rich (i.e. complex and open-ended) are more likely to promote discussion and understanding of evidence in science than are simple or closed tasks.

Students' lack of sufficient factual knowledge of the subject of the task and/or of a systematic and consistent approach to the use of evidence can impede learning about evidence, unless support is given.

Teachers should also be aware of the lack of high quality research evidence in the area on which the in-depth review focused.

Implications for research

Secondary research

Exploration of additional areas of the systematic map would appear to be particularly helpful to provide a broader picture of research findings on small-group discussion work. Such areas would include the following:

- the use of small-group discussions in relation to the development of understanding of socio-scientific issues
- aspects to do with group composition, exploring, for example, relationships between group size or gender balance within groups and development of conceptual understanding
- the effectiveness of small-group discussions for different learning outcomes (e.g. attitude, decision-making)
- the nature of small-group discussions

Primary research

One particularly strong feature, which has emerged from the work undertaken for the review, is that there is a dearth of systematic research on small-group discussion work and considerable uncertainty on the part of teachers as to what they are required to do. Both these factors point to a pressing need for a medium- to large-scale research study which focuses on the use and effects of a limited number of carefully-structured, small-group discussion tasks aimed at developing various aspects of students' understanding of evidence.

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APPENDIX 1

Studies included in review map and synthesis

The 94 studies included in the systematic map were reported in 119 papers. For the purpose of the map and synthesis, one paper was selected as the lead paper for each study. Subsidiary papers are marked with an asterisk*. The 10 studies included in the in-depth review are highlighted in bold.

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