



A systematic review of the use of small-group discussions in science teaching with students aged 11-18, and their effects on students' understanding in science or attitude to science

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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.

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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 focuses on 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 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 (Department for Education and Employment (DfEE), 1998) in England and Wales)

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 review research question is:

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 mapping of the area revealed a wide range of relevant studies. A more limited focus was therefore adopted for the in-depth review, with the review question being limited to evaluative studies of students' understanding of evidence in science.

The in-depth review research question is:

What is the evidence from evaluative studies of the effects of small-group discussions on students' understanding of evidence in science?

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 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 compiling the weighted findings of the collective studies.

Results

The number of studies identified through the searching and screening processes established that small-group discussions were being used in a variety of ways in science lessons. However, a characteristic of many of the studies was that small-group discussions in themselves were rarely seen as discrete independent variables for investigation. Rather, the notion of small-group discussions tended to be wrapped up within other activities, often characterised as ‘collaborative learning’, a term which was used in a variety of ways and often very loosely, such that it appeared to include most activities which did not involve teacher exposition. This resulted in a considerable amount of effort being required to refine searching, screening and keywording strategies to ensure studies fell within the review focus.

Eighty-nine studies were identified for inclusion in the systematic map. The map revealed a number of characteristics of research on small-group discussions, as summarised below:

- The majority of the studies report work that has taken place in the US, the UK and Canada.
- Small-group discussions are used with all ages of student in the secondary age range.
- The majority of work focuses on small-group discussions in relation to students’ understanding.
- A diversity of measures is 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 involve groups of three to four students emerging from friendship ties, and have a duration of at least 30 minutes.
- Typical small-group discussions have individual sense-making as their main aim (as opposed to, for example, leading to a group presentation) and use prepared printed materials as the stimulus for discussion.
- The most common research strategy was that of case study.
- Twenty-eight studies had experimental designs, of which 12 were randomised controlled trials (RCTs).
- The most popular techniques for gathering data are observation, videotapes and audiotapes of discussions, interviews, questionnaires and test results.

Fourteen studies were included in the in-depth review, which focused on the effects of small-group discussions on students' understanding of evidence in science.

The consolidated evidence from this review draws primarily on the findings from studies assessed as *high*, *medium-high* and, to a lesser extent, as *medium*, in terms of the weight of evidence they contribute, as summarised above. Findings from studies weighted as *medium-low* are only considered if these corroborate findings of studies with a higher weight of evidence.

The small number of studies considered for the in-depth review are of variable quality. Therefore many of the findings have, on purpose, been cast in tentative terms because of their narrow evidence base. For that reason the findings below have been reported under two headings: those supported by *reasonable evidence* and those supported by *some evidence*. No findings are claimed to be based on *strong evidence*.

The review suggests that there is *reasonable evidence* of the following:

- The use of small-group discussions based on a combination of internal conflict (i.e. where a diversity of views and/or understanding are represented within a group) and external conflict (where an external stimulus presents a group with conflicting

views) resulted in a significant improvement of students' understanding of evidence. (From one medium-high rated study.)

- Improvement of students' understanding of evidence was not significantly different for members of all-female, all-male or mixed gender pairs. The benefit was greatest for female students when they were given several opportunities to engage with aspects of tasks related to understanding of evidence. (From one medium-high rated study.)
- Improvement of students' understanding of evidence correlated with the initial *dissimilarity* of the group members in terms of their domain-specific understandings; that is, student groups were constructed such that they contained students with as wide a range of domain-specific understandings as was possible. (From one medium-high and one medium rated study.)
- The use of small-group discussions did not affect students' ability to differentiate between observational or experimental data from opinions in a science-based text. (From one high rated study.)
- The use of small-group discussions supported by a specific programme fostering collaborative reasoning (including evaluating and strengthening of knowledge claims) improved students' metacognitive knowledge of collaborative reasoning (including their knowledge of reasoning about evidence) significantly more than for students not following the special programme. However, such gain within the treatment group depended on learners' perspective on learning: students with a *learner-as-explorer* perspective gained significantly more than peers with a *learner-as-student* perspective. (From one medium-high rated study.)
- The improved metacognitive knowledge of collaborative reasoning described above did not translate into better use of strategies while reasoning, including when dealing with scientific evidence. (From one medium-high rated study.)

The review suggests there is *some* evidence that:

- The use of either internal conflict small-group discussions (from one medium rated study) *or* external conflict small-group discussions (from one high and one medium rated study) produced improvement in students' understanding.
- The use of small-group discussions (together with specific instruction in argumentation skills) improved students' ability to construct more complex arguments. (From one medium rated study)
- The effectiveness of small-group discussions in producing an improvement in students' understanding of evidence depended on three types of understanding: understanding of the science domain, the process by which model-revision takes place, and metacognition. (From one medium rated study)
- The use of small-group discussions resulted in a significantly higher achievement in understanding of evidence for students using a cued version (that is, one which gives students specific instructions on what to include in points they make in discussions) of a computer-based instruction (CBI) program compared to a non-cued version. (From two medium rated studies.)

Although outside the specific focus of the in-depth review question, one additional finding worth noting is that there was reasonable evidence to suggest that the gender composition of small discussion groups determined the interaction style for developing students' explanatory understanding: all-male groups confronted differences in their individual predictions and explanations, while all-female groups searched for common features of their predictions and explanations across tasks, and mixed groups secured progress through turn-taking. (From one medium-high and one medium rated study.)

Conclusions

Strengths of the review

- 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.
- 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

- There was a scarcity of studies that focused on small-group discussions as a discrete independent variable, which resulted in very little work emerging which related specifically to the in-depth review question. Only seven studies were judged to be of reasonable quality with respect to the review question; that is, had an overall weight of evidence of medium or higher.
- Although the studies in the in-depth review shared a number of similar characteristics at the broad level, there were considerable differences at the detailed level. For example, there was 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 related to small-group discussions 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 Team 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 small-group discussions adversely affect students’ understanding of the nature of evidence. Therefore there is nothing to suggest that current policy (which is strongly advocating the use of small-group discussion work) should be changed. 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.

Implications for practice

The Review Team 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 teachers should 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 in providing a broader picture of research findings on small-group discussion work. Such areas would include the following:

- the nature of the stimulus provided for the group and its effect on the development of understanding;
- 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. argument, decision-making);
- the use of ICT in small-group discussions.

The Review Group will explore some of these areas in its next review.

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 89 studies included in the systematic map were reported in 114 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 14 studies included in the in-depth review are highlighted in bold.

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