The impact of enquiry-based science teaching on students’ attitudes and achievement

Can enquiry-based teaching improve students’ motivation and learning outcomes in science?
Enquiry based teaching is often seen as a way of engaging students in the learning process through group work and hands-on activities, and by challenging them to support conclusions with evidence and observations.

The researchers in this project introduced small-scale enquiry into teaching science and evaluated the effectiveness of the method in terms of the students’ attitudes towards science, their achievement and their perceptions of the learning environment in the classroom. To compare enquiry and non-enquiry teaching, 165 12-13 year old students from eight classes participated in the action research project which ran for eight weeks.

This use of small-scale enquiry was linked to positive impact on the learning environment in the classroom and some improvement in students’ achievement in science. Students from enquiry classes explored a wider range of materials during their laboratory experiments and discussed the science concepts in more depth, compared with their peers from non-enquiry classes. The effects of the enquiry-based teaching were different for male and female students.

Keywords:
USA, classroom environment, student attitudes, gender, coeducation, science, teaching methods, thinking skills

Contents
Can enquiry-based teaching improve students’ motivation and learning outcomes in science?........................................................................................................................................... 1
How effective was the use of small-scale enquiry in teaching science?................................. 2
What were the gender differences in the effectiveness of enquiry-based teaching?............ 2
What is enquiry-based teaching and how it was used?................................................................. 3
How was the research carried out?............................................................................................... 3
What are the implications?........................................................................................................... 4
Where can I find out more?.......................................................................................................... 5
How effective was the use of small-scale enquiry in teaching science?
The most significant impact of enquiry-based teaching was on student cohesiveness: the students worked closely together, offering advice and suggestions. Improvements were also noted in terms of student engagement, task orientation and cooperation. The achievement (science tests results) of the students from enquiry groups was slightly better than that of their peers from non-enquiry groups. Enquiry teaching did not seem to affect the students’ attitudes towards science.

Although students in the enquiry classes initially struggled to design their own experiments, they later became more familiar with the methods and overall process and needed less prompting and support from their teachers, compared with the students from non-enquiry classes.

During their laboratory experiments the students from enquiry classes explored a wider range of materials and discussed the science concepts in more depth. For example, when studying static electricity, the enquiry groups attempted to produce it with various objects around the room, including clothing, cement walls, floor tiles and wooden tablespots. They later concluded that the insulators were the best materials to use to create static charge. Such leaps in content knowledge were not apparent in the non-enquiry classes, where students simply tested the materials listed in instructions and did not even attempt to suggest a material of their own choice.

What were the gender differences in the effectiveness of enquiry-based teaching?
The researchers found that enquiry-based teaching was experienced differently by male and female students. Significant gender differences were noted for student cohesiveness, teacher support, cooperation and attitudes. Specifically, the teenage girls perceived the learning environment in the enquiry classes as more cooperative and cohesive, but they thought they had less teacher support and their attitudes were less positive than those of the boys. The researchers thought that this could be explained by the fact that due to the openness of the enquiry activities the boys were more likely to try explorations that were potentially disruptive or dangerous (such as climbing on the tables to reach the ceiling tiles) and thus received more attention from the teacher.

Interviews with students and teacher observations revealed that while the teenage boys were enthusiastic about being able to devise their own experiments, the girls were concerned about doing the experiments correctly. This uncertainty among the teenage girls in the enquiry classes was quite persistent, despite the good results they achieved in their
work. Girls’ confidence in this area rose very slowly and the attitude to science scores were lower for the girls from the enquiry classes as compared to the girls from non-enquiry classes, where procedures and guidelines were clearly spelled out.

In general, the study revealed that whereas male students benefited more from enquiry methods, female students seemed to prefer non-enquiry approaches in terms of attitudes to science, task orientation and cooperation.

What is enquiry-based teaching and how it was used?
In the model of enquiry-based learning used by the researchers, students used exploration, reflection and questioning techniques, shared ideas and engaged in dialogue. The role of the teacher during the process was to act as a guide who challenged the students to think beyond their current processes by asking divergent questions. The model drew on research into enquiry-based learning that shows that often students experience difficulties in formulating appropriate questions which focus on the intended content. In this context the teacher needs to help them by drawing their attention to the experimental data and facts relevant to their enquiry and by generally facilitating the discussion.

One of the key issues associated with the use of the enquiry methods in the classroom is time. Most enquiry exercises span several class sessions and can continue for weeks, which makes it difficult for a teacher to use them. This prompted the researchers to try small-scale (taking a maximum of two days to complete) enquiry activities in teaching physics.

Despite being small in scale, the laboratory activities in this project involved all the major characteristics of enquiry, for example:

- developing and planning the investigations;
- collecting and interpreting data;
- working collectively towards a common goal and
- sharing individual findings, etc.

The activities undertaken by the students as a part of enquiry-based learning in this study are similar to those recommended by a 2011 Ofsted report *Successful Science*, which suggests that the most stimulating teaching and the most enthusiastic learning in science occurs when teachers encourage their students to come up with their own ideas and, supported by their teacher, to plan, conduct, record and evaluate their investigations.

How was the research carried out?
The study involved eight classes (165 students in total) taught by two teachers. Half the classes were taught using the enquiry-based approach and half the classes acted as a comparison group. The intervention lasted for eight weeks and covered six consecutive laboratory exercises.
Enquiry and non-enquiry activities differed in their presentation. Students in the four enquiry classes were given a set of materials and a challenge statement or question, for example ‘Explore static electricity’. They were then asked to design their own set of controlled experiments, decide on appropriate data to collect and the ways of presenting it. Students in the four non-enquiry classes were given instructions to follow and data tables to fill in. For both groups each activity lasted for one lesson and was followed by class discussions. Apart from the different styles of conducting the laboratory work and discussing it, all other aspects including content and homework assignments were the same for all students.

As part of the project the students also responded to questionnaires and 20 of them participated in the interviews conducted by the researchers after the intervention to help them interpret some of the findings. A content test was taken by all the students prior to the intervention to establish that the student groups were not statistically different in achievement in physics. A content test was administered after the intervention to assess the impact of the enquiry-based teaching on students’ achievement.

The researchers gathered a range of qualitative and quantitative data; the latter was analysed statistically. The researchers aimed to find a correlation between using enquiry based approaches to teaching physics and learning environment in the classroom, students’ attitude and achievement. They recognised that not many of their results were statistically significant due to the small size of their sample and suggested that further research needs to be undertaken in order to confirm their findings.

**What are the implications?**

In completing this digest the authors began to ask the following questions about implications for practitioners:

- The study explored the benefits of enquiry-based teaching and learning, particularly in the science classroom. How do or can you use enquiry in your teaching? Would it be helpful to discuss with a colleague how you could offer your students more opportunities to come up with their own ideas and then to plan, conduct, evaluate and discuss enquiries that help them test their ideas?

- The researchers suggested that girls often lacked confidence in devising and conducting their own experiments. How could you support them when using enquiry-based learning in your classroom? Will this be something you would consider when planning your lesson, especially when deciding how to group your students for the enquiry?

School leaders might like to consider some of the following implications:

- The study found that enquiry-based learning could have a positive impact on students’ attitudes and achievement in science as well as the learning environment in the classroom, but it needs to be carefully planned and conducted. What professional development opportunities does your school offer, particularly to less confident teachers (such as those without a degree in a particular subject they teach), to support them in introducing more enquiry elements into their teaching? Would, for example,
joint planning with more experienced colleagues or a workshop on how to introduce elements of enquiry into teaching and learning, be helpful?

**Where can I find out more?**

**Original article**  
Author(s): Wolf, S. and Fraser, B.  

[Original title: Learning Environment, Attitudes and Achievement among Middle-school Science Students Using Inquiry-based Laboratory Activities]

**Other digests**  
Associations between students' perceptions of classroom environment and academic efficacy in Australian and British secondary schools – located [here](#).

Teachers' implementation of gender-inclusive instructional strategies in single-sex and mixed-sex classrooms – located [here](#).

Investigating the patterns of differential attainment of boys and girls at school [http://www.curee.co.uk/file/4986/download?token=TdcSzunh](http://www.curee.co.uk/file/4986/download?token=TdcSzunh)

The effects of cooperative learning on junior high school students during small group learning – located [here](#).

**Other research**  
Improving learning through cognitive intervention [http://www.curee.co.uk/node/4846](http://www.curee.co.uk/node/4846)


**References**  