The Institute for Effective Education was funded by the Gatsby Charitable Foundation in 2015 to carry out a short small-scale systematic review of the literature and policy documentation around practical science work. The purpose was to inform the Good Practical Science project. This document lists the studies the IEE identified, and indicates how they were considered as part of the review.

The team carried out a Rapid Evidence Assessment (REA), based on the toolkit developed by the Government Social Research Service (GSR) to “provide a balanced assessment of what is already known about a policy or practice issue, by using systematic review methods to search and critically appraise existing research” (“Rapid Evidence Assessment Toolkit index,” 2013). Further information about definitions and methodology are available in the REA report (Appendix 1) downloadable from this page: www.gatsby.org.uk/goodpracticalscience

‘Purposes’ lists various curriculum documents mapped to the purposes of practical science, and their sources.

‘Studies’, ‘Reviews’ and ‘Opinion pieces’ lists the various types of evidence identified within the Rapid Evidence Assessment and why they were included or excluded, as well as giving the source.

‘March 2017’ lists studies published after the literature search for the REA was completed, and hence are not discussed in the main report. However, the studies have been mapped to the five purposes outlined in the Good Practical Science final report (not those in the REA). Although there are many similarities between the two sets of purposes, the set in the REA was constructed from the available literature and does not reflect subsequent developments in thinking.
<table>
<thead>
<tr>
<th>Country</th>
<th>Document</th>
<th>Purpose of practical science</th>
<th>Age of students</th>
<th>Other comments</th>
<th>URLs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finland</td>
<td>National core curriculum for upper secondary schools: 2005</td>
<td>To understand the significance of experimentation and theoretical speculation in the formation of knowledge in science; to understand how knowledge is built up in science through experimentation and related modelling; to learn how to plan and carry out experiments concerning different phenomena, taking safety considerations into account; to be able to interpret, assess, present and discuss information that students have acquired through experimentation; to improve students' aptitude for scientific work, learn behavior and their ability to use different sources for the acquisition of scientific information and to assess scientific results.</td>
<td>16 to 18</td>
<td>Key word: experimentation is used instead of practical work in the document</td>
<td><a href="http://www.oph.fi/download/47678_core_scho">http://www.oph.fi/download/47678_core_scho</a> ols/2003_work_in_the_document.pdf</td>
</tr>
<tr>
<td>Singapore</td>
<td>National curriculum and Science Syllabus for Lower and Upper Secondary Normal (Technical)</td>
<td>Scientific subjects are, by their nature, experimental. It is therefore important that the candidates carry out appropriate practical work to facilitate the learning of the subject; To be able to select and organise techniques, apparatus and materials; take readings accurately; handle experimental data and observations; interpret and evaluate experimental results.</td>
<td>12 to 17</td>
<td>Key word: practical work</td>
<td><a href="http://www.moe.gov.sg/academic%E8%B3%87%E6%96%99/orange">http://www.moe.gov.sg/academic資料/orange</a> Paradise/curriculum/lower-Secondary_2014.pdf</td>
</tr>
<tr>
<td>Japan</td>
<td>Courses of Study in Japan/Science for Lower Secondary School</td>
<td>To carry out observations and experiments concerned with physical phenomena, to enable students to learn observational and experimental skills, to develop the ability to give consideration to the results of observations and experiments, and to develop and express their own ideas, and at the same time, to enable students to understand similar physical phenomena. - FOR LOWER SECONDARY: To enhance students' interest in nature and sense of inquiry, to enable them to carry out observations and experiments, and to develop attitudes and abilities to investigate scientifically, and at the same time, to deepen their understanding of natural events and phenomena, and to develop scientific views of nature. - FOR UPPER SECONDARY: To enable students to have hands-on experience on investigating concrete examples.</td>
<td>12 to 15</td>
<td>Key word: experiments, hands-on work</td>
<td><a href="http://www.mext.go.jp/b_menu/k01/ko1_17502.html">http://www.mext.go.jp/b_menu/k01/ko1_17502.html</a></td>
</tr>
<tr>
<td>Estonia</td>
<td>National curriculum for upper secondary schools (2011)</td>
<td>There are specific practical work activities and related learning outcomes for each single topic of every natural science subject</td>
<td>15 to 18</td>
<td>There is also some emphasis on discovery-based learning with practical work.</td>
<td><a href="http://www.ibe.unesco.org/curricula/estonia/curricula_2011_eng.pdf">http://www.ibe.unesco.org/curricula/estonia/curricula_2011_eng.pdf</a></td>
</tr>
<tr>
<td>China-HK</td>
<td>National Curriculum and Syllabuses for secondary schools / Science secondary 4</td>
<td>Practical work and scientific investigations are common activities in the learning and teaching of science subjects. They offer students hands-on experience of exploring, opportunities to share their interest, ingenuity and perseverance.</td>
<td>15 to 17</td>
<td>One purpose of practical work is to improve students' practical skills related to scientific investigations.</td>
<td><a href="http://www.edb.gov.hk/en/curriculum-and-op">http://www.edb.gov.hk/en/curriculum-and-op</a> portunities/curricula/curri_cic-sec-index.html</td>
</tr>
<tr>
<td>China-HK</td>
<td>Syllabuses for secondary school / Science secondary 1-3</td>
<td>Practical work is essential for students to gain personal experience of science through doing and finding out</td>
<td>12 to 14</td>
<td>Practical work may be used to develop students' understanding of the scientific concepts and principles involved, as well as their ability to handle and interpret data obtained in investigations.</td>
<td><a href="http://www.edb.gov.hk/en/curriculum-and-">http://www.edb.gov.hk/en/curriculum-and-</a> opportu-nities/curricula/curri_cic-sec-index.html</td>
</tr>
<tr>
<td>China- Shanghai</td>
<td>National curriculum for Science</td>
<td>In secondary schools, science syllabus is divided into physics, biology, earth, and chemistry. They are all separated and there are independent curricula, however English versions do not exist.</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td>Poland</td>
<td>Ministry of Education Report on the system of education in Poland</td>
<td>Upon completion of a secondary education in science, students are expected to be able to demonstrate &quot;scientific thinking&quot;, which is &quot;the ability to use scientific knowledge in order to identify and solve problems, and the ability to formulate conclusions based on empirical observation related to nature and society&quot;.</td>
<td>13 to 19</td>
<td>Secondary education is divided between &quot;stage 3&quot; lower secondary, and &quot;stage 4&quot; upper secondary</td>
<td><a href="http://www.ksr.gov.pl/ksr_publikacje/ksr_publik">http://www.ksr.gov.pl/ksr_publikacje/ksr_publik</a> aje/ksr_2013_szkolna.pdf</td>
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<tr>
<td>Estonia</td>
<td>National Science Curriculum</td>
<td>The purposes of practical work are not separated from the general purposes of science teaching so it is very hard to identify which purposes are for practical science particularly and which ones are for other teaching approaches. Very many skills are associated with practical work through the ways in which those skills can be achieved through practical work (or through any other means of teaching) are not clear. There is a clear emphasis on scaffolding during both practical work and other teaching methods.</td>
<td>15 to 17</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td>Canada</td>
<td>Ontario Curriculum</td>
<td>Practical work aims to provide students with direct experience of nature through age-appropriate activities where practical activities of students with natural objects or their models are important - analyse the natural phenomenon in the field of study through activities that are closely related to student-created and problem-based - The students learn to identify and purposefully observe the animate and inanimate objects and phenomena of nature, and to design and execute simple experiments with the focus on making observations and drawing conclusions that will help them gain important information about the world around them. - practical science is intended to help students to develop some skills of scientific investigation: - planning and designing - observing and recording - analyzing and interpreting - communicating</td>
<td>15 to 17</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td>South Korea</td>
<td>Seo, J., Min, M., &amp; Johnson, S. (1999). A comparative study of attitudes to the aims of practical work in science education in Egypt, Korea and the UK. International Journal of Science Education, 21(12), 1311-1323.</td>
<td>to develop scientific thinking, improve critical reasoning, develop students' abilities to use research methods, build capacity of students to act as reasonable citizens in everyday life</td>
<td><a href="http://www.researchgate.net/publication/26986598_Examining_students'_views_on_the_nature_of_science%2C_results_from_Korean_6th_8th_and_10th_grade_students?ev=3&amp;dir=1&amp;ref=publicationDetail_author_0_0_1">http://www.researchgate.net/publication/26986598_Examining_students'_views_on_the_nature_of_science%2C_results_from_Korean_6th_8th_and_10th_grade_students?ev=3&amp;dir=1&amp;ref=publicationDetail_author_0_0_1</a> &amp;doi=10.1180/095006999290093</td>
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<tr>
<td>England</td>
<td>Science programmes of study: key stage 4 National curriculum in England</td>
<td>to develop skills of scientific inquiry and investigation, to motivate for progressively developing skills, knowledge, understanding and attitudes to develop understanding of scientific concepts, to develop students' practical, problem solving and enquiry skills, to support working accurately and safely both individually and with others, to have an opportunity to evaluate methods of collection of data and consider their validity and reliability as evidence.</td>
<td><a href="http://www.gov.uk/government/uploads/system/uploads/attachment_data/file/381380/Science_KS4_PoS_7_November_2014.pdf">http://www.gov.uk/government/uploads/system/uploads/attachment_data/file/381380/Science_KS4_PoS_7_November_2014.pdf</a></td>
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<tr>
<td>Scotland</td>
<td>Curriculum for Excellence - Sciences: Principles and practice</td>
<td>to develop skills of scientific inquiry and investigation, to motivate for progressively developing skills, knowledge, understanding and attitudes to develop understanding of scientific concepts, to develop students' practical, problem solving and enquiry skills, to support working accurately and safely both individually and with others, to have an opportunity to evaluate methods of collection of data and consider their validity and reliability as evidence.</td>
<td><a href="http://www.education.gov.uk/childenagerights/children-who-are-looked-after/education/learningsciences/2015-syllabus.pdf">http://www.education.gov.uk/childenagerights/children-who-are-looked-after/education/learningsciences/2015-syllabus.pdf</a></td>
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<tr>
<td>Northern Ireland National Curriculum: Science Key Stage 3-4</td>
<td>11 to 16</td>
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<td>----------------------------------------------------------</td>
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<tr>
<td>1. to increase motivation, support collaborative working and connect learning about Science to the real world</td>
<td><a href="http://www.nicurriculum.org.uk/docs/key_stage_3/areas_of_learning/non_statutory">102x237</a></td>
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<td>2. to develop students' thinking skills and personal capabilities</td>
<td><a href="http://ccea.org.uk/curriculum/key_stage_3">110x1016</a></td>
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<td>3. to develop a range of practical skills when undertaking experiments, including the safe use of scientific equipment</td>
<td><a href="http://ccea.org.uk/curriculum/key_stage_4">118x1016</a></td>
<td></td>
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<td>4. to develop inquiry skills such as planning investigations, collecting appropriate data and reporting</td>
<td><a href="http://www.nicurriculum.org.uk/docs/key_stage_3/areas_of_learning/non_statutory">135x102</a></td>
<td></td>
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</tbody>
</table>
This publication was not the outcome of a Delphi study of the expert community but it was rather the result of a systematic review of the literature. The evidence suggests that practical work in science education can help students develop important skills, including critical thinking, problem-solving, and team-working. However, the effectiveness of practical work depends on how it is implemented and evaluated. The review identified several key factors that contribute to the success of practical work, including clear objectives, structured tasks, and opportunities for student engagement.

The review also highlighted the limitations of practical work when it is used as a standalone method of instruction. Practical work is often used as a supplement to other teaching methods, such as lectures and discussions. However, it is unclear how schools, teachers, and students choose to use practical work, and there is little research on the long-term effects of practical work on student learning.

Recommend inclusion: This publication provides a detailed overview of multiple sources and their take on the purpose of practical work in science education. It is a valuable resource for educators and policymakers who are interested in improving the quality of science education.

Recommend exclusion: The study makes a statistical comparison of teachers’ views vs 46 years ago rather than clear explication of the current rank order. Its results are also specific to the England & Wales context so hard to generalise.

The article reports on a case study of a high school student working as an apprentice in a university research laboratory, part of a larger project aimed at evaluating a summer science program. The study investigated one single student and the role of participation in a research laboratory, part of a larger project aimed at evaluating a summer science program. The student was observed in a research laboratory, and the results were used to understand the impact of laboratory participation on high school students' learning processes. The student engaged in a range of activities, including observing and participating in scientific research, which helped to support the view of the laboratory as a cultural system.

The student was observed in a range of activities, including observing and participating in scientific research, which helped to support the view of the laboratory as a cultural system.

Recommendation: The study investigated one single student, and the results cannot be generalized.

Hart, C., Mulhall, P., Berry, A., Loughran, J. and Gunstone, R. (2014). Year 10 in all-girls school (n=30). Mixed method approach The data sources were: * classroom observation, and field notes documenting these, throughout the unit of work (lessons over a 6-week period) * paper and pencil class survey administered about half way through the unit * copies of all student work (including laboratory reports) (n.30) (see Appendix A) * audio-taped / each analysed appropriately.

This study investigated the effects of integrated investigations on understanding of instructional materials on practical work in science. The study investigated the effects of integrated investigations on understanding of instructional materials on practical work in science.

Recommendation: The study investigated one single student, and the results cannot be generalized.
The study investigated the effects of learning simulations and laboratory activities on students' understanding of electricity concepts. Students were divided into three groups: (a) a group that learned about electricity through a simple learning simulation, (b) a group that learned through a laboratory activity, and (c) a group that learned through a combination of both a learning simulation and laboratory activity.

The results showed that students who learned through the combination of a learning simulation and laboratory activity gained more knowledge about electricity than those who learned through either method alone. Specifically, students in the combined group demonstrated a better understanding of the concepts related to electricity, such as current, voltage, and resistance.

In contrast, students in the group that learned through the laboratory activity alone had difficulty understanding the theoretical aspects of electricity, while those in the group that learned through the learning simulation alone had difficulty applying the theoretical knowledge to practical situations.

The study also found that students who learned through the combination of a learning simulation and laboratory activity reported higher levels of engagement and enjoyment compared to those in the other groups. This suggests that a blended approach to learning can be more effective than a traditional or simulation-only approach.

Overall, the study highlights the importance of using a combination of learning simulations and laboratory activities to enhance students' understanding of complex science concepts. It also suggests that educators should consider incorporating both types of activities in their teaching to achieve optimal learning outcomes.
Marcus, N., Cooper, M., & Sweller, J. (1996). Understanding students' understanding of instructions within the context of cognitive load theory. Experimental design with pre-test post-test. The participants were 30 Year 6 students (equivalent to U.S. sixth graders) from a Sydney primary school. They had no previous experience in the subject area of electricity or with diagrammatic schema, cognitive load will be reduced and understanding enhanced.


Preservice teachers' objectives and their experience of practical work. Physics Education Research, 9(1), 1-17.

The study compared students in hands-on and textbook curricula. Pre-test post-test design was used with a sample of about 1000 fifth grade students. The study focused on the effectiveness of different curricular approaches and the influence of students’ prior knowledge on achievement. The results showed little or no curricular effect, with a strong dependence on students’ prior knowledge. The study also highlighted the need for teacher training and support to improve the implementation of hands-on learning activities. Further research is recommended to explore the role of teacher efficacy and student engagement in the effectiveness of these curricula, and the impact on the learning of students from different backgrounds.
In this study, opportunities were examined for reasoning and meaning making that read-alouds of children's literature science information books and related hands-on explorations offered to young Latina/o students in an urban public school.

Using a qualitative, interpretative framework, the study findings highlight the synergistic relationship between informational texts and hands-on explorations and point to the significance and usefulness of incorporating both in science instruction so that the richness of children's learning experiences are maximized by offering them multiple access points and pathways via the assets they bring to the classroom and the ones they co-construct with their teacher and peers.

Recommendation: Setting age, single activities used in the study fall outside definition of practical work.


To investigate 14 and 15 year old students' understanding of combustion in both England and Spain, and explore the effect of practical laboratory experience on students' understanding.

The sample was about 150 students in England and Spain. The teaching and learning styles used with the students in the study were explored using questionnaires and interviews.

England and Spain 14 and 15 The responses of English and Spanish students are significantly different. The quality of the responses is explored in terms of the awareness of students of the involvement of gases in combustion, and it appears, however, that the more extensive use of practical work in English schools has had only a marginal effect on their understanding of combustion.

Recommendation: Only specific to understanding of combustion.


This study aimed to investigate the comparative value of experimenting with physical manipulatives (PM) in a sequential combination with virtual manipulatives (VM), with the use of PM preceding the use of VM, and of experimenting with PM alone, with respect to changes in students' conceptual understanding of the domain of heat and temperature.

A pre–post-comparison study design was used which involved 62 undergraduate students that attended an introductory course in physics. The participants were randomly assigned to one experimental and one control group. The 30 students in the control group used PM to conduct the experiments, whereas participants in the experimental group used PM and then VM. VM differed from PM in that it could provide the possibility of faster manipulation, but it retained any other features and interactions of the study's subject domain identical to the PM condition.

Cyprus undergrads Results indicated that experimenting with the combination of PM and VM enhanced students' conceptual understanding more than experimenting with PM alone. The use of VM was identified as the cause of this differentiation.

Recommendation: Not school age

To conduct a systematic review of research on science programs in grades 6-12. The review is very broad and does not specify a certain focus of science education reform. Experimental and quasi-experimental research were included, with a particular emphasis on meta-analyses. The selection criterion was determined by the students' perceptions and behaviours in the science laboratory. The selection criteria were not very well specified, and the selection process was not systematic. The reviewers wanted to achieve something in the final selection of studies. However, the selection process was not systematic, and the reviewers did not want to see the exclusion of studies in the review process. The results of the review are not very helpful in answering the question of whether science education is effective. The review is quite comprehensive and broad.

Searches were conducted of databases and search engines using a total of 123 search terms to capture studies in peer-reviewed journals that fell under the general description of inquiry-based science instruction. Additionally, a call for research in the form of systematic reviews was issued. The results of the review are not very helpful in answering the question of whether science education is effective. The review is quite comprehensive and broad.

Useful definition of inquiry based teaching: includes forms of teaching that distinguish between cognitive and instructional features of the learning process. Inquiry is a process of inquiry that is driven by the students' questions and hypotheses, and it involves the students in the epistemic domain of science. Inquiry is a process of inquiry that is driven by the students' questions and hypotheses, and it involves the students in the epistemic domain of science. Inquiry is a process of inquiry that is driven by the students' questions and hypotheses, and it involves the students in the epistemic domain of science.

Enhanced Context Strategies (1.48); Instructional Technology (IT) Strategies (0.48); and Knowledge Management Strategies (0.36). Regression analysis revealed that the internal validity was influenced by the type of study, type of test, and other factors. The relationship between the effectiveness of the interventions and the type of study was not very clear. The relationship between the effectiveness of the interventions and the type of test was not very clear. The relationship between the effectiveness of the interventions and the type of study was not very clear.


Jokiranta, K. (2014) The Effectiveness of Practical Work in Science Education. University of Jyväskylä. This work is an overview of the modern studies conducted to map out the factors that shape science policy in developing countries.

To conduct a meta-analysis of the effectiveness of practical work in promoting the students' conceptual understanding of science and their skills in science. The results are quite useful, but they are not very systematic. The results are quite useful, but they are not very systematic. The results are quite useful, but they are not very systematic.

Jokiranta, K. et al. (2014) The Effectiveness of Practical Work in Science Education. University of Jyväskylä. This work is an overview of the modern studies conducted to map out the factors that shape science policy in developing countries.

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A total of 23 studies met these criteria. Among studies evaluating inquiry based teaching approaches, programs that used science kits did not show positive outcomes on science achievement measures (weighted ES 0.02 in 7 studies), but inquiry-based programs that emphasized professional development but not kits did show positive outcomes (weighted ES 0.36 in 10 studies). Technological approaches integrating video and computer resources with teaching and cooperative learning showed positive outcomes in a few small, matched studies (ES 0.42 in 6 studies). The review concludes that science teaching methods focused on enhancing teachers’ classroom instruction throughout the year, such as cooperative learning and science-reading integration, as well as approaches that give teachers technology tools to enhance instruction, have significant potential to improve science learning. Not systematic. The review is divided into five sections: 1. Educational Investment in Developing Countries concerns economic efficiency in education. 2. Science for Adult Life summarizes research on what adults know and what they need to know. 3. Time and Motivation in Science shows the importance of these variables for science learning and continuing study. 4. Science Teaching Reforms describes effective methods of teaching. 5. Science Curriculum Reforms reviews and evaluates some of the major science curriculum ideas since 1960.
### Opinion pieces

<table>
<thead>
<tr>
<th>Article</th>
<th>Statement of purpose</th>
<th>Methodology</th>
<th>Country</th>
<th>Age of students</th>
<th>Key findings</th>
<th>Inclusion &amp; why</th>
<th>URLs</th>
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<tr>
<td>Smith, R. H. &amp; Diuggan, F. (2007).</td>
<td>To forge a link between scientific experimentation in schools and emerging ideas of scientific literacy through argumentation.</td>
<td>Opinion piece paper</td>
<td>England</td>
<td>12 to 16</td>
<td>Public claims can be used to forge a link between scientific experimentation in schools and emerging ideas of scientific literacy.</td>
<td>Recommend inclusion: the paper has many useful ideas to support the necessity of reflection and interaction required for practical work in school science to be effective to achieve its purpose of improving students’ understanding of key concepts.</td>
<td><a href="http://www.tandfonline.com/doi/abs/10.1080/02635140701535000">http://www.tandfonline.com/doi/abs/10.1080/02635140701535000</a></td>
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<tr>
<td>Rolston, L. (2016).</td>
<td>The opinion piece paper urges teachers and teacher educators to draw careful distinctions among four basic learning goals.</td>
<td>Opinion piece paper</td>
<td>New Zealand</td>
<td>12 to 16</td>
<td>The author argues clearly that learning goals should be taken into account in deciding about the teaching approaches including practical work examples.</td>
<td>Recommend inclusion: the paper argues very clearly with appropriate evidence that learning goals should be taken into account in deciding about the teaching approaches including practical work examples.</td>
<td><a href="http://dx.doi.org/10.1080/02635140701535000">http://dx.doi.org/10.1080/02635140701535000</a></td>
</tr>
<tr>
<td>Kirschner, P. A., Sweller, J., &amp; Clark, R. E. (2006).</td>
<td>An examination of the impact of hands-on, participatory learning on students' scientific knowledge and that of developing students' knowledge about science.</td>
<td>Opinion piece paper</td>
<td>England</td>
<td>12 to 16</td>
<td>Although unguided or minimally guided instructional approaches are very popular and intuitively appealing, the point is made that these approaches ignore both the structures that constitute human cognitive architecture and evidence from empirical studies over the past half-century that consistently indicate that minimally guided instruction is less effective and less efficient than instructional approaches that place a strong emphasis on guidance of the student learning process. The advantage of guidance begins to recede only when learners have sufficiently high prior knowledge to provide “intrinsic” guidance. Recent developments in instructional research and instructional design models that support guidance during instruction are briefly described.</td>
<td>Recommend inclusion: the research is relevant but lack specificity to practical work in the sciences.</td>
<td><a href="http://dx.doi.org/10.1207/s15326973ep4102_7">http://dx.doi.org/10.1207/s15326973ep4102_7</a></td>
</tr>
<tr>
<td>Millar, R. (2004).</td>
<td>The role of practical work in the teaching and learning of science Paper presented at the High school science laboratories: Role and vision, Washington, DC.</td>
<td>Opinion piece paper</td>
<td>England</td>
<td>12 to 16</td>
<td>The purpose of this paper is to explore and discuss the role of practical work in the teaching and learning of science at school level.</td>
<td>Recommend inclusion: the research is relevant but lack specificity to practical work in the sciences.</td>
<td><a href="http://www.tandfonline.com/doi/abs/10.1080/02635140701535000">http://www.tandfonline.com/doi/abs/10.1080/02635140701535000</a></td>
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<td>Millar, R. (2004).</td>
<td>Designing a science curriculum fit for purpose.</td>
<td>Opinion piece paper</td>
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<td>12 to 16</td>
<td>The purpose of this paper is to suggest a clear view of the purposes of science education rooted in a view of the purposes of education itself.</td>
<td>Recommend inclusion: the research is relevant but lack specificity to practical work in the sciences.</td>
<td><a href="http://www.tandfonline.com/doi/abs/10.1080/02635140701535000">http://www.tandfonline.com/doi/abs/10.1080/02635140701535000</a></td>
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<td>National Research Council (2000).</td>
<td>Inquiry and the national science education standards: A Guide for teaching and learning. Washington, DC: National Academies Press.</td>
<td>Policy paper</td>
<td>USA</td>
<td>12 to 16</td>
<td>Policy paper: students who use inquiry to learn science engage in many of the same activities and thinking processes as scientists who are seeking to expand human knowledge of the natural world. For the activities and thinking processes used by scientists are not always familiar to the educator seeking to introduce inquiry into the classroom. By describing inquiry in both science and in classrooms, this volume explores the many facets of inquiry in science education. Through examples and discussion, it shows how students and teachers can use inquiry to learn how to think.</td>
<td>Recommend inclusion: the research is relevant but lack specificity to practical work in the sciences.</td>
<td><a href="http://www.nap.edu/openbook.php?record_id=9596&amp;page=R5">http://www.nap.edu/openbook.php?record_id=9596&amp;page=R5</a></td>
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<tr>
<td>Kirschner, P. A., Sweller, J., &amp; Clark, R. E. (2006).</td>
<td>Inquiry and the national science education standards: A Guide for teaching and learning. Washington, DC: National Academies Press.</td>
<td>Policy paper</td>
<td>USA</td>
<td>12 to 16</td>
<td>We reflect on the world around us by observing, gathering, assembling, and synthesizing information. We develop and use tools to measure and observe as well as to specify, information and create models. We check and re-check what we think will happen and compare results to what we already know. We change our ideas based on what we learn.</td>
<td>Recommend inclusion: the research is relevant but lack specificity to practical work in the sciences.</td>
<td>Recommend exclusion: Not relevant to case studies</td>
</tr>
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### Notes
- **Policy paper**: students who use inquiry to learn science engage in many of the same activities and thinking processes as scientists who are seeking to expand human knowledge of the natural world. For the activities and thinking processes used by scientists are not always familiar to the educator seeking to introduce inquiry into the classroom. By describing inquiry in both science and in classrooms, this volume explores the many facets of inquiry in science education. Through examples and discussion, it shows how students and teachers can use inquiry to learn how to think.
<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Title</th>
<th>Country</th>
<th>Document Type</th>
<th>Summary</th>
<th>Recommendation</th>
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<tbody>
<tr>
<td>Wellington, J.</td>
<td>1998</td>
<td>Practical Work in School Science: Which Way Now?</td>
<td>England</td>
<td>Edited book</td>
<td>Chapters contributed by various authors. Wellington concludes that practical science is a necessary part of the curriculum, but there should be no one set format. It should combine hands-on with minds-on (e.g., analyzing third party data sets), use of simulations, IT, controversial issues, and an extended science investigation rather than the artificial, lesson-based ones. Important to link theory and practice. Purposes of practical should be made explicit to students.</td>
<td>Recommend inclusion (Refer: Debnire chapter included under Reviews)</td>
</tr>
<tr>
<td>White, R. T.</td>
<td>1996</td>
<td>The link between the laboratory and learning.</td>
<td>Australia</td>
<td>Opinion piece paper</td>
<td>Paper argues the link between practical work and student learning, discusses the currently available evidence about the effectiveness of practical work. Despite the costs, laboratories are so embedded in the practice of science teaching it is difficult to imagine doing without them. Yet their purpose is not universally agreed, and evidence of their effect is equivocal.</td>
<td>Recommend inclusion</td>
</tr>
</tbody>
</table>
Interviews Taiwan Secondary school Three different types of teachers with distinctive features were identified: technology-infusive (TI), technology
classroom.
doi:10.1371/journal.pone.0120638

discourse analysis Finland 13 year olds Subject-specific language is useful for content and language integrated learning Excl - very small study, focused on language

to explore various concerns about introducing a combination of new technology and pedagogy, eg how to best
design scripted personal technologies, how teachers can be enabled, how the activities support learning.

US 8th grade from one middle school Significant pre/post improvement and large effect size. But no comparison group so really just saying they were
augmented virtual approaches can be useful in real classroom context.

propose a model of adaptive expertise to better understand teachers’ classroom practices 3 case studies US high school using an adaptive expertise model helps professional developers and researchers interested in learning how
contextualized classroom enactment

positive STEM dispositions in secondary school students. Journal of Science Education and Technology, 24(6), 898-
type of activities or gender

to explore students’ understanding of chemical kinetics and their science process skills when engaged in the use of

Incl - tho small scale, no control, identical pre/post test 9 days apart, v short topic

Incl (though small-scale)

Argues that practical work is dominated not by scientific inquiry but by group processes. Though small scale
ethnography, raises interesting points about considering social interaction in practical work as it’s so often based on
small group working.

Rev

Synthesis of post-2005 comparing learning outcomes of trad vs non-trad lab users K-HE 56 studies met the inclusion criteria: 65% showed learning equal or higher in NTL across all six learning outcome