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Synergies in critical reflective practice and science: Science as reflection and reflection as science

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Abstract

The conceptions of reflective practice in education have their roots at least partly in the work of Dewey, who describes reflection as “the active, persistent, and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it and the further conclusions to which it tends” (Dewey 1933, p.9). This conception of reflection has carried on into more-focused efforts to describe critical reflection as a tool for improving professional practice (where academic and educational practice is the particular interest of this study); “… some puzzling or troubling or interesting phenomenon” allows the practitioner to access “the understandings which have been implicit in his action, understandings which he surfaces, criticizes, restructures, and embodies in further action” (Schön 1983, p. 50). Both of these descriptions embody a central idea of critical reflective practice: that the examination of practice involves the divination (in a rational, critical sense) of order and perhaps meaning from the facts at hand (which, in turn, are brought to light by the events that occur as the results of implementation of theory). As part of a lecture series, Gottlieb defined science as “an intellectual activity carried out by humans to understand the structure and functions of the world in which they live” (Gottlieb 1997). While science and critical reflective practice attempt to build models about different parts of our world – the natural world and the world of professional (educational) practice respectively – both embody certain underlying aims and methodologies. Indeed, it is striking that in these definitions the simple replacement of the terminology of reflective practice with the terminology of science (or vice versa) leads to a perfectly comprehensible definition of either.

It is this confluence that this paper studies, building from two separate foundations, critical reflective practice and science. Via their models and exemplars of their “models-in-practice” – action research and the scientific method – the paper forms a bridge between two empirical practices. We contend that the ability to do this is no accident, but stems from a deeper substrate that they have in common: empirical epistemology, as expressed in post-enlightenment models of the development of reliable knowledge.

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> *Another error is an impatience of doubt, and haste to assertion without due and mature suspension of judgment. For the two ways of contemplation are not unlike the two ways of action commonly spoken of by the ancients: the one plain and smooth in the beginning, and in the end impassable; the other rough and troublesome in the entrance, but after a while fair and even. So it is in contemplation: if a man will begin with certainties, he shall end in doubts; but if he will be content to begin with doubts, he shall end in certainties.*
>
> Francis Bacon (1605)

Introduction

The conceptions of reflective practice in education have their roots at least partly in the work of Dewey, who describes reflection as "the active, persistent, and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it and the further conclusions to which it tends" (Dewey 1933, p.9). This conception of reflection has carried on into more-focused efforts to describe critical reflection as a tool for improving professional practice (where academic and educational practice is the particular interest of this study); "… some puzzling or troubling or interesting phenomenon" allows the practitioner to access "the understandings which have been implicit in his action, understandings which he surfaces, criticizes, restructures, and embodies in further action" (Schön 1983, p. 50). Both of these descriptions embody a central idea of critical reflective practice: that the examination of practice involves the divination (in a rational, critical sense) of order and perhaps meaning from the facts at hand (which, in turn, are brought to light by the events that occur as the results of implementation of theory). As part of a lecture series, Gottlieb defined science as "an intellectual activity carried out by humans to understand the structure and functions of the world in which they live" (Gottlieb 1997). While science and critical reflective practice attempt to build models about different parts of our world – the natural world and the world of professional (educational) practice respectively – both embody certain underlying aims and methodologies. Indeed, it is striking that in these definitions the simple replacement of the terminology of reflective practice with the terminology of science (or vice versa) leads to a perfectly comprehensible definition of either.

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Models of Critical Reflective Practice

Although we are primarily interested in critical reflective practice as a tool for advancing teaching practice, it is clearly also a meta-cognitive learning process: it involves thinking and learning about how we think about teaching). Thus much of the background theory for reflective practice

derives from theory about learning. As a result of these broader beginnings, there are many models of critical reflective practice.

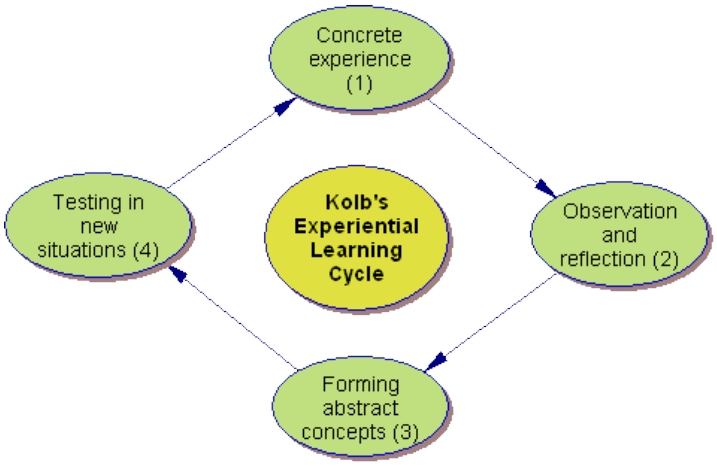

Figure 1. A visualisation of Kolb's experiential learning process. Source: http://www.learning-theories.com/experiential-learning-kolb.html

Possibly the earliest attempt at formalising the ideas of critical reflection (here we specifically emphasise our use of the word critical) is the contrast between single-loop and double-loop learning laid out by Argyris and Schön (1978). They built on their earlier hypothesis (Argyris & Schön 1974) regarding the "mental maps" people (or organisations) use to conduct their actions. The single-loop approach, in essence, does not learn from errors – that is, it does not reflect. Argyris (1980) later argued that much of this behaviour may be due to the people or organisations being unaware of their models of behaviour – that is, they are uncritical. The critical reflective approach, in their conception, is embodied by the double-loop learning approach, in which models are modified in response to failures so that in similar situations the model will hopefully be less likely to fail. Being one of the simpler models, it clearly shows the basic components of critical reflective practice: a critical incident, reflective consideration and modification of mental models, connected in an iterative structure of continually attempted improvement.

Influenced by Piaget's (1926; 2001) ideas of reflective abstraction in developmental learning, Kolb (1984) developed a reflective-practice model based on experimental experience; he wrote that "learning is the process whereby knowledge is created through the transformation of experience" (Kolb 1984, p. 38). In dealing with learning in general, rather than professional practice, Kolb presents a more adaptable model that more clearly identifies four basic steps of critical reflection: experience, reflective observation, conceptualisation (or modelling) and experimentation (Figure 1). The important advancement that Kolb's model makes on that of Argyris and Schön (1974) is the explicit recognition of the importance of experimentation in the learning process. Although Argyris and Schön refer to applying the new model when similar situations arise, Kolb's model explicitly emphasises the conscious and directed act of testing the new model to validate it as a step within the same iteration of the cycle, rather than the start of a new cycle (although all of these models very easily become recursive, generating cycles within cycles). This demonstrates the meta-cognitive component of effective critical reflective practice.

Gibbs (1988) expanded on Kolb's more abstract model by providing a series of practice-oriented tools to help practitioners engage productively in the steps of Kolb's learning cycle. One prominent tool he proposed was the structured debriefing, which employs directed questions to guide the practitioner through the learning cycle. This process is often broken down into six stages:

1. Description
2. Feeling
3. Evaluation
4. Analysis
5. Conclusion
6. Action plan.

Although this process is more detailed than Kolb's broader model, the distinct, important components of identification of a problem (step 1), reflection on the implications (steps 2 and 3), adjustment of current models (steps 4 and 5) and experimental verification or plans (step 6) are again present.

Johns (1994, 1995) provides an even more structured practical guide for critical reflection. Because it was specifically formulated for reflection in nursing practice, Johns's model is quite precise and detailed. However, as Cox (2006) highlights, the fundamental learning cycle is still present in its four underlying stages:

1. Description of experience
2. Reflection
3. Influencing factors
4. Learning.

Here the experimental step is deemphasised. Johns also attempts to bring in other modes of "knowing" (Carper 1978), in a reaction to the apparent over-emphasis of "empirical" observation in nursing. However, a more considered examination of Carper's patterns of knowing reveal that this use of "empirical" is restricted and peculiar – in fact all four modes are empirical in the sense that they are a posteriori rather than a priori knowledge. As Grech (2004, p. 71) notes, "Central to Johns' idea of reflective practice is the goal of accessing, understanding and learning through lived experience."

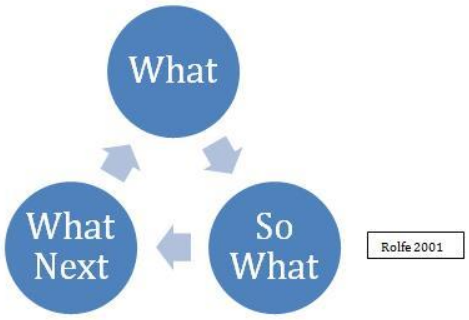

Figure 2. Rolfe et al.'s simplified model of reflection. Source: http://en.wikipedia.org/wiki/Reflective_practice

Rolfe, Freshwater and Jasper (2001) (again from the area of nursing reflection practice) simplify the loop to three simple questions (Figure 2): what, so what and what next? Although this is a much simpler model, it manages to bring forward a key aspect of critical reflection: that it is an active, experiential process designed to gather empirical evidence, analyse it and provide adjustments (possibly dramatic adjustments) to the cognitive models of relevant practice to facilitate improvement.

To bring these ideas back to the philosophical underpinnings, critical reflection is concerned with how models of practice can be altered to be as accurate and useful as possible in a reliable way. That is, critical reflection is a practical implementation of epistemology, applied to conscious practices and processes that humans undertake.

Action Research

Action research is an interesting offshoot of reflective practice, with a variety of generative ideas from various thinkers. It describes a loose series of methods for engaging in action, with the common tie that the processes are reflective. For our purposes it provides examples of robust methodologies for the conduct of research (where we emphasise the French root of the word rechercher – to search).

One theory is developed from Argyris's work on Action Science (Argyris 1970, 1980, 1994; Argyris, Putnam & Smith 1985) that emphasises collaboration and research, in contrast to theories that emphasise the individual reflective practitioner in a situation of professional practice. It can be noted that research itself is a form of professional practice, thus this distinction of context may not be relevant. Action research attempts to draw a contrast to experimental research in that experimental research controls (or attempts to control) all variables in a situation, leading to an isolated environment.

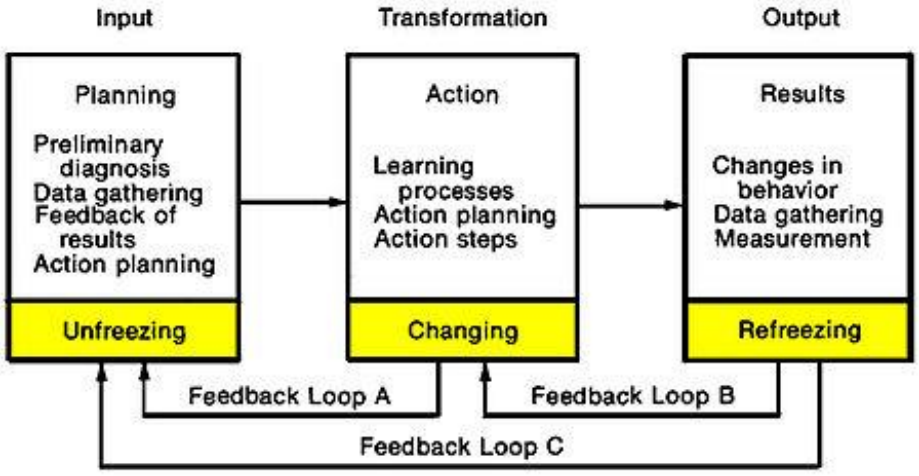

Figure 3. A generalised representation of action research based on Lewin's model (Lewin 1946). Source: http://en.wikipedia.org/wiki/Action_research

Participatory action research builds on social-psychology theory via Lewin (1946) and pedagogy via Freire (1970). Participatory action research also explicitly employs a cyclical approach in which action and research are planned, enacted, observed, evaluated and critically reflected on in

iterative cycles (McNiff & Whitehead 2009; O'Brien 2001). Although the focus in participatory action research is on engaging all stakeholders in the process of action and change, it is constructed as a reflective process.

Figure 4. A simpler representation of action research. Source: https://www.det.nsw.edu.au/proflearn/research/actres.htm

More broadly, action-research processes employ feedback loops to evaluate and modify the aim and methodology of the research in question, during the research. Figure 4 gives a diagrammatic representation of these processes, in which change is enacted through three basic steps: unfreezing, where the need for change is recognised through a critical incident or incidents; changing, where the processes and models are altered and tested; and refreezing, where the new model is evaluated and either rejected or adopted. The feedback loops represent the possible transitions to other states; for example, if a new model is unsatisfactory, loop B is in operation and the model undergoes further change and evaluation.

This conception is in fact a rather complex tangle. Figure 5 gives a visual representation of the untangling. This representation again shows the four basic steps linked together in a feedback loop, where an action is performed, results observed and reflected on and any changes planned. Of particular note is the identification of verbs that describe the transitions between the different stages of the action-research process. These verbs are echoed in the detailed reflective methods of Kolb and Johns.

Models of Science

Science (derived from the Latin scientia, or "knowledge") as we conceive of it in the modern world is a complex and manifold idea. In one sense, it is "simply" a collection of reliable knowledge about the natural world. This meaning dates back at least to Aristotle, although Aristotle only considered high-order theorising as science – the actual gathering of data was secondary (Aristotle n.d., p. VI 1139b). The Renaissance and the Enlightenment reformed this

view through the experimental work of Bacon, Galileo, Kepler, Newton, Brahe, Hook, Lavoisier and others. In this new conception, embodied first by Roger Bacon and expounded in the third volume of Newton's Philosophæ Naturalis Principia Mathematica, empirical observation and experimentation was emphasised as the core method through which science could be advanced. The coalescence of these ideas by the 19th century led to the explicit concept of the scientific method. Before discussing the scientific method further, it is illuminating to consider some philosophical definitions and explanations of science (as science is not identical to the scientific method), bearing in mind the goals of reflective practice.

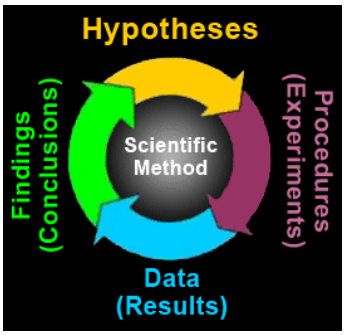

Figure 5. The basic cycle of the scientific method. Source: http://mccarthyi.edu.glogster.com/mrsmacscitoolz/

Siepmann (1999) provides perhaps one of simplest but still meaningful definitions of science as "the field of study which attempts to describe and understand the nature of the universe in whole or part". Considering this in the context of reflective practice, science could be conceived of as reflection on nature, in contrast to the human-practice focus of critical reflective practice.

Gilbert provides an alternative perspective:

> One possibility is to define science as a process of constructing predictive conceptual models. This definition unites both the processes and product of science…. Within this framework, the purpose of research is to produce models which represent consistent, predictive relationships.
>
> (Gilbert 1991, p. 73)

Again, if this definition of science is considered in the context of the aims of critical reflective practice, the synergies become apparent: critical reflective practice aims to produce models of practice that are predictive, in the sense that they provide predictable results, and consistent, in that they match the reality of the practice's context.

One of the key elements of science is that its conclusions are built on observation; that is, its claims should be empirically falsifiable; that is, able to be challenged and perhaps disproved (Popper 1934). Although not formulated in this manner, critical reflective practice employs the same idea: models are formulated (this is identical to making a claim) and tested in practice to discern their applicability; they are compared against observation and either empirically falsified or partially validated.

The Scientific Method

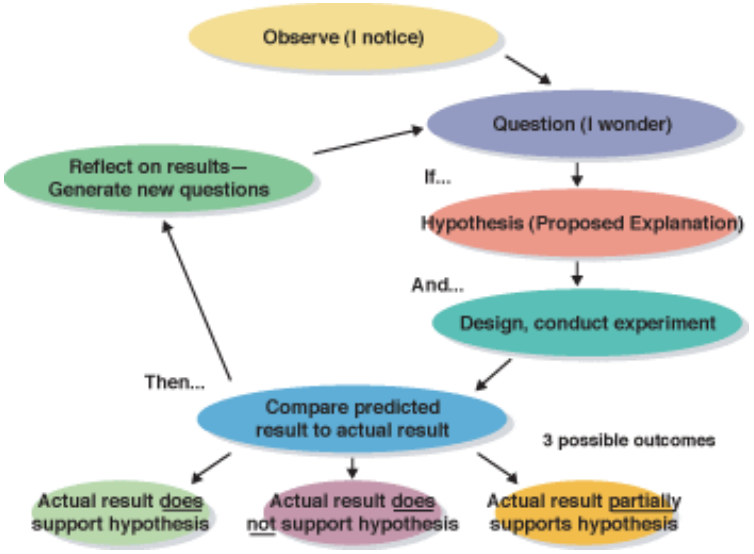

Figure 6. An expression of the scientific method. Source: http://scene.asu.edu/habitat/s_method.html

The key methodological philosophy that guides the vast majority of scientific practice is the scientific method. In practice this term refers to a body of techniques that satisfy certain constraints. Chief amongst these is that the evidence must be empirical and measurable[1] (Newton 1687). This empiricism is summed up by Ørsted (1997, p. 292): "The foundation of general physics...is experience. These...everyday experiences we do not discover without deliberately directing our attention to them. Collecting information about these is observation." Alongside this, four basic steps outline the structure of most expositions of the scientific method (Godfrey-Smith 2003; Jevons 1874; Galilei 1638):

1. Observation of interesting phenomena. (Ørsted 1997)
2. Hypothesis regarding the explanation. (Feynman 1965; Ørsted 1997)
3. Prediction based on the hypothesis. (Ørsted 1997)
4. Experimental testing of the hypothesis. (Galilei 1638)

[1] Though "measurable" is the typical term, "comparable" may be more accurate. Similarly, "quantifiable" tends to cause unnecessary consternation when the real intent is that phenomena be adequately describable such that accurate and useful information can be derived, rather than that there is a particular set of numerical units that can be used to quantify them.

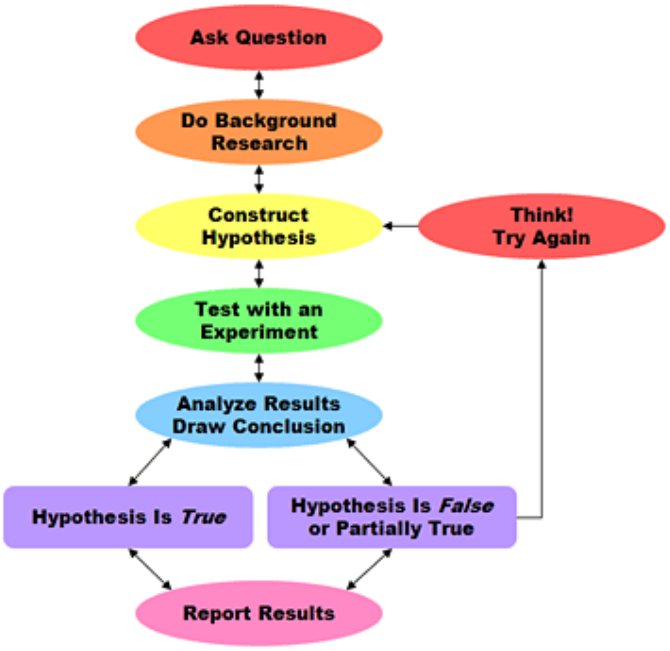

Figure 7. A more complex visualisation of the scientific method. Note the emphasis on the step labelled "Think!". Source: http://www.sciencebuddies.org/science-fair-projects/project_scientific_method.shtml

Importantly, these steps occur in iterations, or even recursions, with whole cycles interleaved between steps. Brody (1993, p. 10) says that this "epistemic cycle starts from an initial model; iterations of the cycle then improve the model until an adequate fit is achieved".

While different presentations of the scientific method vary in complexity and detail, all have at their heart this repeating cycle of observation, hypothesis, prediction and testing, or in the terminology used to describe critical reflective practice, experience, reflection, formation of abstract models and testing. In fact, some formulations make this resonance even clearer. For example, Figure 6, which gives a naturalistic presentation of the scientific method, explicitly includes reflection as a key step – note that it also highlights the cyclical nature of the experimental process, showing reflection as a result of the observation of the results.

Other formulations reflect further aspects of reflective practices. Figures 4 and 5 in particular show the level of congruence in the basic format of the scientific method and the basic format of action research.

Even when different aspects are emphasised, the underlying essence of both processes that embody critically reflective practice and those that embody scientific practice – the dominant example of which being the scientific method – show clear systemic and philosophic congruencies (Gibbs 1988, p.1). In particular, the scientific method emphasises critical reflective thought (Figure 7). The key difference is that critically reflective practice takes as its subject systems and processes enacted by humans in a societal context, whereas the scientific method focuses on natural phenomena and systems.

Empirical Epistemology

While it is clear that critical reflective practice and science share some basic methodological philosophies, the relationship stems from a deeper source. Epistemology is the branch of philosophy concerned with knowledge: what it is, how it is acquired and to what extent things can be known.

Naturally, both critical reflective practice and science are deeply concerned with epistemology, though often tacitly. They are both concerned with acquiring knowledge and using it to advance our understanding and capabilities. Interestingly, despite the depth and complexity of epistemology as a branch of philosophy, both critical reflective practice and science have arrived at essentially the same practical model of epistemology.

Given that critical reflective practice and science are practically oriented, it is natural that in terms of their epistemology they are both primarily concerned with how knowledge is acquired, rather than what knowledge is. While, ultimately, the discourse regarding traditional conceptions of knowledge, the Gettier problem (Gettier 1963), reliabilism (Goldman 1967) and the debate between internalism and externalism (Cohen 1984; Brueckner 1999; Putnam 1981) have implications for both, the fact that they remain unresolved philosophical questions renders them in practice irrelevant to any field of inquiry that requires knowledge to be collected.

A fundamental distinction between methods of obtaining knowledge is whether knowledge is a priori (known independently of experience) or a posteriori (dependent on experience). While there are, no doubt, some who would argue, it seems natural any area of inquiry where the goal is to develop working models of external systems (good professional practice such as teaching, on one hand, the natural world on the other) would come quickly to the conclusion that the relevant knowledge must be a posteriori: while a particular model may be right from first conception, the only way to know with any degree of certainty is to test it empirically.

An examination of a posteriori knowledge leads naturally to empiricism. While there are several types of empiricism, the common element is an emphasis on knowledge gained through experience. In particular, Pierce's (1903) modification of empiricism, pragmatism, ties together elements of British empiricism, phenomenalism, logical positivism and rationalism. It emphasises knowledge from experience and rational, conceptual thinking. By allowing inductive and deductive reasoning to complement each other, rather than compete, and by developing the idea of abductive reasoning (essentially the process of hypothesising in the formal sense), Pierce tied together many notions of science and the scientific method into a coherent whole. It was Pierce's influence that led Dewey to instrumentalism (Dewey 1903), which has come to inform the theory of critical reflective practice as it stands today.

Conclusion, or what was the point of all that?

It is certainly intellectually interesting to examine what seem to be two fields of thought far removed from each other and find such similarity. To trace this similarity back to an essential underlying philosophy of natural and effective knowledge development demonstrates that such methods are often effective well beyond that area. However, this is not the only reason that such an effort is interesting.

It should be beyond doubt that quality science forms one of the key pillars of an enlightened society; to ignore the natural world is at best foolish, at worst fatal. Similarly, quality in education

is essential to the functioning of society. Without an educated populace we cannot hope to improve the world in any significant way. To quote Thomas Jefferson: "I know of no safe depository of the ultimate powers of the society but the people themselves; and if we think them not enlightened enough to exercise their control with a wholesome discretion, the remedy is not to take it from them, but inform their discretion" (Jefferson 1820). Indeed, without education, science quickly crumbles. Education is the cornerstone of functional democracy and the key to diverse, tolerant society (Taylor 1990).

Thus it is important that the methods employed in either area are as good as they can possibly be. Improvement should be continually sought, at both the personal and societal level. Possibly the most effective method for spreading improvement is via the sharing of information gathered through critical reflection. By highlighting the close relationship between science and critical reflective practice we hope to extend the discourse to new participants, to expand the pool of ideas, to draw good ideas from wider sources and to link disciplines together.

The demonstration of such similarities is also important in overcoming academic partitions, currently referred to as "silo-isation". Academic disciplines tend to wall themselves off from each other. In the best case this leads to unnecessary repetition of important research. In the worst one discipline might actively shun ideas from another, to both their detriment. Education academics may reject science, falsely equating it with obsessive measurement and calculation, thus depriving themselves of centuries of methodological learning and scholarship; similarly, scientists may reject educational theory to the obvious detriment of their students and thus their fields. There is no reason why this should remain the case. Education needs to embrace science, and science, education. As Snow (1959, p. 53) writes, "there are steps to be taken which aren't outside the powers of reflective people", and while "education isn't the total solution to this problem, without education [we] can't even begin to cope"; therefore, "closing the gap between our two cultures is a necessity.... When those two senses have grown apart, then no society is going to be able to think with wisdom".

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