Science, Normal Science and Science Education – Thomas Kuhn and Education

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ABSTRACT Thomas Kuhn is a rarity. Widely regarded as one of the most influential theorists of the physical sciences, he has also, largely through his concept of the 'paradigm', had a sustained effect on the social sciences and education. His classic The Structure of Scientific Revolutions *is read and cited by scholars in an astonishing range of disciplines, in part due to its acquired association with progressive social research and practice. This article takes issue with Kuhn's conceptions of science and its translation into educational practice, and suggests that they do not deserve the warm embrace they have received. It is argued that Kuhn's popularity among progressive thinkers is somewhat ironic, since his portrayal of 'normal science education' is inherently indoctrinatory, presenting insurmountable barriers to acceptance as part of a liberal educational philosophy.*

INTRODUCTION: KUHN'S INFLUENCE

Thomas Kuhn was one of the most influential theorists of science of the 20th century. His views, actual and supposed, have spread through academic disciplines with a force and range of extraordinary dimensions. A recent citation analysis of publications in a wide range of disciplines (Loving and Cobern, 2000) found that Kuhn's name was invoked in a mind-boggling variety of fields, from the original topic of his theorizing, the physical sciences, to law, business studies, library science and bee-keeping! Moreover, his major philosophical work, *The Structure of Scientific Revolutions* (1962/1970a), is that rarest of academic books, a best-seller. It has sold, at the last estimation, more than one million copies, and has been translated into 20 languages (Sandar, 2000). This, alone, would seem to make it a candidate for the most influential academic book of the last century.

How is it that Kuhn's work has attracted such attention? His central ideas were by no means novel. As Michael Matthews (2000) has shown, many of the elements of his philosophy of science were extant when he published *The Structure of Scientific Revolutions*. Perhaps it is that Kuhn brought these

different elements together in an unusually persuasive manner. Another possibility is that the publication of *The Structure of Scientific Revolutions* in 1962 was remarkably timely, coinciding with a popular rejection of traditional conceptions of science, and thus a need for a replacement.

This second point highlights an irony at the heart of Kuhn's work. In his book on Kuhn, Steve Fuller (2000) traces the origins of *The Structure of Scientific Revolutions* to Kuhn's work as a teacher of science, and to his goals of promoting a widespread understanding of the nature of scientific knowledge and an appreciation of its great importance in the dawning 'Atomic Age'. The irony lies in the adoption of this most conservative treatise by scholars in the humanities and the social sciences as a foundational text of the emerging postmodern revolution. Part of the confusion may have lain in the well-documented divide between scientists and academics from the humanities. The latter knew almost nothing of the context and development of Kuhn's ideas. Nor did they appreciate that many of these ideas had been around for a long time in the philosophy of science, and particularly in the Wittgensteinian tradition (Barker, 1989; Merton, 1977; Maudgil, 1989). It seems that these scholars believed they had struck upon a radical attack on the scientific enterprise. So Stanley Fish (1989) placed Kuhn alongside such postmodern luminaries in the so-called 'Science Wars' as Jacques Derrida, Michel Foucault and himself, whilst Ernst von Glasersfeld (1989, p. 121) claimed that *The Structure of Scientific Revolutions* 'brought to the awareness of a wider public the professional crisis of faith in objective scientific knowledge'.

It was largely through Kuhn's influence that philosophy of science took its 'historical turn' in the 1970s, and under his (albeit reluctant) influence that it took its 'sociological turn' in the 1980s (Geertz, 1997; Matthews, 2000). Stephen Weinberg (2001) attributes Kuhn's popularity among philosophers, historians, sociologists and cultural critics who question the objective character of scientific knowledge, preferring to describe scientific theories as social constructions, to his radically sceptical conclusions about what is and can be accomplished in the work of science. And Ian Hacking (1981, pp. 1-2) claimed that *The Structure of Scientific Revolutions* spelled the end of the host of previously fundamental notions (realism, demarcation, cumulation, observer-theory distinction, foundations, deductive structure of theories, precision, discovery and justification, the unity of science). Hacking's assertion is overstated with regard to practising scientists, but it does capture the sweeping methodological and epistemological relativism that characterizes the euphemistically named 'science studies' programmes, as well as influential strains of thought within the humanities, the social sciences and educational studies (for example: Guba, 1990; cf. Bailey, 2001). So, here is an irony at the heart of Kuhn's image of science: it is directly to Kuhn's intended advocacy of science that much of the current critique of science can be traced.

In fairness to Kuhn, it should be acknowledged that he consistently

strove to separate his work from that of his sociological disciples. In fact, a considerable amount of his later work can be seen as an attempt to correct what he believed to be misunderstandings arising from *The Structure of Scientific Revolutions*. In a statement reminiscent of Marx's denial that he was a Marxist, Kuhn, in 1991, assessed the sociological turn in the history and philosophy of science, acknowledging that it was 'emphasised and developed by people who often called themselves "Kuhnians"', but added that 'I think their viewpoint damagingly mistaken, have been pained to be associated with it, and have for years attributed that association to misunderstanding' (cited in Matthews, 2000, p. 5). Towards the end of his career, Kuhn became particularly uncomfortable with his apparent links with the so-called 'Strong Programme' in the sociology of science, with its combination of sociological ambition and methodological relativism (Bloor, 1991; Nola, 1990). About this movement, Kuhn remarked, 'I am among those who have found the claims of the strong program absurd, an example of deconstruction gone mad' (Kuhn, 1992, unpaged). However, despite his disavowal of such radical sociological analysis of science, indeed his routine avoidance of the social sciences in general, Kuhn's name continues to be summoned up by advocates of such views (Sander, 2000, and Hawkins, 1994, for example).

Kuhn's influence on educational matters is as significant as in other areas. It is hardly possible to pick up an educational research journal or attend a seminar without being confronted with the Kuhnian concept of the 'paradigm'. Cathleen Loving and William Cobern (2000) found that virtually all social science and educational research textbooks appealed to some notion of paradigm. Their citation analysis of two leading science education journals (*Journal of Research in Science Teaching* and *Science Education*) suggested a similar picture, with frequent references to paradigms, scientific revolutions, incommensurability, and other Kuhnian or Kuhn-inspired concepts.

Kuhn's *The Structure of Scientific Revolutions* might justifiably be labelled as a classic. However, as Mark Twain quipped, a classic is a book that everybody ought to read and nobody has. I suspect this might be the case with Kuhn. His name is invoked by advocates of positions from which he has explicitly distanced himself, which suggests that it is not Kuhn's work, but the supposed authority of his name, that is valued by those who use it in this way. This view is supported in the context of science education by Loving and Cobern's (ibid.) finding that almost all authors in their survey were citing Kuhn in support of some position, and *none* of the articles examined from 1985 to 1998 offered any real critique of Kuhn's position.

In this article, I argue that other virtues of Kuhn's work notwithstanding, his conception of science in general, and science education in particular, do not deserve the warm embrace they have received. Indeed, I suggest that there are features of his characterization of science and education that present insurmountable barriers to acceptance as part of a liberal educational philosophy.

KUHN'S PHILOSOPHY OF SCIENCE

At the centre of Kuhn's analysis of science was his conception of the *paradigm*. In his earlier work (1957), Kuhn used the term in what might be called an 'ordinary English' sense, that is, as a shorthand for some accomplishment that then serves as a model for future work. In *The Structure of Scientific Revolutions,* however, paradigms were defined more distinctively as 'universally recognized scientific achievements that for a time provide model problems and solutions to a community of practitioners' (Kuhn, 1970a, p. viii) or as 'what the members of a scientific community share, *and*, conversely, a scientific community consists of men who share a paradigm' (ibid., p. 176).

Kuhn's view of the nature of science can best be understood by considering the way in which he sees the history of science developing in relation to paradigms. Following an initial 'preparadigmatic' stage, during which there is little or no agreement amongst scientists about the methods, techniques or questions in a particular field, there comes a point when a particular model begins to gain wider acceptance and emerge as dominant within the community of scientists. This 'paradigm' eventually gains wide or universal acceptance within the field and provides scientists with an accepted way of posing problems, conducting investigations, designing experiments and considering solutions. In one of his earliest descriptions of a paradigm, Kuhn wrote:

> I mean to suggest that some accepted examples of actual scientific practice – examples which include law, theory, application, and instrumentation together – provide models from which spring particular coherent traditions of scientific research.
>
> (Kuhn, 1962, p. 10)

It is partly defined and expressed by an exemplary scientific achievement in which some puzzles have been set and solved by using some conceptual and empirical techniques. A paradigm becomes established when it is successful enough to attract a group of scientists to tackle the problems defined by the model, and when the paradigm is sufficiently 'open-ended' to leave enough unresolved puzzles to occupy the scientific endeavours of the newly-attracted scientists. By working through solutions described in their exemplars, and by learning certain key concepts, techniques and what sort of things count as puzzles, members of a mature scientific discipline pick up deep-seated assumptions about the nature of the world and about what observations and concepts are relevant for properly carrying out inquiry in that discipline.

Kuhn characterized scientific work within a paradigm as puzzle-solving. He differentiated his conception of science from those, like Popper, who viewed science as fundamentally concerned with problem-solving, innovation and exploration (Popper, 1994; Notturno, 2000). On the contrary, Kuhn argued that the paradigm determines the puzzles to be addressed, and protects the scientist from the insoluble:

> Puzzles are, in the entirely standard meaning here employed, that special category of problems that can serve to test ingenuity or skill in solution ... It is no criterion of goodness in a puzzle that its outcome be intrinsically interesting or important. On the contrary, the really pressing problems, e.g., a cure for cancer or the design of a lasting peace, are often not puzzles at all, largely because they may not have any solution.
>
> (Kuhn, 1962, pp. 36-7)

Paradigms guide ordinary scientific practice, which Kuhn labelled 'normal science'. Normal science is research based upon previous scientific achievements that have been adopted by a scientific community (ibid., p. 10). It is the everyday practice of scientists, as they exercise their skills against a restricted range of puzzles. Scientists within the same paradigm are engaged in an enterprise which is structured in the same way by the paradigm. Thus, the theories, methods, practices and puzzles they attempt to solve are very similar. Therefore, paradigms determine the entire nature of normal science and its activities:

> The study of paradigms ... is what mainly prepares the student for membership in the particular scientific community with which he will later practice. Because he there joins men who learned the bases of their field from the same concrete models, his subsequent practice will seldom evoke overt disagreement over fundamentals. Men whose research is based on shared paradigms are committed to the same rules and standards for scientific practice. That commitment and the apparent consensus it produces are prerequisites for normal science, i.e., for the genesis and continuation of a particular research tradition.
>
> (Ibid., pp. 10-11)

Within the scientific community basic rules and standards are unquestioned, with dogma an essential element in the process: the normal scientist 'largely ceases to be an explorer at all, or at least to be an explorer of the unknown' (Kuhn, 1970a, pp. 96-7). So Kuhn's view of science was as essentially stable and secure. The pursuit of normal science is not to produce new discoveries or challenge existing theories: 'the puzzles under which (the normal scientist) concentrates are just those which he believes can be both stated and solved within the existing scientific tradition' (Kuhn, 1977, p. 234). Within normal science, fundamental presuppositions, such as the scope and method of inquiry, are not in question. The work of the normal scientist is, in the apt phrase of Mark Notturno (2000, p. 229), to attempt to fit the pieces of nature in the predefined patterns of the scientific community's paradigms.

However, as normal science proceeds and puzzle-solving activities are carried out, anomalies inevitably begin to develop, when the paradigm does not work as it is supposed to, or when circumstances arise that are not soluble within the current paradigm. Over time, these discrepancies mount up until

some scientists begin to doubt the paradigm itself, and a crisis develops. Eventually, competing paradigms emerge, and a scientific revolution occurs when a new paradigm usurps the old one. Kuhn called the period of crisis, when new paradigms are proposed and compete for the allegiance of the scientific community, 'revolutionary science'.

The new paradigm is 'incommensurable' with the one it replaced. Since the new paradigm 'necessitates a redefinition of the old' (Kuhn, 1962, p. 103), and since the standards and criteria for the evaluation of paradigms are *internal* to the paradigms, the change from the old to the new cannot come about by appealing to some neutral criteria. Since the old and the new are incommensurable, the process of abandoning the old in favour of the new cannot be a gradual, logical or scientific process based upon evidence or reasoning: 'paradigms are not corrigible by normal science at all' (ibid., p. 122). Kuhn argued that in scientific revolutions, progress in science does not occur on the basis of shared standards. The differences between advocates of competing paradigms at the time of crisis will be so great that they are unlikely to agree on what would constitute good grounds for preferring one to the other, since the criteria for those preferences are internal to the different paradigms. Thus, according to Kuhn's early work at least, the scientist does not reason herself into the new paradigm; Kuhn compared it to a conversion experience (ibid., p. 151) which 'can only be made on faith' (ibid., p. 158).

Kuhn's incommensurability thesis has been the focus of a great deal of discussion. In contrast to the view of realists like Popper (1970) and David Stove (1982), the acceptance or rejection of paradigms is not a rational procedure. Kuhn's presentation focuses on sociological rather than epistemological considerations. The change from one paradigm to another occurs through a bandwagon process of ideological and political conversion. It is perhaps unsurprising that such talk of ideology, faith and conversion was met by some of Kuhn's contemporaries with bewilderment. Popper (1976) nicknamed incommensurability 'the myth of the framework', and understood Kuhn's thesis to be equivalent to saying that theories are like mutually untranslatable languages (Popper, 1970, p. 267). Kuhn (1970c, p. 198) denied that competing paradigms were untranslatable. He argued that when paradigms compete,

> the parties to such debates inevitably see differently certain experimental or observational situations to which both have recourse. Since the vocabularies in which they discuss such situations consist, however, predominantly of the same terms, they must be attaching some of those terms to nature differently and their communication is inevitably only partial. As a result, the superiority of one theory to another is something that cannot be proved in debate. Instead … each party must try, by persuasion, to convert the other.

From the first edition of *The Structure of Scientific Revolutions* in 1962, Kuhn progressively backed away from his more extreme relativistic and

subjectivist presentation of scientific development, such as his assertion that rationality and truth were entirely intra-paradigmatic. By the second edition, he resorted to different puzzle-solving capacities to differentiate, compare and rank theories and paradigms: 'This is not a relativist's position, and it displays the sense in which I am a convinced believer in scientific progress' (Kuhn, 1970a, p. 206). However, even if Kuhn were not committed to relativism, he remained committed to the claim that there is no growth of knowledge across scientific revolutions, since he maintained that science does not replace theories with others that are closer to the truth. Progress, he insisted, occurred when scientists resolve more puzzles, produce more successful predictions and gain greater accuracy in predictions *within* paradigms. So, there does seem to remain a 'whiff' of relativism in Kuhn's view of science (Bailey, 2000), since arguments concerning the merits of rival claims cannot be judged from an external position. What counts as a good reason for a claim depends on the paradigm from which one judges it.

NORMAL SCIENCE EDUCATION

The education of the scientist, according to this image of science, is a process of enculturation into the dominant current scientific paradigm. Beginning in the secondary school, Kuhn's model of science education, or 'normal science education' (Van Berkel, et al., 2000), is one that aims to produce competent puzzle-solvers, fully familiar with standards and methods. In large part, this training is achieved through students attempting repetitively to solve puzzles closely modelled on exemplars, until their performance of the different operations within the paradigm are somewhat habitual. It is a tradition-preserving activity in which the 'characteristic problems are almost repetitions, minor modifications of problems that have been undertaken and partially resolved before' (Kuhn, 1977, p. 233).

At the centre of this enterprise lies the textbook, which is the standard resource through which the student learns the procedures, vocabulary and standards of the paradigm. Science is distinguished from other disciplines by its dependence upon standard, up-to-date, authoritative textbooks, which act as its primary legitimizer: 'science education remains a relatively dogmatic initiation into a pre-established problem-solving tradition that the student is neither invited not equipped to evaluate' (Kuhn, 1963, p. 351). Or, as Kuhn put it elsewhere:

> Until the very last stages in the education of a scientist, textbooks are systematically substituted for the creative scientific literature that made them possible.... Of course, it is a narrow and rigid education ... But for normal-scientific work, for puzzle-solving within the tradition that the textbooks define, the scientist is almost perfectly equipped.
>
> (Kuhn, 1970a, pp. 165-6)

Textbooks ought not describe the puzzles that the community deals with in abstract forms, such as in terms of generic rules and procedures, but

> exhibit concrete problem solutions that the profession has come to accept as paradigms, and they ask the student ... to solve for himself problems very closely related in both method and substance to those through which the textbook or the accompanying lecture has led him.
>
> (Kuhn, 1977, p. 229)

Different textbooks available to students within a mature science should differ mainly in terms of the level at which they are aimed or their detail; they should not differ significantly in substance or conceptual structure (Kuhn, 1963, pp. 350-1).

The education of the normal scientist is, according to Kuhn, 'an initiation into an unequivocal tradition' (1977, p. 352). Students are not introduced to the history of their discipline, nor to original research (until they start their own research as postgraduates), since only the currently accepted results are of relevance to the initiate members of the scientific community.[1]

Kuhn presents a rather unattractive image of science education; one more akin to certain forms of religious education. Indeed, there are close parallels between Kuhn's model of normal science education and so-called 'transmissionist' approaches to schooling, both of which consist of introducing students into a conceptual framework through which they can comprehend the world (Bailey, 2000, pp. 189-94). In its extreme form, the transmissionist approach presumes that tradition, custom and key beliefs are presented as beyond doubt and criticism, at least to the uninitiated. Predictably, this model is a popular one among some religious groups. Richard Tames (1982, p. 128), for example, explained that, to a Muslim, education is 'primarily a process of ensuring cultural continuity and preparing individuals to perform predetermined social roles'. Recent calls for 'back to basics' have also been couched in the language of transmission, with the implication that there are some beliefs and 'facts' that are simply above consideration; one example of this being the cultural literacy movement in the United States of America (Hirsch, 1988), with its apparent suspicion of critical thinking skills (cf. ibid., p. 132).

Science has traditionally been seen as the apex of rationality and critical thinking. Predictably, Kuhn's portrait of normal science education has received a frosty reception from a number of philosophers and scientists (cf. Siegel, 1988; Popper, 1970; Watkins, 1970), although science educators seem to have been less critical (Loving and Cobern, 2000). Popper's comment is typical:

> 'Normal' science, in Kuhn's sense, exists. It is the activity of the non-revolutionary, or more precisely, the not-too-critical professional ... The 'normal' scientist, in my view, has been taught badly. I believe ... that all

> teaching on the University level (and if possible below) should be training and encouragement in critical thinking. The 'normal' scientist, as described by Kuhn, has been badly taught. He has been taught in a dogmatic spirit; he is a victim of indoctrination.
>
> (Popper, 1970, pp. 52-3)

Some explain this disagreement as due to the fact that Kuhn's view was primarily descriptive in nature (Notturno, 2000). However, Kuhn himself rejected this classification. In response to Paul Feyerabend's (1975) claim that his theory of science is ambiguous as to whether it offers historical description or methodological prescription – and that this ambiguity had a purpose in providing a safe line of retreat: 'those who dislike the implied derivations of values from facts can always be told that no such derivation is made and that the presentation is purely descriptive' (p. 199) – Kuhn (1970b, p. 237) wrote that:

> The answer, of course, is that they should be read in both ways at once. If I have a theory of how and why science works, it must necessarily have implications for the way in which scientists should behave if their enterprise is to flourish.

Kuhn acknowledged that his presentation of normal science education is not the only form science education can take, and he recognized that his model might be antithetical to 'even the most faintly liberal education theory' (Kuhn, 1977, p. 227). Nevertheless, he found it a historical fact that 'exposure to a rigid tradition has been immensely productive to the most consequential sorts of innovation' (ibid., p. 230).

Of course, Kuhn's criteria of progress in science relate specifically to his concept of normal science. According to this view, the continuous use of accepted theories enables the scientist to move faster and penetrate deeper than if dramatic theory change was required all the time. Kuhn's puzzle-solving-centred view of normal science means that achievements and progress are measured by solving puzzles, and it is much easier to see progress if only one theory is followed.

THE STATUS OF NORMAL SCIENCE EDUCATION

Kuhn's model of normal science education centres on the principle that the student is initiated into the dominant scientific paradigm of the day. A primary aim of science education, therefore, is to produce competent researchers, and research can only occur in line with the methods and concepts of the paradigm that define the puzzles being researched. Kuhn acknowledged the dogmatism inherent in this approach (1963, p. 351). Others have gone further. Popper's objection to normal science education – that it promotes dogmatism and indoctrination – has been noted before. Likewise his colleague, John Watkins (1970), found Kuhn's model abhorrent, since it is

not only *un*critical but actually *anti*-critical. Watkins portrayed the scientific community as a 'closed society of closed minds' (ibid., p. 27).

That Kuhn's model is uncritical is, I think, beyond doubt. Whether it is indoctrinatory, however, requires a little more thought. Analyses of the concept of indoctrination have tended to fall within three categories. Some theorists have defined indoctrination in terms of aims, that is, the intention of the teacher determines whether the inculcation of a certain belief can accurately be said to be indoctrination (Snook, 1972). Others have associated it with a particular method or approach to teaching, such that the learner's critical scrutiny of beliefs is suppressed (Smart, 1973). A third group of theorists comprises those who understand indoctrination to be linked to a particular content, such that indoctrination occurs when a student is taught something that is false or uncorroborated (Siegel, 1988).

Normal science education, as portrayed by Kuhn, seems to qualify for the label 'indoctrination' on all grounds. The normal science educator certainly intends that the students will come to accept the methods and content of the paradigm, and that they do so regardless of reasons or evidence. Indeed, such reasons and evidence would be forever inaccessible to them until they entered the paradigm, since it is the paradigm itself that frames reasons and evidence. Similarly, critical scrutiny of the paradigm is absent. The transition to a paradigm is, according to Kuhn (1970c, p. 6), 'precisely the abandonment of critical discourse', as normal science is marked by a lack of debate about the basic concepts. The movement to revolutionary science, however, is no more characterized by critical discourse than the earlier phase. Scientists cannot critically assess competing paradigms, since each paradigm carries its own criteria of evaluation; there are no neutral standards against which judgements can be made. A scientist's decision to adopt one paradigm rather than another has the character of a 'gestalt switch', rather than the result of critical scrutiny and rational deliberation.

So, Kuhn's model of normal science education resembles two interpretations of indoctrination. It also matches the third, most morally objectionable, form, namely that of deliberately misleading students. In prescribing the use of textbooks as the cornerstone of training, Kuhn suggested that the objective of such guides is to provide the reader with an economical and accessible statement of what the particular scientific community accepts to be true: 'Information about how it was acquired and why it was accepted by the profession would at best be excess baggage' (Kuhn, 1977, p. 186). In other words, the presentation of the current state of scientific knowledge ought to make invisible the revolutionary periods that established that state, or, as Kuhn (1970a, p. 138) bluntly put it: 'the textbook-derived tradition in which scientists come to sense their participation is one that, in fact, never existed'.

CONCLUDING REMARKS

> It is puzzling ... why Kuhn is seen – as he invariably is – as a radical theorist of science, whereas Popper is remembered as a grumpy autocrat.
>
> (Fuller, 2003, p. 2)

This article has examined features of Kuhn's philosophy of science and his model of science education. Whatever other virtues Kuhn's work may have, it is suggested that there are features of his characterization of science education that present insurmountable barriers to acceptance, specifically those relating to the implicit indoctrinatory character of Kuhn's normal science education. It is ironic, then, as Fuller (ibid.) points out, that Kuhn's name is so frequently called upon in support of supposedly progressive, even radical, educational ideas. Perhaps this is because Kuhn's portrayal of science, with its description of incommensurable, incomparable and context-dependent paradigms, seems to offer substance and justification to the well-intentioned relativism that has been sweeping through education and the social sciences for some decades. And, just as relativism starts by promising radicalism but 'ends up by saying that what is, is right' (Jarvie, 1984, p. 82), Kuhn's vision of education cannot offer the support for democratic forms of learning that many who use his name might wish.

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NOTE

1 It could be argued – indeed, it has been argued by an anonymous reviewer – that I am presenting only one aspect of Kuhn's view of science, namely the dogmatic element. To some extent this is the case: Kuhn talks about 'revolutionary science' and 'paradigm shifts', and he does not present science as invariably stable. Like Popper, Kuhn's view is that science is in flux (Agassi, 1975). However, an acknowledgement of this situation does not, it seems to me, weaken the argument made here, which is explicitly concerned with Kuhn's philosophy of education, which seems to be premised on the importance of presenting a partial, possibly misleading, image of science as stable. It is possible to conceive of a model of education reflecting both the normal and revolutionary phases of science. But this does not seem to be what Kuhn does. And, since this is at odds with the popular perception of Kuhn's views among social scientists and educationalists, and is somewhat different from other aspects of his philosophy of science, I chose to rely on Kuhn's own words to make this clear. To reiterate this difficult point, I will use another quotation from Kuhn's most influential text:

> The study of paradigms ... is what mainly prepares the student for membership in the particular community with which he will later practice.

> Because he there joins men who learned the bases of their field from the same concrete models, his subsequent practice will seldom evoke overt disagreement over fundamentals. Men whose research is based on shared paradigms are committed to the same rules and standards for scientific practice. That commitment and the apparent consensus it produces are prerequisites for normal science, i.e., for the genesis and continuation of a particular research tradition.
>
> (Kuhn, 1962, pp. 10-11)

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