

Against Science Education: the Aims of Science Education and Their Connection to School Science Curricula

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ABSTRACT

To clarify: in this chapter I will speak only of compulsory science education in schools; much of what I say will not transfer across to either science electives in schools or to undergraduate science.

Such science education, like all compulsory education, is an exercise in force against students. Overriding individual autonomy in this way is not to be lightly done and should involve appeal to aims that are of sufficient importance for the individual, or the group/society, to outweigh such loss of freedom over one's own mind's contents. Moreover, the loss of freedom is guaranteed; in order to outweigh it, the benefits aimed at should not just be of sufficient moral importance but be attainable with sufficient probability for a sufficient proportion of students. Finally, to justify the imposition of science education requires not just the probable achievement of ends that are of sufficient importance to outweigh the loss of freedom that is their cost but the absence of better candidates that might occupy the same "time-slot" of lost freedom.

All very vague, admittedly, and it is the burden of this chapter to examine this issue in further detail as an exercise in sustained argumentation. My contention will be that such argumentation in justification of compulsory science education cannot be satisfactorily advanced at the moment and, in any event, does not seem to have been yet advanced in the extant literature. Accordingly, as compulsory school science education is without a satisfactory available warrant, it should be excised pending the provision of one.

INTRODUCTION

From at least the time of the Sputnik scare, the state of science education has been a topic of concern and controversy in Western nations. Familiar to readers will be the flurry of reports and reforms concerning such education. I have no intention of rehearsing the detail of this here¹. I will make one observation, however. Much, not all, of the discussion takes for granted that it is a good thing for school students to have a substantial introduction to the ideas and processes of science and then proceeds to fuss about how that might most effectively occur. In effect, in the terms of this chapter, this is to assume as satisfactory some set of aims for science education and devote one's intellectual energies to the task of judging how to achieve those aims. Less attention seems to have been focused upon what those aims should be and even less upon a thoroughgoing exercise in justification of those aims. And, even

¹ Michael Matthews gives good overviews in his introduction to William McComas's edited anthology and in a monograph of his own (see Matthews, 2000 and Chapter 3 of his 1994, respectively).

assuming those aims, the literature seems inadequate in *thoroughly* justifying curricular proposals as means to their achievement. The focus of this chapter is upon those latter tasks as aspects of addressing the question: 'what would justify compulsory school science education?'. My judgement is pessimistic as to the chances of such a justification being available or, at least, being available for anything that very much resembles the sorts of curricula common in schools.

INDIVIDUAL AUTONOMY AND THE ONUS ARGUMENT

In a recent paper (Davson-Galle, 2006) I recanted from earlier works (Davson-Galle, 1994, 2002, 2004a) of mine in which I had advocated greater presence of philosophy of science in school science education. In that recantation, I persuaded myself that no good case could be made out for having philosophy of science (in any of a range of versions that I examined) as part of a compulsory curriculum in schools. At the end of that paper, I observed that the broad architecture of the paper's argumentation 'would seem to apply to other parts of the compulsory curriculum, including much of science' (p.32 of online listing) but that exploring such matters was not my concern in that paper. This chapter *does* have such exploration as its concern. The broad argumentative strategy of the chapter is identical to that earlier paper. The only difference is that it is directed at the proposal that *science* be compulsory, not that philosophy of science be compulsory. As before, the chapter rests its case on an onus argument. The portrayal of such a general onus argumentative strategy was more elaborate in that paper than I will reproduce here and for further details I simply refer readers to that paper².

The key assumption of the onus argument which I will follow is that it is a good thing, in and of itself, for people to be able to think what they wish to and to act as they please. This is *not* to champion personal autonomy no matter what. Rather, it is to say that if one is to advocate stopping someone from acting or thinking as they please, then the *onus* is on such a would-be autonomy suppressor to come up with some good enough reason for that. Such an argument would generally³ involve establishing that some sort of benefit would ensue as a result of the type and extent of autonomy reduction involved and, moreover, *enough* such benefit to outweigh the autonomy loss that is its cost. Unless such a case can be made out, the "default" position of allowing someone to exercise autonomy is operative.

Note the "logical geography" of such an onus argument. It is *not* for *me* to *argue* that autonomy is a good thing. I take it as an assumption that, other things being equal, it is. (I also take it that granting this assumed moral status to autonomy is not wildly morally idiosyncratic of me.) It is for the *other* party to *argue* that sometimes other things are not equal and outweigh autonomy; that is, to argue that, on these matters, for these *reasons*, autonomy should be suppressed. I am taking the exercise of autonomy to be some sort of *prima facie* right of a fundamental sort, a "good" in itself that doesn't need warranting by appeal to some further moral principle. It might be outweighed in importance by some higher good and such a higher good's attainment might demand autonomy-suppression but that has to be *established* in order to discharge the onus. I am willing to allow that there are all sorts of good reasons for

² See the section entitled: 'Individual Autonomy and General Grounds for Its Denial'.

³ I say 'generally' because there is one other possibility, as will be elaborated upon below - that of an agent retrospectively approving of what had earlier been forced upon her.

restricting a person's autonomy and sometimes reasons for restricting it in a temporally sustained way (prison, for example). My point is simply that those reasons have to be advanced and be satisfactory.

Turning to education, I take the institution of schooling to indeed be a sustained exercise in autonomy suppression. I take it as obvious and general knowledge that most students would not voluntarily choose to be at school studying the subjects impose and for the length of time that they have them imposed upon them. Generally, then, schooling is an exercise in *force*. Can such compulsion be warranted? If not, then the onus is not discharged and student autonomy should be restored. Schooling is, of course, made up of various subjects and activities and it might well be that some of these are more able to be warranted than others. In this chapter, my focus is limited to science and, broadly put, the issue is if such an onus can be discharged - can *forcing* scientific knowledge, skills etc upon students who wouldn't choose to have them be justified?

Of course it is but autonomy *reduction*. It is not as if compulsory science education constitutes total enslavement of mind and action. However, nor is such force to be treated as a trifling concern. The point of the onus argument is that *any* interference with an individual's autonomy requires warranting. An appreciation of this point is reasonably easily gained. I surmise that few adults would countenance being told that they had to lose control over however many hours school science curricula involve to learn things that they do not wish to learn. Saying that it was only a *partial* loss of autonomy so what was the fuss all about would be, I surmise, inadequate mollification of their outrage. At the very least, such an adult would rightfully demand to know *why*, to know what was supposed to justify her loss of control over a part of her life - ditto for students. Indeed, it is instructive to keep in the back of one's mind, when considering the putative warrants considered below, if they would be satisfactory warrants for forcing *adults* in relevantly similar circumstances to think and act as they would not choose to.

How, then, might such an onus be discharged in the case of compulsory school science education?

POSSIBLE JUSTIFICATORY STRATEGIES IN DISCHARGE OF THE ONUS

There seem to be four broad sorts of putative warranting strategies that one might advance for such autonomy reduction:

1. the future adult that the student will become would retrospectively endorse such loss of freedom in order to satisfy some curricular aim or other;
2. such autonomy reduction is for the benefit of the individual;
3. such autonomy reduction is for the benefit of the group; or
4. some combination of the above.

In what follows, I methodically work through a number of possible candidate aims as warrants for compulsory school science education (hereinafter mostly just 'science education' for short). Some will be standard fare, some not so much. For each, the issue will be if such an aim, *to the extent to which it seems plausible to believe that it can be achieved by some curriculum*, is of sufficient importance to outweigh the loss

of individual freedom involved. Of course, in doing this, I will be making moral judgements as to the relative importance of some aim's level of achievement versus the loss of autonomy that is its cost and others might order their priorities differently. My supposition is that my deliberations won't be wildly morally idiosyncratic and will at least count as "food for thought" for other moral agents interested in addressing these issues.

Note the italicised words above. Crucial to my case will be the suggestion that it is not so much the worthiness of an aim, in and of itself, that is to be put against student loss of freedom, it is the plausible *extent* to which it would be achieved in students. That, say, peace on Earth for all time would be sufficiently meritorious to outweigh school students' loss of freedom hardly counts as an aim that warrants science education if students' participation in the science education curriculum in question simply doesn't have the desired consequence to any significant extent. (I don't, obviously, suggest that anyone has tried to warrant compulsory school science education in this particular way; it is simply an illustration of the point that, however noble the end is, it doesn't warrant a means unless the means *actually achieves* the end - and achieves it to what is deemed to be a satisfactory *extent*).

Note also that not all of the possible content that might constitute a science education curriculum will necessarily fare equally well as means to the achievement of various candidate ends, or aimed at results. The above point about the achievability of aims being an important element in their chances of warranting a compulsory curriculum will likely be nuanced by such curricular detail. Note that this fine structure is not just a matter of biology versus physics versus geology, or integrated science studies versus discipline-based subjects, or science content versus science process, or even, with a gesture at recent enthusiasm for various constructivist theories, passive transmission of received knowledge versus active construction of one's own "knowledge" (a misnomer in my view). Within any of these there are variations as to the quantity of material covered (the size of the curriculum, if you like) and the level of generality/specificity that one might go into.

Finally, students vary and it is possible that what one might be able to warrant forcing on *some* students, one cannot warrant forcing on *others*. One issue here would again be the *extent* to which a particular aim was able to be achieved. Johnny might gain much from his school science education in terms of fulfilling some aimed-at end, whilst Janie might not.

As will be readily appreciated, the above spread of intersecting variables forms a multi-dimensional matrix with quite a lot of cells. As this is a book chapter and not a book in its own right, I will clearly not be able to address each possibility in fine detail. Fortunately, groupings of possibilities seem to share enough features to be able to be profitably considered together. Despite this, my treatment is, perforce, embryonic, although, in my view, a useful starting framework for further work.

A recurring theme in what follows is that, generally speaking, there seems to be a problem in finding *realistic* aims, ones plausibly achievable to an extent that would warrant freedom loss on the part of all students. I allow that that sort of judgement rests upon empirical propositions (that this means doesn't achieve that end to such and such an extent). Although not my field (I am a philosopher, not a social scientist of

any sort) what I have accessed of the science education literature seems rather thin to the point of transparency when it comes to longitudinal studies linking science curricula of various sorts with the achievement of various candidate aims - especially if those aims refer to situations later down the track concerning the adult citizens that the students become. Of necessity, my conclusions rest more upon assumptions than I would like, although I do take the assumptions to be plausible ones. If I am correct about the paucity of empirical research on these matters, then I do not see this as a problem with *my* argumentation. The whole point of the (above outlined) onus argumentative strategy of the chapter is that the burden of proof is *not* upon me but upon those who would impose science curricula. It is for them to establish that those curricula perform as advertised by reference to aims which (were they to be achieved to a satisfactory extent) would warrant the freedom loss that is their cost. No news is bad news for such theorists, not for me. That said, there may well be studies that have escaped my attention and that possibility is a potential weakness in the empirical premises that my arguments (to the effect that the onus obligation has *not* been satisfactorily discharged) rest upon. As things stand, I will, to an uncomfortable extent, rely on common sense plausibility appraisals of the truth of most of my empirical claims. Despite this potential weakness, what I assert *does* seem to me to be plausible and, if I am wrong, then I would be delighted to have that shown by reference to competent empirical research.

So, even if making a series of what I will suggest to be unsubstantiated and dubious empirical claims, what might an argument attempting to discharge the onus and warrant science education look like? I suggest that all such arguments would be variations on the following schema:

MP1 having aim X satisfied in an individual to extent Y would be of sufficient benefit to the individual and/or the group to outweigh the loss of autonomy involved for that individual in achieving that aim to that extent

DP1 having compulsory science education of sort A would achieve aim X to extent Y

DP2 no other expenditure of the same resources would achieve aim X to an equal or greater extent than Y

M/DP1 no other aim beneficial to the individual and/or the group that is in rivalry to having aim X satisfied to extent Y is able to be satisfied to an extent that brings equal or greater benefit to the individual and/or the group than aim X being satisfied to extent Y

So,

MC1 there should be a compulsory science curriculum of sort A

A few words of clarification are probably in order as, although familiar to analytic philosophers, laying cases out like this as formal arguments seems, from the literature that I have read, to be an unfamiliar business within science education circles.

Note that the idea is that every proposition before the word 'so', when conjoined, form a set of premises whose role is to entail the argument's conclusion. For this to occur, things commonly left as "hidden assumptions" in less rigorously portrayed arguments become explicitly listed. The merit of this is that all of the elements constitutive of

the case in question for the conclusion are explicitly laid out for critical scrutiny. My contention will be that all of the usual attempted justifications for forced science education have a weak spot somewhere (commonly the version in question's DP 1). That any particular argument for a given conclusion has a flawed premise (or premises), and thus fails in establishing its conclusion, does not automatically count against the conclusion being satisfactory. It just means that such a conclusion can't be warranted in the proposed manner. That this is so doesn't at all count against the chances of some other, independent, argument for the same conclusion faring better. (Thus I will be examining independently on their merits a number of putative warrants for forced science education.) Mind you, if the standardly advanced warrants for some course of action fail and nothing more promising looms on the horizon, one would be beginning to view the course of action in question (in our case, forced school science education) as *literally indefensible*.

Looking at this schema, note that the supporting premises are of two distinct sorts. Some are labelled as *MPs* and some as *DPs*. The 'M' stands for 'moral' - these premises express some sort of moral or ethical stance that the author endorses. The 'D' stands for 'descriptive' - these premises express the author's claims about what is some sort of factual truth (commonly causal connection claims, as is the case here). I also have M/DP1 which has aspects of both propositional types. Ideally, this would be dis-aggregated into those aspects as separate premises but I have judged it to be clearer in this context to leave things as they are.

So, one form of challenge to any argument putatively warranting its conclusion is to dispute some premise upon which the case rests. This might involve disagreeing with the author about what is right or wrong, good or bad - in short, entering into a moral dispute with the author about the merits of some MP. Then again, it might involve challenging some descriptive premise by suggesting that the author has not got his facts straight or, perhaps, that there is no reason to believe that he has. Or one might find fault with instances of each type of premise. In what follows in considering various putative justifications, I will be advancing each sort of complaint.

SOME POSSIBLE AIMS OF SCIENCE EDUCATION OFFERED IN DISCHARGE OF THE ONUS

The key moral motivation is provided by MP1. Although, as we will see below, each of the other premises can be vulnerable, I will initially focus on that premise. So, what might be advanced as benefits that outweigh the loss of autonomy that is their cost? In effect, what is to be filled in as X, an aim that is sufficiently worth achieving that it seems worth autonomy loss (if achieved to a certain extent)? I suggest the following as a fairly comprehensive list of what emerges in discussions of the aims of science education. Some of the following have official imprimaturs, some do not. All seem worth consideration regardless of their status as currently fashionable or not, especially given the difficulty that will emerge below in having any warrant succeed. Note that it is not as if each is necessarily a "stand-alone" candidate aim; it might well be that combinations of aims form a package of benefits that is more successful in warranting autonomy loss than its component parts considered severally. Finally, note that, in the discussion of the following, reference will be made back to the four broad strategies for warranting any overriding of someone's exercise of autonomy that were outlined earlier.

So, one might attempt to support compulsory science education by appeal to a schooling aim that as many students as possible should:

- 1) be prepared for the workforce;
- 2) contribute to the nation's economic wealth;
- 3) be able to cope in an increasingly technologically and scientifically sophisticated world;
- 4) understand the workings of the world around them as part of a "liberal education";
- 5) be prepared to successfully pursue their own life goals; and/or
- 6) be prepared to be able to fulfil the role of citizen.

In each case, apart from any general agreement that it is "a good thing" for people to have these qualities, the key thing that makes these candidate aims for *compulsory* school science is presumably the view that (severally, or in combination) they could act as warrants for some variation on the spread of science curricula currently enacted or proposed. But, for such warrants to work as warrants, as ends justifying some science curricular type as means, the latter would have to work in achieving the end and, moreover, work to an extent sufficient to warrant the loss of student autonomy that it entails. Moreover, any such warrant is always one that can only be adequate if there is no *other* course of conduct which is a rival for the same (or a lesser) amount of autonomy suppression yet is *more* beneficial in some way than the current proposals. Such benefit might not necessarily be by reference to the same putatively good ends that are appealed to by science curricula. Curricular warrants are *always* relative. It is not just that something is to be good enough to be worth autonomy reduction, it has to be more worth it than rival possibilities or else that particular substitute for autonomy won't be warranted. I rehearse such familiar points from the theory of practical reason just to remind us that it is not as if discussions of aims of particular disciplinary curricula are events insulated from consideration of other curricular possibilities. (My impression is that, for rather too much of the time, issues to do with possible science curricula are indeed considered in an overly insular way.)

However, in most of what follows, I will put such complications to one side as the broad thrust of what I will suggest is that, regardless of any claims of its rivals to warrant autonomy reduction and to warrant it more robustly than any variation of science education, the latter simply fails anyway. The concern is not so much that other things are better, it is that, regardless of their merits, science education might not be good enough to even get on a "shortlist" for prioritisation as it seems to achieve nothing worthy enough to warrant the loss of autonomy involved.

I will first consider the candidate warranting aims individually and then talk about their possible combination. As touched on earlier, in each case, the general nature of the putative benefit that is to outweigh autonomy reduction will involve appeal to one, or a combination, of the three sorts of strategy generally available for those who would seek to justify stopping anyone doing what they would choose to do. We met these earlier when discussing the onus argument strategy of this chapter. To use as an illustrative example the "preparation for employment" aim listed above (one which I will discuss in the moment), one would be asserting the following in fleshing out MP1 in our argument schema. Either the adult (John) that Johnny will grow into will have to be of the view that he is grateful that he was made to study science because look how useful it has been for his career or, regardless of what John comes to think, it will

indeed be of sufficient use in his employment to yield enough benefit to him, or to the rest of us, to warrant imposing it on him against his will. (The above disjunction is inclusive and thus these warrants might combine to outweigh his autonomy loss even if they fail to do that when considered severally.)

WORKFORCE PREPARATION?

Turning to those candidate aims, the most easily dismissed is any suggestion that science education is able to be justified by appeal to the end of having students prepared for the workforce. I have several observations concerning this suggestion.

First, in clarification of the putative warrant, it is not to be taken as being limited to preparing students for whatever jobs they might be able to enter immediately upon leaving school. Especially in modern Western societies, students would likely proceed to post-school education before entering whatever employment path they have in mind. So the school level preparation might be more like stage one of a multi-stage process of preparation for employment. Further, it is no part of the suggestion that science education *alone* would constitute employment preparation. Rather, the suggestion would be something like that it was a *necessary component of* a suite of measures that constituted the best such preparation. What would have to be established would be it actually having that status.

Even so, the claimed warrant looks silly. Even in today's world there are simply not enough jobs that deploy the knowledge and skills of science to warrant students being forced to engage in science education. That some will go on to become scientists or to enter some other profession or trade that directly utilises some science in the performance of the job is not a warrant for science education being compulsory across-the-board. Not enough school leavers will have such futures to warrant imposition of science upon all. Moreover, closer thought about the jobs that do utilise science makes it quickly obvious that they do not utilise the full breadth of science that would be standardly considered constitutive of school science curricula. For instance, an auto-electrician might find some areas of physics useful background and contextual knowledge for specialised trade study but not even all areas of physics are relevant to such an occupation - consider astronomy - and certainly many standard areas of science curricula, like biology, are totally irrelevant to such a job.

I take the above to be blatantly obvious and put it that if there is an aim of science curricula that provides warrant for the autonomy-reducing compulsoriness of such a curriculum, then it will lie elsewhere. As it stands, one would be replying to a student challenge: 'why do I have to do this when I don't want to?' with 'you all have to do all of this because some of you will find bits of it useful in your later employment'. I judge this to be a very unsatisfactory reply indeed and to not constitute a satisfactory warranting of autonomy reduction by reference to any, or all, of our three broad ways of discharging the onus argument.

None of this, of course, counts against various parts of science being *voluntary* options in school nor against various tertiary educational institutions and employers stipulating various particular areas of science as pre-requisites for entry to a course or

for employment but all of that is beside the point of my focus in this chapter upon *all* students being *made to* study science at school.

CONTRIBUTION TO SOCIETY'S WEALTH?

What, then, of the second of our putative warrants for science education - that of contributing to the nation's wealth?

Presumably two of our onus-discharging categories of justification, that John will post-factum approve of the autonomy lost by Johnny, his earlier stage, and that science education is for John's individual benefit, are not so much the point here. The focus of this putative warrant seems clearly to be "the good of the group".

No doubt if one trawled through the economics literature, one would find ample evidence of correlations between a population's level of educational achievement and its collective material wealth. There might even be a correlation between its level of education *in science* and its wealth. That correlation might even be causally based such that, to some extent, the collective societal wealth level is *caused* by the level of science education (though no one would presumably claim the latter to be the *proximate* cause, even in part, of the former; the causal chain is going to have more connecting links, ones to do with the thoughts and activities of those scientifically educated).

Let me allow all of this. Although I am unaware of data analyses connected to anything finer grained than the first claim of the last paragraph, my possible ignorance of other levels of analysis is beside my point. Even if *all* of the above claims were to be true, they do not constitute adequate enough descriptive premises to act in arguments discharging the onus facing the autonomy restrainer.

It is hard to see how Johnny's school science education is going to help society's collective wealth except via John's job-related activity. As such, much of the previous discussion applies again. By all means one might target *some* areas of science, or *some* areas of science for *some* individuals, as ones conducive to wealth creation. Whatever the detail of all of this turns out to be, it is not even faintly plausible that much, if any, greater economic benefit will ensue if the net is spread more widely to include *all* students and the curriculum to cover the fairly comprehensive spread of disciplines and areas typical of school science curricula. My suspicion is that, when one looks for causal connections, the story will be more particularised and such detail is masked by simply noting blanket relationships.

Or so I assert. The assertion seems obviously true to me but the history of science is larded with views that seemed obviously true at the time but came later to be held not to be. So, as usual, I might have my facts wrong. However, again as usual, it is not *my* task to fuss over much about this. It is for those who would deploy appeal to such improvement in societal wealth (or economic benefit) as an aim of science education aim to discharge the onus. It is for them to provide the data analyses supporting their claims that such consequences would, indeed, ensue and ensue better than with more targeted science education.

Finally on this aim's use as a putative warrant, it is worth reiterating a point made in an earlier paper (Davson-Galle, 2006). Even if it is established that, in virtue of what John ends up doing, it is true that Johnny having science education forced upon him will lead to an increase in society's wealth and, moreover, that it would be a large enough increase to outweigh the loss of Johnny's autonomy whilst at school, would the argument work too well for comfort? If we are willing to metaphorically chain Johnny to his desk for the sake of the group's wealth, then why wouldn't such a warrant transfer, *mutatis mutandis*, to the case of John? My surmise is that those who might think in terms of this sort of economic argument for science education would balk at such an extension from Johnny's to John's autonomy being forcibly removed - but why? Why wouldn't this be some sort of "ageist" double standard of an insupportable sort? And, if the cases are morally relevantly similar, and the proscription on constraining John's autonomy for the sake of our wealth is upheld, then that case for constraining *Johnny's* autonomy would similarly collapse on pain of inconsistency.

Of course, we sometimes do constrain adults' autonomy for the collective good in all sorts of ways. But none of those seem to provide a precedent of any useful application here. An obvious case is that of criminals and some criminals' actions (like large scale fraud, perhaps) have consequences for the group's wealth but presumably no one would suggest a parallel with school students. They are not having their autonomy restriction proposed as a punishment. A closer parallel, and one that operates in some countries, is that of forcing the unskilled unemployed (but not the unemployable) to engage in some sort of vocational training as a pre-condition of continuing to receive unemployment benefits from the group. Assume that this is warranted, would it provide a way of discharging an onus that would transfer to our purported economic case for compulsory school science education? I think not. Look at the adult case more closely. Basically, what is being relied upon is some sort of principle to the effect that no one has the right to be an economic burden upon the group if they have the potential not to be. And, if that potential is not yet realised but could be with appropriately targeted retraining, then that retraining should occur, by force if need be. But it is one thing to warrant autonomy restriction in order to achieve the benefit for the group of avoiding financially burdensome individuals and quite another to impose such a restriction in order to *increase* societal wealth. I am an academic. Were the job market for academic philosophers to collapse and I were to become unemployed and reliant upon the benevolence of the group, then it might be proper to insist that I retrain in some way so that my negative contribution ceases. Then again, pleasant way of life though it is for me and no negative financial drain on society (in that I have a salary, pay taxes and so on) there is little doubt that I could contribute *better* to increasing societal wealth by doing something other than philosophising. Should I then be forced to retrain as a widget entrepreneur just because that would be of greater economic benefit for the group?

I trust that the answer to the last question would be 'no'. Given this, and assuming that young people should not be forced to do things for the group's benefit to any greater extent than old people have to, there are entailments here for the societal economic benefit rationale for compulsory school science education. The most that seems warranted as an imposition on students' autonomy is that they are forced to do something or other that will (directly, or indirectly via being the foundation for later study) enable them not to be a financial burden upon the rest of us (assuming that they

have that potential). The focus is negative, not positive. Their duty to the group is simply not to be a burden on it as opposed to positively contributing to it. But such burden-avoidance might be achieved with no science education at all and via schooling totally devoted to preparing them for success as a widget entrepreneur, a subsistence-level, garret-living, artist, a clerk in a bank or even a society-rejecting survivalist hermit.

To reiterate, we don't push adults around unless they impact negatively upon us. Maybe we should but I am operating on the moral assumption that we shouldn't. We don't insist that adults contribute positively to the economy and forcibly retrain them if they do not do so and, unless a morally significant difference can be pointed to, we should not do so to students either. At least, that is what consistency seems to demand and the onus is on anyone wishing to draw an age-based distinction to present arguments for its legitimacy. Keep in mind that I am *not* presenting arguments for student autonomy (there is a literature within philosophy of education on that). I am *assuming* that it is a good thing and it is for others to present arguments for its negation via forced science education.

In any event, as touched upon above, the societal wealth argument hardly seems to hold promise as a warrant for science education being inflicted upon *all* students as opposed to it being inflicted upon *some* students as not all students would be able to contribute positively to the economy *via* what they learnt from their science education anyway.

I take this to be a failed warrant attempt.

"COPING"?

What, then, of our third putative way of discharging the onus - that compulsory science education is justified in virtue of it preparing students to "cope" in an increasingly technologically and scientifically sophisticated world? This seems mostly to be in the camp of "benefit to the individual" as a type of warrant. But does it succeed?

One of the refrains of the previous discussion has been that the aims under scrutiny seemed, at best, to provide warrants for some, but not all, students undergoing forced science education in virtue of the fact that the future circumstances appealed to did not seem to apply across the board. On the face of it, this aim looks more promising in that respect at least in that, except for folk like the Amish, all students will go on to live in such an increasingly technologically and scientifically sophisticated world. So, the *scope* of the applicability of the warrant seems on safer ground than before. Despite this merit, the case also seems to be hopeless as a warrant for anything like a standard science curriculum being forced upon students. This is for a number of reasons.

The first of these rotates around the idea of "coping" - what counts as *coping* in a technologically and scientifically sophisticated society? Consider the case of an ex-colleague's father, a renowned symphony orchestra conductor. Reportedly, if a light bulb in his house needed changing, he would call an electrician. If the external rear-

vision mirrors on his car were out of adjustment, then he'd drive to the garage and get a service attendant to carry out the adjustment. And so on. Perhaps the story has been embellished in the telling but its truth or otherwise is irrelevant to its illustrative power. Is such a person *coping* with the technology of light bulbs and cars? I fail to see why one would bother to withhold judging that he is, albeit *indirectly*. And, in any event, if not, then I fail to see that learning theories of electricity or optics or mechanics would assist. Even in a very technologically and scientifically sophisticated environment (indeed, perhaps *especially* in such an environment) most people are but *users* of science and technology and can satisfactorily perform that role with minimal understanding of what they are using and with reliance upon the expertise of others and certainly without much of a glimmer of the science involved. That I now use a computer instead of a pen and paper to write this, does not require me to understand the boolean algebra employed in the software used in the computer (although, as it happens, I do).

My second reason for dismissing this aim as a way of legitimately discharging the onus is to look at the mismatch of the areas of science covered in a standard school science curriculum and those manifested in those aspects of the world impinging upon citizens' lives. For this warrant to work, one would have to show a fairly tight alignment. I suggest that more is contained in usual science curricula than is so manifested. Given this, the best that this sort of aim could justify would be a curriculum of less breadth than those for which warrants are sought.

Finally, it is not as if one copes or does not in an on/off way. Rather, one copes to a greater or lesser extent and what would have to be established by anyone attempting to discharge the onus by appealing to this "coping with science and technology" aim is that the individual would benefit sufficiently much *more* from the increased coping gained from science education to outweigh the loss of autonomy that is its cost. I don't find the prospects of this demand being met to be great enough to provide any comfort for the advocate of compulsory science education.

I take this, then, to be another failed warrant.

Clearly, my view is that the foregoing attempts at discharging the onus fail in fairly clear-cut and obvious ways. I am, of course, open to challenge concerning my discussion of them but, pending such counter-argument, I think that serious defenders of forcing standard school science curricula on un-unwilling students should look elsewhere for a viable warrant. Others of our possible ways of discharging the onus look more promising.

(INTRINSIC) WORTHWHILENESS OF SCIENTIFIC UNDERSTANDING AS PART OF A LIBERAL EDUCATION?

Another possible rationale for forced science education is, to my mind, the most promising. This is the "liberal education" aim.

What is at stake here is a conception of how we (or, in this chapter's case, *I* or *you*) want people to be. This is not so much so that they can do things that I judge to be good (like become research scientists, or good citizens, or productive workers) either

for their own sake, or that of the group. Our previous discussion was of a broadly consequentialist sort in that I was discussing the merits of science education in terms of outcomes that would benefit them, or us, in the future. The general pattern of discussion was to ask if, as a result of their science education and the knowledge and skills that are residual from it into their adult lives, there was (sufficiently) increased benefit across-the-board (for the individual and/or for the group) to warrant the blanket autonomy suppression involved. Generally speaking, my judgement was that it was hard to see enough of an effect for enough people to warrant blanket prescription and forced acquisition. Given the swiftly dismissive nature of my analysis, it didn't much matter that we were operating with a fairly rough and ready conception of the benefits involved. I just "took it as read" that a nation being economically wealthy, or an individual being employed, or an individual being able to "cope" in a scientifically/technologically sophisticated society was a good thing without much bothering with the "why?" of things. Even on a rough understanding of these, the problem was that there was a disconnection of an obvious sort between science education and these supposedly consequential goods and what the detail of any deeper story was as to what counted as a benefit was beside the argumentative point.

At this stage of my discussion, however, I want to clarify things a little further (though still only as much as my argumentation demands as opposed to refining ideas in fine detail as an exercise in its own right).

In the foregoing, if we were to ask questions like: 'what is employment, societal wealth or "coping" good *for*?', and then, whatever the answers, further ask what *they* were good for and kept asking, then, on pain of a vicious infinite regress, such a chain of justification would have to run out in one or more valued states of affairs where, if asked why *that* is such a good thing, the answer would be that it *just is*. In short, that someone is, say, employed is *extrinsically* valuable and, in cashing out that extrinsic (or, as it is sometimes called, instrumental) value, we would, sooner or later, be appealing to something else that is *intrinsically* valued (in and of itself) as its deep motivating warrant.

Without wishing to rehearse the byzantine details of utilitarian or consequentialist theories of ethics, I suggest that the likeliest candidate intrinsic value appealed to in cashing out answers to such questions would, in some sense, be *human happiness*. Why do we want someone prepared for the workforce? - because (with some intervening causal links) he would most likely have a *happier* life were he to be so prepared than if not. Why do we want society to be economically wealthy? - because its citizens would have their *happiness* improved as a result. Why do we want John to be able to "cope"? - because he would most likely have a *happier* life if he were to be able to than if not.

As alluded to above, there are all sorts of complicating issues that are familiar within the moral philosophy literature but are unexplored here. One is the tension between group happiness and individual happiness. Depending on quite how the scarcely pellucid former gets cashed out, it might be best achieved by having John unhappy, a sacrificial lamb for the sake of the higher happiness of the group, collectively. But such complexities are indicated only to be ignored. My point is simply that, in some form or other, *happiness* is likely to be the intrinsic value at the bottom of the idea of

individual or group benefit. I wished to expose and stress this because the rationale that I wish now to explore, and with which I have some sympathy, has a *different* intrinsic value in mind in its putative warranting of forced science education. Moreover, it is one that is arrived at directly rather than via a chain of arguments connecting some extrinsic good with its ultimately warranting intrinsic one (happiness in the above discussion).

The warrant appeals to some sort of conception of how all citizens should ideally be. It might well be a complicated picture with many elements and some of those elements might be in tension with others in that one couldn't maximise all of them in all citizens because more of one might involve less of the other. We have seen this sort of tension illustrated above in that more happiness (via, say, more wealth) might be the cost of less autonomy. As is almost always the case in ethical decisions on complex matters, it is difficult to sort out where one's sympathies lie in a neat rank order way and such decisions are complicated by issues of degree concerning *how much* loss of one thing is the cost of *how much* gain in the other. My above judgements that the already considered putative warrants did not plausibly give *enough* benefit to outweigh the amount of autonomy loss that is their cost have already been nuanced by considerations of this sort as to the *extent* of benefit involved.

This putative warrant is different though. The claim is not that we, or John, will be *happy* as a result of some regimen of forced science education; rather, the appeal is to *another* intrinsically valued state of affairs, one that is part, at least, of my conception of how all citizens should ideally be. How so?

I will assume that the style of science education involved is meant to give students some knowledge of how the world works (or, at least, of our best warranted hypotheses concerning that). I am not, that is, concerned to consider any case for some of the more radical constructivist construals of science education⁴. I also assume that such science education is meant to give some grasp of how it is that such knowledge is arrived at and of why it is that such views receive that imprimatur as knowledge. Call these: 'knowledge about the world', 'knowledge of scientific method' and 'knowledge of the epistemic status of scientific claims'.

What might thus be claimed is that science education is worth losing some autonomy for because it is an *intrinsically good thing* for individual citizens to have those three types of knowledge as part of their intellectual suite. I mean this primarily as a good thing *for the individual*. There is no suggestion that it is good for the group in any way that is not merely additive of those individual intrinsic goods⁵. Nor, to repeat, am I claiming that any happiness benefit will flow to the individual by having such knowledge - it might, it might not; but that is not the motivation here. The suggestion is simply that, other things being equal, an individual having such knowledge is an *intrinsically better individual* than one relevantly ignorant. In some sense, a better

⁴ For discussions of Constructivism in science education, see my 1999 paper, the papers in the 1998 anthology edited by Michael Matthews (and Harvey Siegel's 2004 essay review of it) and Andreas Quayle's 2007 paper; apart from these, the journal *Science and Education* is generally a rich lode of ore to mine on this topic.

⁵ See my 2006, pages 28-29 (of this online version) for a fuller discussion of this "merely additive" point.

life is lived just in virtue of knowing something of the workings of the world, of how that knowledge has been arrived at and of why such knowledge claims should be deemed justified.

Others' moral priorities might differ but all of this strikes me as having more chance of successfully discharging our onus as would-be autonomy reducers than our previously considered candidates. In answer to the old question: 'what is the good life?', I, at least, am inclined to reply that, in part anyway, it is a life lived in knowledge of the matters listed. And the suggestion that such knowledge is so intrinsically valuable than it is worth forcing people (or is it just students?⁶) to acquire it, is a suggestion that has justificatory promise - at least by reference to *my* priorities. After all, I have not said that nothing could ever be warranted that involved forced acquisition; all that I have suggested is that forced science education doesn't seem warranted by our earlier considered possibilities. One fault with some earlier putative warrants was that the many suffered autonomy loss for the individual good of the few or, at best for the good of the group via what that few might do. This concern seems, on the face of it anyway, not to apply here. *Each* person would be a better person (other things being equal) with such a suite of knowledge than without it.

But there is another worry with this putative rationale, one that has concerned me in the past when considering the inclusion of compulsory philosophy of science in school curricula (Davson-Galle, 2006). How *much* of an intellectual transformation is it reasonable to expect science education to achieve across-the-board and how much *decay* of that intellectual state would occur over time?

Answers to these questions will, I suggest, depend on just what one has in mind here. Two things are, however, blatantly obvious. First, the more abstract and complex the ideas involved, the more difficult it will be for them to be established in students' minds by science education. Second, the more the curriculum is a mass of detail, the more that detail will, generally, be forgotten.

The former is a concern but the latter is not. Considering the latter point about detail, I am not advocating anything like a detailed content-rich traditional science curriculum working through the detail of laws of physics, chemical formulae and reactions, biological taxonomies and so forth. That such detailed clutter is lost quickly upon leaving school doesn't particularly upset me because that is not the level of understanding which I am considering as possibly being worth forcing upon students. What I have in mind here is a "broad sweep" introduction to our scientific understanding of ourselves and the universe of which we are part⁷. If we are talking of across-the-board science education, then what I would value is a skeletal treatment of the major ideas and themes of our current scientific picture of things with the flesh to be left to later specialist training or to those voluntarily pursuing such further knowledge. Of course all of this is rather vague and the chapter and verse of such a curriculum's content would be a largish task to articulate and would, no doubt, involve considerable debate even among those inclined to agree with such a shift from detailed science content to a focus merely upon "big ideas". That chapter and verse will not be pursued in this chapter.

⁶ There is a concern here: were adults not to value being as *we* value them being, should we force them to comply with our template, not just as to how they must behave but, as to the contents of their minds?

⁷ See Matthews, 1994, Chapter 3 on trends of this sort of a decade or so ago.

Of course we could, with enough time, do both the big ideas and the detail. My point is simply that, so far, I can't warrant to myself such further loss of student autonomy especially when so little of the detail would be retained over time.

Mind you, even a "big picture" science curriculum has concerns to be raised. It seems plausible that discussion-style pedagogy might be best suited to moving students' frameworks of belief from whatever they start with to the preferred framework. If the latter is not to be merely dogmatically held (and I find a dogmatically held set of beliefs to dubiously count as an intrinsic good) then students will have to not just hold the beliefs but understand something of how they came to be held and why that process is epistemically meritorious (if it is⁸). (These constitute the second and third areas of knowledge articulated above.

Here things become awkward fast.

These points, about the methods of scientific enquiry and about the epistemic justification of scientific frameworks of belief, become complex and sophisticated as soon as one enquires seriously into them. The latter one, concerning epistemology, is one that I have addressed previously (Davson-Galle, 2006) and the results of my analysis then were not sanguine. As observed above, the more abstract the material that is taught the less likely it is to be understood across a school cohort. Yet, if even the "broad brush" ideas of science are to be understood in a non-dogmatic way, then some grasp of epistemology is enjoined. I won't rehearse the detail of the earlier paper but the upshot of my analysis was that, beyond the most basic level of (partly misleading) "Nature of Science"-style dogma, epistemological understanding is not plausibly achievable to any great extent. There is some dispute as to what would be on the list⁹ of uncontroversial claims about the nature of science but say that, with respect to epistemic elements, some sorts of propositions like the following were among those that were the target for Johnny (and, later, John) to have as items of knowledge: 'one should generally believe what scientists are confident is true, because those beliefs are based upon observation and experiment (although belief should always be tentative because new data may be difficult for current theories to explain or new theories might be invented that to an even better job of explaining existing data)'.

This is fine, the philosophically naive might think. But it leaves all the hard epistemic questions un-addressed and un-answered. Yet to pursue that complexity is, as I have noted in that earlier paper, unfeasible. Perhaps I am overly pessimistic but I will simply rest this chapter's case upon the assumption of that earlier paper's argumentation's soundness.

In short, across the spread of school students, anything but achieving mere assertion of epistemic stances that are, perforce, overly simplistic, is not an available option. But is what *is* perhaps available, mere "learning off" of epistemic propositions, worth its cost in autonomy? In particular, is having such a collection of epistemic beliefs about the status of science of any *intrinsic* merit? In that previous paper, when I

⁸ See the references on Constructivism mentioned in Note 4, above.

⁹ See Matthews, 1994, pp. 37-40 for a candidate list and McComas et al., 1998, p. 513 for another one (a version of the latter paper occurs as Chapter 1 of McComas, 2000).

considered this question as part of a more general question about the role of philosophy of science in school science, I was in two minds concerning this but I was inclined to think that it might well be. However, the more I consider the merit of possessing such simplistic beliefs the more I consider it to be dubious that they are of any intrinsic benefit as part of the framework of belief of an intellectual agent.

Consider the way that I spoke earlier. I listed three items of *knowledge* that might be judged intrinsically worthwhile for citizens to have. If the most that most students can have as a curriculum outcome is *mere belief* that such and such warrants a scientific hypothesis, then they don't seem to have epistemic *knowledge* concerning the status of such (putative) warrants. Certainly they don't have their epistemic views "first-person" warranted by having worked through the epistemological debates in the manner that academic philosophers might. Of course, in and of itself, that might not matter for the status of the belief as knowledge. It is familiar for epistemic agents to distribute such justificatory tasks so that much of what we would ordinarily claim that we know is justified on the basis of *testimony*. I hold a belief on the basis that a body of experts in that area hold that belief and that they have done their epistemic homework and are able to justify their views. In short, I am an epistemic parasite upon their expertise and judgement.

Generally speaking, this is quite sound practice and, indeed, unavoidable unless one is to have an enormously restricted subset of one's beliefs that one can claim to know. Of course there is one glitch with this. In effect, what is being said is that I know because the experts know and I know that they know. It is the last bit that is problematic. One of the difficulties in sub-contracting epistemic tasks to others is knowing to whom that task can be safely passed. It is notorious that some humans are gullible in their endorsement of various "new-age" religious and alternative medical beliefs and practices on the basis of "expert" advice. I will assume that some such "experts" are deluded and their positive answers to a request for epistemic assurance: 'do you know this stuff to be true?' would be very unwisely relied upon¹⁰.

The problem is by no means a trivial one. The United States would count as a fairly intellectually sophisticated country by world standards yet it is also well known as having a surprisingly high proportion of Christians of a fairly unsophisticated sort with anti-scientific frameworks of belief¹¹. Such people have undergone some sort of science education and, presumably, adjudicating between conflicting "experts" endorsing and advocating conflicting propositions on the same issue is part of the problem they face, and have failed to cope with, as intellectual agents. But upon what basis can they sensibly choose?

One way to assist such agents is to walk them through a detailed exercise in philosophising about semantic and epistemic issues at hand. But, as noted above, this is simply beyond most students (and, I would suggest, teachers, for that matter) if what is in mind is a sophisticated enough engagement with the epistemic issues

¹⁰ Nor is the problem automatically just a problem to be found in some sort of intellectual fringe; controversies occur within the mainstream as well - the philosophical naivety of a good number of mainstream scientists is notorious within philosophy of science.

¹¹ See Mahner and Bunge, 1996, on religious and scientific views' incompatibility and Matthews, 1994, p. 34 (and the "conceptual change" literature generally) on the persistence in students of what would be deemed to be false views despite them having undergone science education.

involved to be able to sort "sheep from goats" in choosing whose testimony to trust as a suitable authority on the matters at hand. One can assert authority and offer "Nature of Science" *nostra* for simple acceptance but the issue remains that others might offer contrary advice.

This sounds to be quite a bind for students' chances of scientific *knowledge*. They can't justify their first-order scientific beliefs in any *direct* way by their own epistemic thought. Nor do they have the capacity to sensibly choose which of a range of competing claimants to authority to trust as legitimate sources of testimony to warrant their views *indirectly*.

As far as I can see, this rules them out as having scientific knowledge in the sense of *knowing that* their scientific beliefs are justified. Admittedly, that doesn't stop those views been indeed justified¹². The epistemic status of an agent's beliefs is not automatically as that agent is in a position to judge. Thus Johnny's belief in various propositions of science might be without him being able to give any satisfactory warrant (of either a direct or an indirect sort) for such beliefs yet they might be warranted in the sense that epistemically competent judges judge them to be so.

So, were we to be optimistic¹³ about the epistemic status of the broad architecture of some scientific framework of beliefs, could we legitimately force belief in such a framework upon Johnny in virtue of it being, indeed, knowledge, despite us being unable to have Johnny capable of judging that it is so? In effect, that is for us to ask him to take the offered propositions on trust without him being in a position to properly judge us as a trustworthy source of testimony. Why should he take our view rather than that of Pastor Pangloss of the Blessed Brethren of the Shoe? I don't see how we can answer this question in a way that is both generally comprehensible to students and philosophically legitimate.

I deal with this issue of epistemic warrant at some length because it strikes me as a very serious issue for this "*intrinsic* worthwhileness" attempt to warrant a forced acquisition of at least the broad framework of a scientific picture of the world. Assuming the above pessimism about being able to rationally justify a scientific belief system to Johnny, science education (or, perhaps, "education") is tantamount to a form of indoctrination. As observed above, it is by no means clear to me that students' possession of a framework of belief that is held without conscious warrant is a state of affairs that I would favour *in and of itself*. (This is not, of course, to say that such a state of affairs is not *extrinsically* worthwhile; it might well be. But if such a framework of belief is good for something else to an extent that warrants imposing it by force, then there had better be some justification available that is more satisfactory than the ones considered in earlier sections of this chapter.)

But what perhaps *could* be known by students is not that, say, species evolved by natural selection of some genetic variations over others but that most biologists *believe* that. Presumably this would require something like survey data concerning biologists' views being available. Yet, if so, then the same issues arise again. Do students have to follow enough statistics to see why some survey data warrants a

¹² Dancy, 1985 is a readable introduction to these matters; see Chapter 9 in particular.

¹³ Again, see Dancy, 1985; this time, Chapter 1.

particular interpretation? This is obviously too big an ask. Should they, then, just take things on trust and judge the survey claims as trustworthy testimony given that the work was done by reputable authorities? There is certainly enough dodgy social science around to cause some misgivings here¹⁴ thus the issue of judging claims to authority arises again. However, independently of the issue of surveys, one might assume that if a set of views is presented in textbooks, then that shows that such views constitute accepted conventional scientific wisdom. There is, of course, some danger that texts are over-simplified or just out of date but we are, after all, only talking of broad frameworks so perhaps they could be allowed to be a close enough approximation to "conventional wisdom". So, despite some misgivings, let me allow that there would be no great epistemic impediment to students being able to *know that* most scientists (in a field) believe such and such a suite of views. They could know *that* a thesis was conventional wisdom in science *without knowing the thesis itself* (that is, without themselves having any justified belief in it). Would such knowledge *about* scientists and their beliefs be worth having (in and of itself)? Maybe not.

In effect, this would amount to Johnny knowing that one particular intellectual institution's members believe the world to be thus and so. Johnny might also know that those scientists believe their views to be justified. He might even believe those views himself¹⁵. What he *doesn't know* is whether these views are to be trusted or not. But what is so great about this situation? Is this an *intrinsically* worthwhile way for an intellectual agent to be? Not in my view.

So, my present inclination is to think that this epistemic roadblock undermines the claim that student belief in the broad framework ideas of science is worth having *in and of itself*. So much, then, for the third and first of the three knowledge elements that I had in mind as constituting a possibly intrinsically valuable version of science education; what of the second: scientific method?

Others may differ in their value-judgements but I had this in mind as part of a package with that package being intrinsically valuable. Concerning science, what would be intrinsically good would be for those three items of knowledge to be possible but if the only one that is possible is knowledge of the methods of scientific enquiry, would that be intrinsically worthwhile just by itself? Not to me.

In any event, it is not at all clear that such *knowledge* is any more available than its fellows anyway. My previous concern, the general inability of students/citizens to comprehend complex and abstract ideas, arises again. There are at least two construals of this "knowing scientific method/s" potential aspect of science education. One is a normative, a priori, conception of how scientists *should* go about their enquiries. The other is a social science style description of how scientists *happen to* go about their business. I said that the former was normative. This is now a somewhat un-popular meta-philosophical conception of the intellectual status of philosophy of science. In effect, it suggests that philosophy of science might legitimately say something like: 'scientists should pursue their enquiries in such and such a manner, not in the manner that they are'. On the latter, one simply reports that scientists do, as it happens, pursue their enquiries in so and so a manner. Whether

¹⁴ See Huck and Sandler's (1979) delightful analyses of dubiously interpreted data in published research reports.

¹⁵ But see Note 11, above

philosophy of science has this intellectual authority over science is controversial and it is no task of this chapter to engage in such meta-philosophy¹⁶. My purposes in mentioning this distinction are two.

First, if one takes the normative construal of knowing the methods of science, then the issues are basically epistemic ones about the justifiability of the candidate method of operating in seeking to know what the world is like and my above discussion of this with its attendant pessimism applies again. In short, even if such knowledge is intrinsically worthwhile, the justification of such epistemic claims is a very complex business and having adequately considered views on such matters is beyond most students¹⁷.

Second, if one instead construes the knowledge as merely *descriptive* of the practice of scientists, then I will allow that such knowledge might be as readily available as our earlier discussed knowledge of what theses scientists in the field would subscribe to as true. Again there methodological concerns about the sorts of social scientific enquiry that yield such generalisations but, again, I will pass over any such hesitations and allow that such knowledge is available and that students could, at least, know that scientists pursue their enquiries in such and such a way (or ways). Here the issue is the worthwhileness of such mere knowledge *that scientists act* in certain ways without the capacity to appraise those actions. (Compare *knowing that* witchdoctors act in certain ways.) And note that it *will* have to be sufficiently worthwhile to warrant *forcing* such knowledge upon students. Again, I can't see enough value in such knowledge to warrant its forced acquisition. Others may differ of course but, if so, they should at least be clear that in attempting to warrant this aspect of possible science education as an element of a broader liberal education, then it is mere knowledge *that practices occur* without the capacity to appraise the legitimacy of those practices. (Again, compare this with knowing that witch doctors act in certain ways.)

The upshot of all of this is that, despite its initial appeal (to me at least but it is certainly a common view), trying to warrant forced acquisition of a broad framework of scientific views in virtue of having such scientific knowledge being an *intrinsically* valuable thing seems to fail because the views in question would not be held by students as things that they *know* but would, at most, have the status of *mere belief* or, at best, knowledge that others have certain beliefs. And, I suggest, that is not status enough to be intrinsically valuable enough to over-ride agents' own wishes about the contents of their own mind. In any event, if some version of this warrant is accepted, it would have to be by valuing mere belief as the desired state. The merit of such mere belief in central tenets of science as opposed to, say, superstition, would be their truth. This may be enough for some but not for me. This is, though, the closest of those that I consider to constituting a satisfactory aim upon which to rest discharge of the onus.

So, another failed attempt. So far, so bad for justifying forced science education but what of our remaining putative rationales? As said before, however, even if what is

¹⁶ See my 1990 for my engagement with that issue.

¹⁷ And, as touched on already, I suggest that teachers and scientists would find the same issues out of their field of expertise - my point does not, however, depend on the truth of that suggestion.

learnt from compulsory science education is not *intrinsically* valuable, that does not stop it being *extrinsically* valuable.

PURSUING LIFE GOALS

One thing that is sometimes advanced as a rationale for compulsory schooling is that students should be made to acquire various skills, items of knowledge and affective qualities because such things are "enabling"; in particular, they are things that assist students to successfully pursue their own life goals. As an illustration, being able to read and write and to communicate in a comprehensible way with substantial conformity to linguistic conventions is a precondition for pursuing most life goals especially if those goals require funding and the usual available source of sufficient money is via paid employment. Of course, there would be exceptions to this but, except when it is clear who these exceptions are (those severely intellectually disabled, or those with a substantial inheritance, for instance) it would seem that the probabilities favour forced literacy (to at least some set level) for all. Generally, this would seem to be a rationale that would discharge the onus in two ways. The first is that whatever Johnny might think of forced literacy, John is likely to retrospectively approve of it in that he appreciates being able to better pursue his life goals. Second, for most life goals at least, having such goals achieved is likely to be for John's individual benefit.

I mean this literacy case only as an illustration and it doesn't matter if the above sketch is overly optimistic about its chances of success in discharging the onus in this "pursuit of one's own life goals" way. My point is: can compulsory science education (in some usually discussed variation or other) manage such a route to discharging the onus? In a word, no.

For this putative rationale for forced science education to succeed, enough of the skills, content and so forth acquired by school science students would have to be present to a sufficient extent to contribute sufficiently to enough life goals of enough students (and without superior substitute causal elements being readily enough available) to outweigh the degree of across-the-board loss of autonomy that is entailed by the forced acquisition. I have left this as one rather convoluted sentence to emphasise just how many "boxes have to be ticked" here. The rationale won't work if enough individuals' life goals don't involve the deployment of whatever they would gain from science education. Nor would it work if, although relevant, things would not be in place to enough of an extent to have the effect desired. And so on down the various qualifications just listed.

Note in particular the presence again of those qualifiers to do with the degree or extent of the success of the relevant causal connection. This focus upon the *extent* of the achievement of ends is a recurring theme of the chapter.

Looking down my list, my judgement is that someone appealing to this sort of warrant in discharge of the onus is near doomed to failure. As is also a recurring theme of the chapter, I know of no empirical research that tracks such connections and, while I would be delighted to be pointed to such work, I simply don't think that it exists; and, if I am correct in this, then the appeal to the usefulness of science in the pursuit of

one's life goals constitutes rhetoric without proper empirical support. Education is too expensive of society's resources and individuals' freedom to rest on mere rhetoric.

One intermediary link in the causal chain from science education (as means) to goal satisfaction (as end) is if the goal is not directly science-connected but involves money. As was touched upon in the literacy illustration, the most common route to having money is employment and if the skills and knowledge etc acquired from science education were sufficiently connected to the performance of a sufficient number of jobs then our justificatory task would be more clearly satisfied. But, as discussed in an earlier section, it is simply blatantly obviously false that enough jobs require the spread of knowledge and skills under discussion for that to constitute a warrant for their acquisition.

So, if this warrant is to work, one would have to be suggesting some other causal connection of either an indirect sort (as with the employment case but involving some different intermediary link) or a direct sort (where pursuing one's goal directly utilises scientific knowledge or skill).

I can come up with various instances of particular connections (as I can with all of our putative warrants) but the difficulty facing the advocate of forced science education is that, to discharge the onus, there has to be something (or a summation of individual somethings) that applies fairly much *across-the-board*. Unless this is so, we are again replying to a student challenge with the unsatisfactory response: 'you all have to do all of this because some bits of it will prove to be useful, and in some cases necessary, for some of you achieving some of your life goals'. The trouble is that it is obviously *not* so.

I take this to be an obviously failed warrant.

BECOMING A "GOOD CITIZEN"?

The last candidate sets out to warrant science education by suggesting that it has a role to play in preparing students to fulfil the role of citizen. Of our three broad warrant strategies, this seems to most firmly fall into the camp of force being justified by appeal to the good of the group.

Allow that we have some sort of broad aim of *schooling* generally being that it should help turn students into good citizens (or, perhaps, less directly, provide them with skills and knowledge that will assist them in being able to act as good citizens¹⁸). Even so, can we warrant the forcing of *science* education as being a sufficiently important part of the means for the achievement of the end: "good citizens"?

I take the science education literature to consider this to be a major justification for school science¹⁹. I have considered this type of warrant in a past paper (Davson-Galle, 2006) but as a warrant that might be held to justify compulsory *philosophy* of

¹⁸ Note that one should distinguish being *able* to do something from doing it; one obvious way in which the former, but not the latter might obtain is if one is without relevant motivation.

¹⁹ See Driver et al., 1996, p. 18 and Bell and Lederman, 2003, p. 353 for some discussion of what Driver called 'the democratic argument'; see also Matthews, 1994, Chapter 3 (especially p.36).

science education (especially the ethics of science) and ended up thinking that it failed in that task. This is, however, a different kettle of fish and perhaps forced science education can be warranted in this way even if forced education in philosophy of science can't be. Despite that different focus, there are some similarities in my argumentative strategy to that earlier treatment.

As will be a familiar refrain by now, the tasks facing the would-be onus discharger are many.

First, "good citizen" has to be unpacked.

Second, the knowledge, skills and attitudes that would be gained from science education that, *prima facie*, would seem to play some role as means to the achievement of the end of having good citizens will need to be identified.

Third, these plausible "means-end" connection claims' soundness would have to be investigated and, in particular, two things would have to be clear: for what percentage of students we would get what degree of achievement of those aimed at ends and, for how long such achievement would last.

Fourth, the pervasiveness, extent and persistence of the effects of the science education curriculum would have to morally add up to enough of a benefit to outweigh the loss of autonomy that is their cost.

As will be predicted, I find each of these tasks to be problematic.

First, the idea of the "good citizen" here seems to be one that has as one of its elements, the citizen making, or being *able to* make, decisions of a certain sort. (Note again the disjunction here. It is one thing to have a capacity and another to exercise it.) So, what decisions are in mind here?

In this context, presumably the focus would be on decisions that involve the application of scientific knowledge and/or the exercise of the skills of scientific enquiry and/or the influence of the affective attitudes typically driving scientific enquiry. Given that the driving idea is that of the "*good citizen*", I take it that it would be only those decisions that impact upon the group that we are talking about. As earlier, I will consider this impact to eventually appeal to the happiness levels of the group.

So, we have citizens making decisions and some of those decisions affect the happiness of the group. *Good* decisions of this sort by citizens are those that increase the happiness of the group (or, at least, avoid decreasing it). In order to make some such good decisions, a citizen would have to have the sorts of knowledge, skills or attitudes fostered in school science curricula. Other things being equal, the extent to which someone is a good citizen is a function of the extent to which, when faced with such decisions, they make good ones. Even at this stage, I have two concerns.

One is that it is by no means clear to me just how many science-using civic decisions are actually faced by citizens. Nor, of those, how many are of very much importance to the happiness of the group. No doubt *some* citizens are in the thick of things but for this to be a warrant for science education for all students, one would want one of two things to obtain. Either a fair majority of citizens will be in such decision circumstances often enough for their employment of the science forced upon them in

school to generate enough group happiness to outweigh the across-the-board loss of autonomy involved or, alternatively, it may be that only a minority will be in such decisions situations but we can't, with enough probability, predict who and the decisions those few will make will be of such importance that it is worth society inflicting the knowledge (etc) on all students for the sake of the increased group happiness generated by the few who actually get to use their school science. Of course, to pick up on the earlier disjunction, we are also going to be making assumptions about citizens *bothering* to engage in such decision-making and, if they do, using their scientific knowledge (etc) to inform, and partly guide, their decisions.

In short, with respect to the civic decisions made by good citizens, it is not at all clear what the likelihood is of enough citizens being faced by, and willing to engage in, enough science-informed decisions of enough importance that the resultant boost in group happiness outweighs the autonomy loss. Perhaps there is some empirical research on this issue but, as usual, my impression is that there is not (I know of none). Unless there is, the chances of this putative way of discharging the onus being anything beyond empty rhetoric are slim.

Moreover, to return to the idea of the "good citizen", the role played by science in being such a citizen is, at best, partial. First, all that such science can supply to the arguments constituting rational deliberation about the issue at hand is what I earlier called 'descriptive premises'. What it *won't* do is supply *moral* premises²⁰ articulating the *ethical* stances *driving* the decision. One can be scientifically informed concerning the options facing one in a decision situation yet be evil and choose an option that is anything but for the benefit of the group. It might be objected that no one is suggesting that science would be the whole story of such civic decision-making, just an important part²¹. Such a response is, however, unsatisfactory.

If one is to warrant science education by appeal to its role in producing *good* citizens and unpack the relevant part of that as making good decisions then the warrant will not work if what one gets is scientifically informed but *bad* decisions. The moral and descriptive premises conjoin to generate the decision and, unless the former properly in place, then it is hard to see how just the latter would be of much use in the attainment of the desired outcome.

A further problem here is that the most effective way of producing citizens with good values is by indoctrinating those values into them. There is possibly something to be said for this²² but note that there are all sorts of concerns about the whole notion of what the right values might be, ones that the briefest of forays into any undergraduate text in moral philosophy will make manifest²³. I earlier unpacked the idea of a good citizen as one acting for the happiness of the group because that has been my impression of the values driving this putative justification of science education. However, that that is what one should be aiming for is itself controversial²⁴. In any

²⁰ See my 2002 and, more elaborately, my (forthcoming) 2008.

²¹ Focusing on this aspect is what people usually have in mind when talking of someone making an *informed* decision.

²² I have discussed this in my 1995a and 1995b.

²³ See my forthcoming 2008, Chapter 9, for a sketch of some of the issues.

²⁴ The proposal is a version of Utilitarianism and the moral philosophy literature is extensive on the issues.

event, it is one thing to be confident that you have a set of values that you are happy to endorse and another thing to be willing to indoctrinate them in other people. Any such indoctrination of "good values" inherently involves further loss of freedom of thought (on those matters) and is, indeed, a somewhat more severe and long-lasting negation of autonomy than the limited prison-sentence style loss of autonomously directed time that is entailed by most compulsory curricula (including forced acquisition of scientific knowledge and skill).

Finally on this point, even if it were thought that it was good enough that having and deploying scientific knowledge was an *aspect* of acting in the manner of a good citizen, this putative justification would only work if there were not other aspects that were in rivalry with science education and even better served the end of having good citizens. This is no slight concern. Given the limited amount of time available for schooling and the jostling of competing claimants for time and space, to include science is to exclude something else. Perhaps better analytical skills in making critical sense of complex issues would be time better spent than learning science, or a greater understanding of political history, or... and so on.

Anyway, there are rival *ends* suggested as curricular aims that might be worthier of pursuit. For instance, think back to the earlier quick discussion of being able to pursue one's own life goals. Such an aim would likely involve different curricular foci than a "good citizens" one.

All in all, as soon as one begins to think seriously about the idea of students becoming good citizens as a possible motivating end for forced science education, problems emerge that are not manifest if things are left at the rhetorical level of "feel good" slogans.

A *second* task facing those tempted to follow this path to discharge of the onus is to articulate a little more clearly the aspects of the mooted science curriculum that are seen as serving the "good citizen" end.

One trouble here is much as before. Is it really possible to see the spread of disciplines of science and topics within them that constitute a usual science curriculum as *all* being relevant to the sort of science-involving decisions that citizens might face? I think not but the onus is on those using this aim to warrant compulsion to supply more detailed "chapter and verse" analyses. My hypothesis is that, at best, what would end up being warranted as a result of any such analysis would only be various fragments of science.

No doubt some students will face situations where they will be wanting to make decisions (as voters, say) and, in order for such decisions to be well-informed, some scientific knowledge would have to be utilised as descriptive premises in the arguments constitutive of their deliberations. But even in such cases, it is simply not at all clear how much use school science education would be. This is not because most of it would be forgotten (though I find that plausible) but because the science involved in such decision-making is usually too complex to have been covered at school level. Two illustrations will suffice.

At the time of writing, citizens in my region are in dispute about the desirability of a pulp mill (turning woodchips into pulp for paper manufacture) being built. One issue among many is if the proposed mill will impact upon the environment in various ways to an extent that, for some citizens at least, would be deemed to be a negative that would outweigh plausible economic benefits arising from the mill²⁵.

Environmental groups have commissioned scientific advice, as has the company proposing the mill and the State government has an odd history of setting up one appraisal process, aborting it and then hiring external consultants to produce another report in a faster manner. Needless to say, there have been competing claims about the lack of disinterestedness of each of these parties in choosing what scientific claims to put forward and emphasise but there has also been some first-order scientific dispute concerning those claims themselves. Will such and such a level of the emission of this gas, or that liquid effluent, produce this particular effect upon humans or that effect on seals or...? Will such a mill produce so-and-so level of toxic product or only such and such a level? And so on.

Even if I remembered all that my science teachers had taught me, I can't see how that would help me in such a decision situation. I am in the hands of the experts. The best that I can manage is trying to decide which experts to believe; in terms used earlier, to whom I should "sub-contract" such premises in virtue of them being appropriate authorities. This is a difficult business and, as noted, school science is scarcely going to help.

A second, more general, example is the global warming controversy. Again, competing claims are made and, curiously, it might seem as if the issue is resolved and that I can confidently trust that global warming is indeed a fact and, moreover, significantly caused by humans. In short, whatever debates there have been in the past, isn't the issue now settled? Fine but then there bursts upon the scene an article in the serious press counselling caution on the grounds that the vast majority of scientists have agreed on things before and been shown to be subsequently wrong and that they might be wrong this time as well because they seem to be not properly considering a rival hypothesis emphasising the role of cycles of solar emissions - at least according to some scientists.

Again, I have a conflict among competing authorities' testimony and my school science will not be of any use in adjudicating such disputes. Even if it seemed to me that, say, the solar emissions theory is more plausible than the rising CO₂ levels theory, some of those better educated in science than I am would disagree. Why should I trust my own semi-ignorant appraisal? But if not, whom to believe?

The issues that I wish to come from these two examples are that, even if I recalled all of my school science and explicitly deployed it in making science-involving decisions facing me as a citizen, it is simply not at all plausible that the right connections exist between what is acquired in school science and the making of "good decisions", even to the limited extent of making merely scientifically informed decisions.

²⁵ In pondering upon this example one can perhaps entertain the idea that compulsory economics would be another candidate school curriculum item.

It might be objected here that no one was ever suggesting that school science will cover the sort of chemical, biological and medical issues that arise in the pulp mill case, for instance. The claim would rather be that it would provide a basis for acquiring the relevant scientific knowledge so that an informed decision could then be made.

At best, this sort of argument would seem to warrant aspects of school science but not the full spread of topics as not all of those topics would plausibly perform such a "basis providing" function. However, this is not the major difficulty. It is simply not established by research (and is, in any event, implausible) that even if citizens were to retain what was taught to them in their school science curricula, most would have the capacity to build upon that basis to become scientifically informed upon the issues or even to become informed enough to adjudicate among rival candidate authorities. Nor is it even established that a *sufficient proportion* of citizens will so use their science education to even attempt to become informed and (assuming other decision-making elements are present) make good decisions such that the resultant group benefit gained from this intellectually active subset of students warrants across-the-board compulsion to ensure that the subset is "caught and taught". Moreover, one would have to be confident that this subset could not be predicted in advance (so that one could, instead, selectively force science only upon those who are likely to produce such future group benefit). One would also have to be confident that, without school science, they would not be able to become sufficiently scientifically informed on an ad hoc basis in various decision situations to generate the benefit. That concerned citizens might pursue relevant knowledge regardless of what they learnt in school is not, on the face of it, an implausible suggestion to make. As is a familiar refrain in this chapter, I contend that no one has bothered to do research on the spread of issues at all and that, in the absence of the findings of such research, rhetoric and wishful thinking seems to be the rather unsatisfactory basis for stopping students choosing to learn what they wish to (or not learn as the case may be).

The *third* of the above-listed tasks for the autonomy suppressor concerns the actual presence of the right causal chains between forced science education as means and good decisions as ends. Even were none of the afore-mentioned concerns to be crippling, any such "good citizen making good decisions" attempted warrant would plausibly fail owing to two other concerns. As noted above in another context, there are genuine concerns to be aired about the level of retention of whatever is gained from forced school science education. What are necessary for this line of justification to succeed are longitudinal research studies tracking students years and decades down the track to see if most still retain, to any sufficient extent, whatever aspects of their school science are deemed to be connected conceptually and argumentatively to science-relevant decisions they face and have faced and will face. I conjecture that the results of such research would be dispiriting for the advocates of forced science education (not to mention science teachers).

Moreover, even if the elements relevant to some decision were still substantially in place in John's head as a result of Johnny's schooling, would John deploy them? To do so is for John to be *willing* to pursue the making of an informed decision. I question how much is known of citizens' serious engagement with the big science-relevant issues of their time. Quite possibly there is a literature more generally on citizens engagement or apathy and intellectual sloth concerning various civic issues

and even if there were to be no such literature specifically connected to science-relevant issues (as I suspect to be the case) then it might well be that those mounting this putative defence of forced science education could find plausibly transferable research findings from other such issues. My conjecture is, though, that the results would be mis-pleasing. I am perhaps overly cynical about the qualities of my fellow citizens but I surmise that engagement would only generally occur if the issue were to be a local one that impacted directly upon individuals or one that bore upon high-level commitments that the citizen had.

To illustrate my conjecture, consider my pulp mill example from above. I live in Tasmania and it is mainly one part of the north of Tasmania that would be affected directly one way or another by the mill's construction. The State government will ultimately exercise power on the matter and, in due course, voters will exercise power over the State government come the next election. So, one opportunity for them to make good decisions as good citizens is how they vote. My suspicion is that it will only be those in the north who would have bothered to try to follow the scientific "ins and outs" of the debate and in so far as the government's role in the pulp mill controversy is a factor in the thinking of voters from elsewhere in the State (itself a dubious assumption) the decision will be made in relative ignorance of the scientific issues involved. Why? - because it does not directly affect them.

An instance of motivation to connect to an issue because of high-level beliefs and commitments would be the controversy concerning the history of the earth and thus the proper contents of the science curriculum. Some of those engaged with the debate (not necessarily as vocal contributors) are engaged because of religious convictions concerning the interpretation and truth-status of the Bible. Given that, they deem geological theory to be false. Hopefully they would make good decisions as good citizens but, as the history of this particular debate attests, objectivity of appraisal of the science involved (even if John is intellectually capable of it) is not plausibly going to happen if extra-scientific yet powerful motivations exist for one stance in the debate being adopted. It is by no means clear how efficacious any science education could²⁶ be in the face of such a prior conviction.

In summary of this point, will John retain enough of his forced school science to contribute usefully to decisions of a science-relevant sort that face him as a citizen? And, even if he did, would he bother to deploy such skill and knowledge rigorously enough, enough of the time, to make forcing such skill and knowledge on Johnny justified? As is patently obvious, I am pessimistic here. However it is not my intellectual duty to support my pessimism so much as that of the user of this "good citizen" putative warrant to support their optimism so that the onus can be discharged.

Fourth, I reiterate that whenever empirical evidence is available, it would have to demonstrate, or at the least very plausibly suggest, that forced science education *for all* gives a benefit to an extent judged sufficient to outweigh attendant autonomy loss. So, it would have to establish that what occurs in such science education would be relevant to some particular range of civic decisions for some number of citizens, that the results of such science education would be generally retained to some identified extent and that such residual skills and knowledge would actually be generally

²⁶ See note 11, above, Siegel, 2004 and my 2004b.

deployed with some degree of rigour in some specified subset of civic decisions to which they are relevant.

This is a complex "ask" of empirical researchers but something like this would have to be available for the onus to be discharged for we have to have a feeling for *how much* of a benefit we are likely to get as a group from forced science education before we can judge if it is *enough* of a benefit to outweigh its cost - diminution of student autonomy.

In summary, the upshot of all of this is that it is not at all clear that those advancing such a "good citizen" rationale can provide the requisite evidence that forced science education actually produces benefits for the group of the sort envisaged and/or to an extent that outweighs the loss of autonomy involved in the achievement of that benefit.

It should also be remembered that if the goal is group benefit, then there may well be ways of negating student freedom that would more plausibly produce enough benefit to outweigh such autonomy loss. So, even if I am wrong and forced science education comes out ahead on a (group benefit/loss of freedom) benefit/cost "equation", *rival* courses of action might do even better. For instance, if what one wants is good citizens and if that is clarified as those that act for the increased happiness of the group, then we might be better off spending the time freed up by dropping the compulsory science curriculum for moral indoctrination of the virtue of benevolence.

I judge this to be another failed warrant, one that fails to make its case beyond rhetorical flourishes.

COMBINATIONS?

Sometimes warrants that fail individually can succeed collectively. Although I have judged that none of what are sometimes aired as justifying forcing science on Johnny have made out a case either in terms of John's retrospective endorsement, benefit accruing to John and/or benefit accruing to society, perhaps a plus point here from such and such a rationale added to another plus point there from another rationale, added to... would all add up to enough of a *total* benefit to outweigh autonomy loss and thus successfully warrant forced across-the-board science education for all students.

Perhaps.

It's very hard to sensibly judge this in an empirical vacuum. I have suggested that little has been done to longitudinally track the extent to which putative good consequences actually do obtain. Given this, it is hard to do any such additive calculations where what are being added together are of unknown extent. The best that can be managed is an informal guess based upon one's general knowledge of the world and of one's fellow citizens. In my case, I judge matters pessimistically. For me then, the onus would no more be discharged by our rationales in combination than by them severally.

CONCLUSION

The conclusion that I reach from the above is that none of the extant warrants for forcing science education on all students succeeds in discharging the obligations associated with the onus argument. Unless either some error has occurred in my argumentation (perhaps concerning some impressions of mine about the paucity of empirical research on key matters) or some other rationale is offered that fares better, the current situation in schools is morally indefensible. Science education in anything like its present form should cease to be compulsory and should be an option. It is without aims of sufficient merit and achievability to be worth forcing on people.

I have noted that I finished an earlier paper by observing that its argumentative strategy might have success against more targets than that of that paper. I could make the same observation again (the compulsory mathematics curriculum, for instance, seems to me to in large part be a total waste of time). Does this mean that I am some sort of mad radical enthusiast for total liberty of thought and action on the part of students (and older folk)? No. There are certainly areas of learning that I would force into students' (and, for that matter, deficient adults') heads with a clear conscience and for reasons that I consider to satisfactorily address the challenge of the onus argument. It is just that science is not one of them.

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