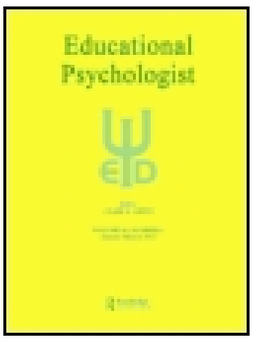

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Post-truth and science identity: A virtue-based approach to science education

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ABSTRACT

Post-truth trades on the corruption of argument and evidence to protect ideological commitment and social identity. We distinguish two kinds of post-truth environments, epistemic bubbles and echo chambers, and argue that facets of post-truth are countered the more science (and general) education encourages the development of intellectual virtues and internalization of science identity. After first locating our perspective on intellectual virtues within virtue epistemology and Aristotelian virtue theory, we argue that intellectual character is strongly metacognitive and requires a concept of science identity to provide a motivational force to the work of virtues. Our educational response to post-truth focuses on Aristotelian-inspired pedagogy for teaching virtues, metacognitive virtue strategies, and the development of science identity. The internalization of science identity is further developed in terms of moral education and Self-Determination Theory. We suggest further lines of theory and research and conclude that science education is in the business of character education.

One of the challenges facing contemporary science is how to confront the rise of science denial by segments of the general public on issues of almost existential urgency (McIntyre, 2019b). The most concerning example is denial of evidence for anthropogenic climate change, but claims for the safety of childhood vaccinations and genetically-modified foods are not entirely accepted, and the struggle for consensus about evolution, the Big Bang and, surprisingly, the spherical shape of the earth, is still not completely won. Indeed, the Pew Research Center (2015) reports wide gaps between the attitudes of scientists and the public on a number of issues. About half of U.S. adults do not attribute climate change to human activity, one-third do not endorse evolution or the requirement to vaccinate children, and two-thirds are wary of genetically modified food. Meanwhile, the Flat-Earth Society has serious doubts about the sphericity of the globe (McIntyre, 2019a).

Recent surveys show that most Americans trust scientists and value the contributions of science (Krause et al., 2019; Pew Research Center, 2019), and virtually no one denies well-established scientific consensus across the board (Fischer, 2019). Yet, respect for science is put to the test when scientific consensus collides with ideological or political commitments (Hamilton, Hartter, Lemcke-Stampone, et al., 2015; Hamilton, Hartter, & Saito, 2015; Lewandowsky et al., 2016). Lewandowsky and Oberauer (2016) argued that partisan rejection of science is triggered when well-attested findings challenge entrenched tenets of people's world views, and currently "generalized distrust of science and rejection of specific scientific evidence is concentrated primarily on the political right" (p. 218). But that could change, on their view, when data challenges core assumptions of the political left insofar as the mechanisms that drive motivated rejection of science are the same (e.g., appeal to simplifying heuristics that reach desired conclusions).

Indeed, across the political landscape the evidentiary basis for many social policy debates can be obscured by partisan interests that degrade the quality of public discourse while making the acceptance of spin and "alternative facts" distressingly common. The term "post-truth" is now part of the lexicon to describe the epistemic hazards of the present information-rich media culture. In 2016, the Oxford English Dictionary (OED) named post-truth the "word of the year" and defined it as "relating to or denoting circumstances in which objective facts are less influential in shaping public opinion than appeals to emotion and personal belief." And like all good definitions, OED used it in a sentence: "in this era of post-truth politics, it's easy to cherry-pick data and come to whatever conclusion you desire."

Consider two facets of the post-truth phenomena noted by McIntyre (2018). One facet is cognitive bias that convinces individuals that their conclusions are based on sound reasoning, whereas the views of others are fallacious. A second facet is that individuals operate within information silos that report only confirming evidence and supportive conclusions, and fail to see or do justice to the other side. Moreover, information silos are seemingly fortified by bunkers of belief systems that are relatively immune to correction by countervailing information (Kuhn et al., 2020). This is particularly the case if belief systems undergird a sense of social identity. Indeed, group identity is an important driver of whether individuals accede to politically

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controversial scientific conclusions (Walker et al., 2017). An information silo that is guarded by identity-protective cognitions will help ensure that factual claims will be interpreted in ways that vouchsafes one's ideological (or theoretical) commitments, or safeguards a sense of membership in a group (Cohen, 2003; Kahan et al., 2007; Sinatra et al., 2014).

Epistemic bubbles and echo chambers

The role of identity-protective cognitions and fortified information silos in promoting post-truth elides a useful distinction between epistemic bubbles and echo chambers. According to Nguyen (2020), epistemic bubbles form, almost incidentally, around social networks of individuals who hold compatible, like-minded beliefs and opinions. The mutually-reinforcing nature of epistemic bubbles provides little incentive to increase information coverage, to seek out divergent views, or to evaluate them thoroughly, especially when regnant beliefs serve to justify and confirm one's own perspective.

Inhabitants of epistemic bubbles have been likened by Brown (2019; also, Brennan, 2016) to information "hobbits" who are thinly informed of current events and the social-scientific knowledge base to understand them. They lack accurate information and exposure to relevant evidence because they are self-satisfied with what they know and rarely hear contrary voices (Nguyen, 2020). In contrast, echo chambers are intentional epistemic communities that actively silence, exclude, and discredit alternative points of view (for an example, see Jamieson & Capella, 2010). Inhabitants of this epistemic space are likened by Brown (2019) to information "hooligans" who engage in "epistemic discrediting" to blunt the persuasive appeal of arguments that are sourced to outsiders (Brown, 2019; Jasny et al., 2015; Nguyen, 2020). If hobbits simply ignore or rarely encounter contrary information, hooligans engage in active resistance and disparagement of dissenting opinion.

Nguyen (2020) argues that the distinction between epistemic bubbles and echo chambers is important for understanding the appropriate response to post-truth. Inhabitants of epistemic bubbles are not necessarily hostile to divergent views but are more likely unaware of them. The information silo they occupy is insufficiently exposed to wider sources of evidence and argument. But identity-protective cognitive mechanisms are more likely engaged by partisans of echo chambers. Indeed, Brown (2019, p. 52) calls echo chambers "hooligan factories." Exposing hooligans to contrary evidence will likely increase their desire to resist it, making intervention more difficult. Hence, while escape from epistemic bubbles may require only sustained attention to the evidence and increasing informational coverage, to escape an echo chamber "may require a radical rebooting of one's belief system" (Nguyen, 2020, p. 141). If so, a more promising approach to combat this facet of post-truth might be prevention rather than remediation.

Intellectual virtues and post-truth

How, then, to undermine post-truth approaches to information, evidence, and argument? We argue for an educational response to post-truth, one that equips students with the intellectual virtues to resist the attraction of epistemic bubbles and echo chambers in the pursuit of true beliefs and understanding. On a standard account, intellectual virtues are cognitive excellences or habits of mind that dispose an agent to good thinking in the pursuit of epistemic goods such as knowledge and warranted true beliefs (Battaly, 2012; Zagzebski, 1996). According to Baehr (2011 p. 18), "An intellectually virtuous person is one who thinks, reasons, judges, interprets, evaluates, and so on, in an intellectually appropriate or rational way, while an intellectually vicious person is one who is deficient or defective in this regard." Intellectual virtues are essential for successful inquiry, and their formation is a defensible aim of both general education (Kotzee, 2019) and character education (Baehr, 2013), and we will argue it is also indispensable for science education largely because of the adverse effects that epistemic bubbles and echo chambers have on the appraisal of scientific claims. Consequently, the intellectual virtues required to counter post-truth are best learned, we argue, in the educational contexts where the practice of science is learned.

There are paradigm examples of intellectual virtues. Brown (2019) nominates open-mindedness, skepticism, intellectual courage, and intellectual humility as four intellectual virtues that could challenge the epistemic threats posed by post-truth. Intellectual honesty, curiosity, perseverance, being fair-minded, impartial, and objective are also important intellectual virtues (Baehr, 2011; Roberts & Wood, 2007). Intellectual humility, for example, is a willingness to own up to one's intellectual limitations, to embrace fallibility and be ready to yield convincing evidence or stronger argument (Leary et al., 2017; Porter & Schumann, 2018). Pritchard (2020) argued that intellectual humility is fundamentally an *other*-regarding disposition "such as being open to points of view different from one's own, being willing to change one's mind if necessary, being willing to reflect on the soundness of one's beliefs if called upon to do so" (p. 403). This intellectual virtue is scarcely found in epistemic bubbles and echo chambers, and post-truth would seem to thrive in its absence.

Hence, we will argue that possession and display of intellectual virtues are required to prevent recourse to identity-protective comforts of echo chambers. They would burst epistemic bubbles by encouraging a broader consideration of evidence and argument, and thereby promote better discernment of important public policy alternatives. For example, open-mindedness, intellectual curiosity, and fair-mindedness should undermine the insular informational space of epistemic bubbles by seeking out, asking questions of, and indeed considering information from outside these bubbles. Similarly, intellectual humility, curiosity, and skepticism should work against the tendency to seek only confirmation of one's own perspective but to do justice to the other side of an argument or discussion. Identity-protective mechanisms that guard echo chambers are ideally replaced with

identification with science virtues and the scientific attitude, which is to say, a science identity. McIntyre (2019a) argues that the most important weapon against post-truth is the "scientific attitude," which we identify with intellectual virtues that sustain inquiry and argument, debate, and deliberation on topics informed by science.

Outline of the article

Our argument will unfold in the following way. First, we locate our approach to intellectual virtues within virtue epistemology. Chinn et al. (2011) convincingly argued that virtue epistemology has important insights for expanding the dimensions of epistemic cognition, and we will derive a similar advantage from virtue epistemology for understanding intellectual virtues as a response to post-truth. One of the challenges of drawing upon philosophical insights about virtue and morality is the necessity for translation into psychological constructs that render them amenable to research and application. The second section explains the cognitive and motivational aspects of the dispositional excellence required by virtue theory. We will argue that the work of intellectual virtues is strongly metacognitive. Moreover, we will appeal to the moral identity literature for insights on the motivational work of intellectual virtues and will suggest that the internalization of science identity is usefully described by Self-Determination Theory. Finally, we will explore approaches to science education that are attentive to the development of science virtues and suggest instructional strategies to inculcate intellectual virtues and science identity, and take up some possible objections that will require further consideration.

Virtue epistemology and intellectual virtues

Virtue epistemology has emerged as a field of study whose central premise is that intellectual virtues, understood as individual excellences or cognitive dispositions are essential for addressing normative problems of knowledge and belief justification, among other epistemological issues (Greco & Turri, 2012). Unlike traditional analytical epistemology where the chief concern is with epistemic evaluation of beliefs, and where issues of warrant and justification are primary, the chief concern of virtue epistemology is with epistemic evaluation of agents, where virtues and vises are primary considerations (Battaly, 2012). Virtue theories in epistemology work much the same way as virtue theories in ethics. In ethics, virtue theories evaluate an agent's action in terms of moral virtues and vises. In epistemology, virtue theories define or explain beliefs in terms of intellectual virtues and vises.

However, some argue that there is no necessary and sufficient connection between moral virtues and right action (Battaly, 2012). This has its own analog in moral psychology research that finds weak empirical relations between moral judgment and moral action (Blasi, 1980). Knowing the right thing to do and then doing it turn out to be different things. Knowledge of the moral law, or of what virtue requires, is insufficient for motivating moral or virtuous behavior. Weakness of will and incontinent virtue is always a possibility (Aristotle, Book VI). For this reason, theories of moral judgment, personality, and virtue have introduced self-identity as a construct to provides motivational force to moral evaluation (Blasi, 1983; Colby & Damon, 1992; Hardy & Carlo, 2005; Lapsley, 2016). Constructing the self on moral grounds is to view morality as something essential, central, and important to self-understanding. On this view, one is more likely to follow through on what morality and virtue requires because failing to do so would put self-identity at risk. We will extend these considerations below to account for science identity as a motivation for engaging the scientific attitude and instantiating the intellectual virtues.

Virtue reliabilism and virtue responsibilism

There are various perspectives within virtue epistemology on how best to understand intellectual virtues. Two options are prominent. The virtue reliabilist position conceives intellectual virtues as reliable faculties whose function is the attainment of true beliefs (Sosa, 2007). Paradigm examples of reliable faculties include vision, hearing, memory, introspection, induction, and deduction, critical and logical reasoning skills (Greco & Reibsamen, 2018). Some reliabilist virtues are natural faculties (e.g., vision) while others (e.g., critical reasoning) are acquired through learning, much like the learning of skills and competencies (Sosa, 2007).

In contrast, the virtue responsibilist tradition conceives of intellectual virtues as states of character that are "deep qualities of a person, identified with her selfhood" (Zagzebski, 1996, p. 104). They are acquired traits that require intellectually virtuous motivation (e.g., to seek understanding and attain truth) and the appropriate intellectual actions that lead to that end. Natural faculties do not count as intellectual virtues on this account, nor do skills and competencies, insofar as they either lack the requisite virtuous motivation or else virtuous motives are not essential to their operation (Baehr, 2011; Zagzebski, 1996).

There are, of course, varieties of virtue reliabilism and virtue responsibilism and the main lines of argument have attracted supporters and critics. Yet, we agree with Baehr (2011) and Battaly (2012) that the two perspectives are complementary. Both are necessary for a general theory of knowledge. Both can be reasonably invoked to describe the excellent thinker. Our ordinary intuitions of the excellent thinker will include a suite of reliable faculties like critical reasoning, good vision, and memory, but also include dispositional tendencies to open-mindedness, intellectual humility, intellectual courage and other responsibilist virtues. One feature of virtue reliabilism, its emphasis on critical and logical reasoning, is particularly attractive to us. Although these are not treated as intellectual virtues by some on the responsibilist side, it cannot be denied that the effective and appropriate deployment of critical thinking skills is at least instrumentally required by the intellectually excellent thinker (Facione, 1990). And there is a reasonable case to be made

for intellectual skillfulness to be classed among the virtues in any event (Annas, 2011; Stichter, 2018).

That said, virtue responsibilism holds attractions for the specific task of defeating the facets of post-truth noted earlier. A person who is intellectually inquisitive and who cares about the truth will insist on expanded information coverage in order to be exposed to different or contrary perspectives so as not to operate within limited information silos. Intellectual open-mindedness is required to consider unfamiliar ideas or contrary points of view. Intellectual justice will consider them fairly. Other virtues include intellectual humility (so that one might yield to better evidence and argument), sobriety (to avoid misguided optimism about the truth of one's perspective), and intellectual courage (to persevere in the test one's ideas in the face of criticism). These virtues may counter the lure of epistemic bubbles and echo chambers.

We are also attracted to responsibilist virtues for an additional reason. On at least Zagzebski's (1996) account, intellectual virtues are deeply personal character traits that are identified with selfhood. The role that self-identity plays in the work of intellectual virtues is insufficiently considered in virtue epistemology, but there is certainly a robust literature on moral self-identity that can guide reflection both on the motivational aspects of intellectual character and also serve as a model for conceptualizing the role of science identity in inquiry. We take this up in the next section, along with consideration of the metacognitive aspects of intellectual virtue.

Intellectual virtues, metacognition, and science identity

Virtue ethics carves out a crucial place for phronesis, or practical reasoning, in driving the work of virtues (Kristjánsson, 2015). In Aristotelian virtue theory, phronesis is an intellectual virtue that has been described as practical reasoning (or practical wisdom). Indeed Russell (2009, p. 3) argued that virtue ethics requires a strong conception of phronesis because without it virtue ethics "cannot establish an appropriate connection between having a virtue and doing what is right." The work of intellectual virtues similarly requires a conception of phronesis which we will associate with metacognition (Lepock, 2014). We will argue further that the phronetic and metacognitive exercise of intellectual virtues in post-truth informational environments will require (following Aristotle) a blueprint of a good life lived well. We will argue that identification with "science virtues" and a commitment to science identity provides just such a motivational blueprint.

Phronesis and virtues

Aristotle's (1985) *Nichomachean Ethics* is a continuing source of insights about the nature of the virtues. Phronesis refers to excellence in practical reasoning. It is a virtue of the intellect that disposes one to detect ethically relevant features of situations. It guides deliberation so that context-sensitive decisions align properly with some conception of living well (Russell, 2009). Moreover, phronesis coordinates the pull of individual virtues and adjudicates their application when several are summoned (Darnell et al., 2019). Phronesis orients each virtue toward its characteristic mean, which is to say, to what is fitting in action (Russell, 2009): "to feel them at the right times, with reference to the right objects, toward the right people, with the right motive, and in the right ways" (Aristotle, 1106b). The key point of Aristotle's "Golden Mean" is flexible judgment attuned to the requirements of particular situations (Kupperman, 1999).

Phronesis also requires a conception of what it means to flourish (Aristotle, Book VI). How a virtue is exercised in a specific context is partly informed by how the decision aligns with a blueprint of a good life. To follow Russell's (2009, p. 29) example, sometimes courage means pushing on, other times standing down, and "one can know the difference in a particular circumstance only by understanding what is worth fighting for, and at what cost, and this means having an overall conception of the good."

Metacognition and intellectual virtues

How should intellectual virtues and phronesis be understood as psychological constructs? Our approach to intellectual virtues is informed by social cognitive approaches to personality that account for dispositional coherence in terms of the availability and accessibility of social cognitive schemas for appraising and evaluating the morally salient features of situations (e.g., Cervone & Little, 2019; Cervone & Shoda, 1999; Lapsley & Narvaez, 2004). A person with virtuous character is one for whom virtuous categories, norms, and schemas are readily primed or chronically accessible for social information-processing. An intellectually virtuous individual would have schematic understanding of open-mindedness, curiosity, humility, and the like, readily accessible for as guides to regulate inquiry. Yet, if virtue theory is correct, then no intellectual virtue can operate effectively without phronesis. Phronesis is required to determine which intellectual virtue is required in *this* situation under *these* circumstances, and how it is to be manifested. It is required to adjudicate between intellectual open-mindedness and conviction, for example, or calibrate more generally the "golden mean" between excess and deficiency in the application of any virtue.

Barzilai and Zohar (2014) argued that epistemic thinking overlaps substantially with metacognition. There is consensus that metacognition involves metacognitive knowledge of cognition and metacognitive control processes (e.g., Schraw & Moshman, 1995). Metacognitive knowledge includes declarative knowledge (knowing *that)*, procedural knowledge (knowing *how*), and conditional knowledge (knowing *when* or under *what conditions*). Metacognitive control processes include skills of planning, monitoring, and evaluation of cognition. Similarly, epistemic metacognition involves metacognitive knowledge about the nature of knowledge and knowing as well as metacognitive skills of planning, monitoring, evaluating and controlling epistemic processes and in ways responsive to the particularities of diverse situations

(Barzilai & Zohar, 2014). We argue that phronetic guidance of intellectual virtues is similarly metacognitive in nature (Lapsley, 2019).

Both categories of metacognition should underwrite the application and display of intellectual virtues as guides to inquiry: Knowing that specific inquiry tasks require open-mindedness, or intellectual courage, for example, knowing how intellectual virtues work and under what conditions, and having the skills to plan and monitor their application. Metacognition is required so that intellectual virtues hit their characteristic mean, are flexibly summoned, and strategically applied given the requirements of a specific epistemic task.

Metacognitive operations are realistic candidates for understanding the phronetic deployment of intellectual virtues in inquiry tasks. As Kuhn (2000) points, out, meta-level cognition is required to explain phenomena across many domains, including epistemic reasoning, memory, problem-solving and knowledge acquisition, and to these we include intellectual character and the work of virtues proper to the scientific attitude. Individuals who possess well-developed metacognitive understanding of the nature of intellectual virtues, why they are valuable, and when and how to apply them should reason their way out of epistemic bubbles and resist echo chambers better than individuals who do not.

Intellectual virtues and science identity

Although various aspects of metacognition are plausible candidates for conceptualizing the phronetic elements of intellectual (and other) virtues, there is still the matter of how much phronesis requires a sense of flourishing or a conception of a good life. As we have seen, Aristotelian virtue theory requires a blueprint of a good life to inform phronetic decisions about concrete cases, and this is true for the application of both moral and intellectual virtues (Burbules, 2019). Moral identity is one such blueprint for ethical decisions and moral judgment, and science identity, by extension, is a blueprint for purposes of intellectual inquiry. In both cases, moral and science identity carve out what is essential, central, and important to self-understanding in a way that provides "the frame or horizon within which I can try to determine from case to case what is good or valuable or what I endorse or oppose" (Taylor, 1989, p. 27). Someone whose personality is imbued with a strong science identity cares about intellectually virtuous inquiry, identifies with its requirements, and wishes to instantiate its considerations as a regulative ideal in charting the trajectory of one's life. In this sense, science identity provides a blueprint for decision-making that Aristotelian virtue theory insists is a feature of phronesis. It also provides motivation for following through on what intellectual virtues demand of us, insofar as not to do so would put our very self-identity at risk.

Science identity and motivation

The motivational aspect of science identity is modeled on the moral identity literature. For example, Blasi's (1983) Self Model of moral behavior attempts to explain the common observation that moral behavior does not always follow moral judgment. Making a moral determination does not automatically motivate behavior. What is required, in addition, is a subsequent judgment that the self is responsible for enacting the moral judgment. The extent to which this is deemed obligatory further depends upon moral identity (the degree to which morality is central, essential and important to selfhood) and the desire to act in ways consistent with self-understanding. Similarly, Colby and Damon (1992) showed that a common theme of individuals who led lives of extraordinary moral commitment was the fact that pursuit of moral goals was closely identified with their sense of self. Indeed, moral identity is commonly featured in componential models of moral-virtuous character (Cohen & Morse, 2014; Lapsley, 2016; Nucci, 2019) and is a robust predictor of a wide range of moral behavior (Hardy & Carlo, 2005; Hertz & Krettenauer, 2016) and moral emotions (Lefebvre & Krettenauer, 2019).

This conception of moral identity informs our account of the intellectual virtues that underwrite science identity in two ways. First, as noted earlier, Aristotelian virtue theory insists that character virtues require a blueprint, some regulative ideal or conception of a good life in order to manage the application of virtues and to guide decisions. Science identity provides such a blueprint. It denotes the "importance of what we care about" (Frankfurt, 1988) and the "horizon of significance" (Taylor, 1989) that informs where we stand and what is to be done. A second reason is that intellectual virtues require a motivational push to see it through. This might seem odd from the perspective of responsibilist virtue theory that understands motivation to be constitutive of virtue itself. But intellectual virtues are no more auto-motivating than are moral judgements. Moreover, weakness of will and incontinence leave open the possibility that virtues can sometimes fail their possessor. Yet, responsibilist virtue theory also anticipates the necessity for a concept of intellectual self-identity insofar as it understands intellectual virtues as "deep qualities of a person, identified with her selfhood" (Zagzebski, 1996, p. 104). It is the identification of virtues with selfhood that is precisely the definition of intellectual identity, and keeping faith with this conception of the self is the source of intellectual motivation.

Science identity and self-determination

Yet, claiming to be an intellectually virtuous person (or moral person or science person) could mask different motivations and be integrated within the self-system at different levels of internalization. Self Determination Theory (SDT, Ryan & Deci, 2000, 2017) is a useful framework for understanding the connection between science identity internalization and acting on intellectual virtues. Indeed, in the moral domain, Krettenauer (2020) argued that moral action is at the service of identity maintenance, a notion that accords with the Self Model of moral identity noted earlier. "As a consequence, the motivation to act morally might become stronger, more reliable, and more robust once it is backed

by moral identity" (Krettenauer, 2020, p. 3). Similarly, the motivation to exercise intellectual virtues during inquiry and evidence appraisal should be more robust to the extent that it emanates from science identity.

How well values are integrated within the self-system can range along a continuum of autonomy depending on the perceived locus of causality as external or internal to the self. SDT posits four kinds of extrinsic regulation (external, introjected, identified, and regulated) along with self-determined intrinsic regulation (Ryan & Deci, 2000). Each step along the continuum from completely external to completely intrinsic motivation represents a graded integration of regulation and self-beliefs.

Externally regulated behavior, for example, is driven completely by considerations extrinsic to the self and is experienced accordingly as alienating and subject to contingent control. Introjection describes regulations and values that one internalizes but not completely. The locus of the regulation is felt to be external to the self but one takes it on to avoid guilt or feel pride in one's achievement. Regulation through identification, the next step, is characterized by conscious acceptance and valuing of the regulation as something personally important. Integrated regulation occurs when identified regulation is more completely integrated with the self. Integrated regulation is certainly the most autonomous of the several kinds of extrinsic motivation insofar as actions are fully assimilated with the self, but fully intrinsic motivation is realized when these actions are experienced as a source of enjoyment and pleasure in their own right and for their own sake. "By definition, intrinsically motivated behavior, the prototype of self-determined action, stems from the self" (Ryan & Deci, 2000, p. 74).

Hence, a psychologically adequate account of intellectual virtues requires a conception of science identity to provide a motivational push to practical reasoning. Science identity provides the blueprint required by phronesis to guide the application of intellectual virtues in concrete situations. But identification with science virtues is not all-or-none. How completely they are internalized and identified with the self can be arrayed along the continuum of extrinsic-to-intrinsic regulation identified by SDT. As Ryan and Deci (2000, p. 73) put it, "As people internalize regulations and assimilate them to the self, they experience greater autonomy in action."

Science identity is already a familiar construct in the educational sciences. It is typically defined by reference to social identity theory as a sense of self that is derived from group or category membership (Burke & Stets, 2009). Hence a science identity "… is a socially-based identity grounded in the extent to which individuals seem themselves and are accepted as members of a STEM discipline or field" (Kim et al., 2018, p. 591).

Our approach to science identity is complementary to this literature but fortifies it with identification with intellectual virtues. In the absence of intellectual virtues, science identity is not a reliable defense against post-truth. The social identity conviction that "I'm a science person" (an item that recurs on standard indices of science identity) could just as easily be turned to the defense of creation science as to evolution, or support a claim that denial of anthropogenic climate change is the mark of the true scientist. What is required is a fortified science identity that is grounded by a commitment to intellectual virtues and made chronically accessible by its centrality and importance to self-understanding. We also want individuals to care about intellectual virtues and epistemic goods, and evince the motivational desires to keep faith with these values because failing to act with what is central, essential and important to self-understanding is to risk self-betrayal.

Yet, self-identification with intellectual virtues and the scientific attitude admits of degrees as illustrated by SDT. Students who identify with science for externally regulated or for introjected reasons, for example, might prioritize transcript values (e.g., grades, awards, class points and class rank) as the motivation for inquiry rather than intrinsically motivated pursuit of knowledge for its own sake. Individuals who inhabit epistemic bubbles and echo chambers might value forms of inquiry that meet social identity needs to retain the affirmation of a closed epistemic community rather than pursue warranted true beliefs out of respect for the truth.

Of course, science education (indeed, all education) should help students nurture a motivation to value knowledge and truth for its own sake and to encourage internalization of epistemic values as something constitutive of self-identity. In the next section, we explore several educational options for teaching intellectual virtues and for developing a science identity that is responsive to the challenges of post-truth.

Educational implications

We group educational implications under three aspects: themes from Aristotelian virtue theory, metacognitive instruction, and internalization of moral identity as understood in SDT and character education literature. Figure 1 is a working model of how instructional strategies relate to the formation of intellectual virtues, the conditions that underwrite their internalization as science identity (e.g., in learning contexts that are caring, relational and autonomy-supportive), and the way science identity moderates the influence of post-truth on inquiry and evidence appraisal.

Teaching intellectual virtues

Much recent writing on the development and instruction of virtues draws inspiration from Aristotelian themes (Baehr, 2013; Battaly, 2016; Kristjánsson, 2015). Although virtues are said to be different from skills (Baehr, 2011), both share a common framework with respect to instruction (Russell, 2009). We learn the virtues by doing them with regular and consistent practice under the guidance of a virtuous tutor (Steutel & Spiecker, 2004). From these considerations, Aristotelians draw three lessons: (1) development of virtue requires the mentorship of tutors to provide formal instruction in virtue; (2) virtue requires imitation of exemplars so

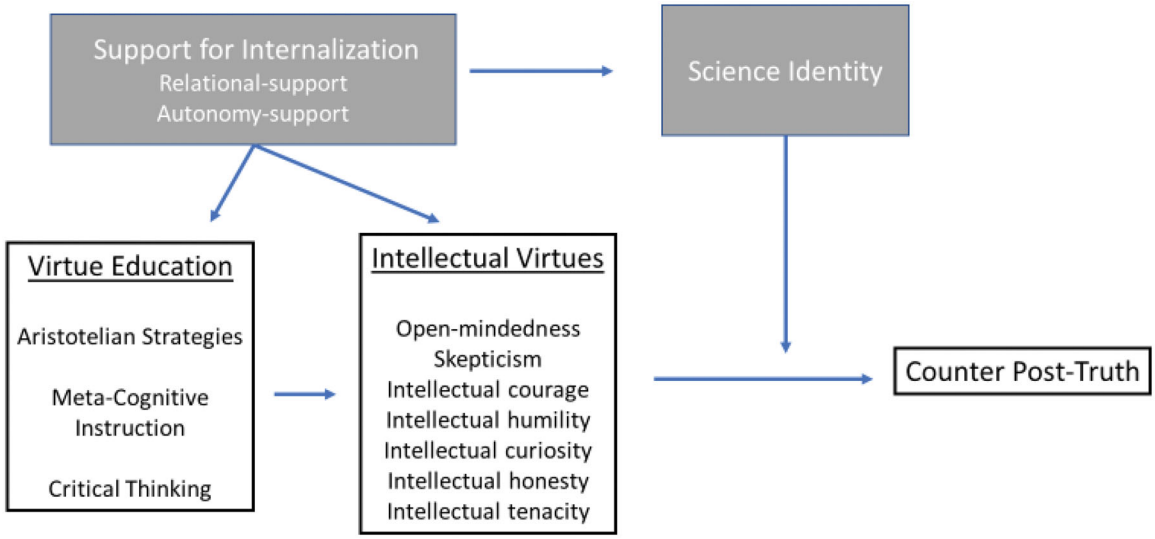

Figure 1. A process model for instruction and internalization of intellectual virtues and science identity.

that we come to take on the tutor's characteristic feelings, motivations and actions; and (3) habituation of virtue requires regular practice.

The Aristotelian approach in instantiated in different ways by virtue educators. For example, Byerly (2019) articulated five pedagogical strategies for teaching intellectual virtues: direct instruction, use of exemplars, identifying intellectual virtues and vises, giving students opportunities to practice the behaviors characteristic of the virtues, and self-assessment. Direct instruction about virtues, their definition and key features, what they entail, and how they are different from intellectual vice is prominent in all approaches to intellectual character education (Baehr, 2013; Battaly, 2016; Ritchhart, 2002). The rationale for explicit instruction on the virtues is to give students new conceptual categories and a shared vocabulary to help them develop a schematic lens for guiding and appraising inquiry (Dwyer, 2017).

Virtue concepts taught through direct instruction are then illustrated by reference to exemplars of the virtues (Byerly, 2019). Exposing students to exemplars shows how intellectual virtues (and vises) are manifested in real lives and real life contexts, both to increase students' sensitivity to the diversity of situations that require them and to illustrate the characteristic emotions that exemplars bring to their exercise (Battaly, 2016). Exemplars are not necessarily teachers, although having teachers, mentors and supervisors think aloud their use of intellectual virtue strategies could provide cognitive modeling that is found so effective for strategy learning in other instructional domains (Zepeda et al., 2019). Roberts and Wood (2007) illustrated various intellectual virtues using fictional characters in literature. Using scientists as exemplars of virtues and vises can be a natural feature of science education at all levels (Paternotte & Ivanova, 2017; Pennock & O'Rourke, 2017), particularly if exemplars are also shown to be "someone like me," that is, someone who also struggled, overcame obstacles and persevered rather than as exemplars of uncommon genius as is typically done in science textbooks (Lin-Siegler et al., 2016). Identification would also be enhanced when exemplars are not over-represented by one race or gender.

A third and fourth strategy for teaching intellectual virtues is to help students identify intellectual virtues and vises using contextualized vignettes and to give students practice in performing the behaviors characteristic of intellectual virtues (Byerly, 2019). The use of vignettes will help students identify the situations that provide opportunities to exercise virtues, insofar as each virtue has its own characteristic manifestation (Baehr, 2015; Battaly, 2016). Practicing focal virtues in their characteristic range of application is fundamental to Aristotelian virtue education.

Baehr (2015) provided numerous examples of concrete instructional practices that encourage growth in intellectual virtues. Peer-led or teacher-led group discussions where students are assigned to articulate viewpoints contrary to their own are designed to promote open-mindedness and humility. Rewriting drafts of paper can highlight the value of perseverance. Intellectual courage and tenacity can be promoted by encouraging growth mindset and by mitigating student fears of getting the wrong answer. Baehr (2015) also illustrated the importance of student assessment of virtues, which is the fifth aspect of teaching for intellectual virtues (Byerly, 2019). Students must reflect on their own virtues and design a plan for monitoring growth in virtues across the term. Students are also given opportunities to write about the kind of intellectual character they aspire to be and the concrete steps needed to move in that direction. In the language of moral identity and phronesis used earlier, students are asked to think and write about the ideal person they want to become and the blueprint that gets them there.

A recent metanalysis reported substantial evidence that classroom instructional strategies like these support the acquisition of critical thinking skills and critical thinking disposition (Abrami et al., 2015). Four instructional strategies produced significantly positive effect sizes: *direct instruction, infusion* (making critical thinking an explicit feature of content courses), *immersion* (critical thinking not explicit in a content course), and a *mixed* strategy whereby

critical thinking was taught as an independent track in a content course. A finer-grained analysis categorized instruction in terms of *dialogue, authentic instruction*, and *mentoring*. Dialogue included learning through a variety of discussion formats (teacher led small group and whole-class, debates, online discussion, oral and written discussion). Authentic instruction presented students with genuine problems in the form of case studies, vignettes, hypothetical dilemmas, simulations, and role-play situations. Mentoring includes one-on-one teaching and peer-led dyadic interactions. All three forms of instruction were effective for promoting critical thinking skills and dispositions, particularly when used in combination (Abrami et al., 2015). Moreover, mentoring "may serve as a catalyst for critical thinking; it can augment other strategies in a powerful way but is not especially successful if provided in isolation" (p. 302). Hence these findings give confidence that Aristotelian-inspired strategies can be effective for teaching the critical thinking dispositions associated with intellectual virtues.

Metacognitive instructional strategies

We argued that the phronetic aspects of virtue requires a metacognitive account of the knowledge and regulatory processes involved in the application of virtues to concrete situations. There is a substantial literature that underscores the importance of metacognition in learning concepts across many educational domains (Dunlovsky & Tauber, 2016; McCormick et al., 2013), including science education (Zohar & Barzilai, 2013). Yet, there is every reason to believe that teacher *pedagogical knowledge in the context of teaching metacognition* (Zohar & Barzilai, 2013) would look similar for leading instruction in intellectual virtues as it does for science education (for example).

Modeling strategy use, using prompts and probes, thinking aloud, guiding whole class and small group discussion, encouraging reflection, providing reflective feedback, and opportunities to practice—these standard ways for teaching metacognition are also evident in teaching intellectual virtues (Ritchhart, 2002). They were evident in interventions to improve critical thinking skills and dispositions (Abrami et al., 2015). Moreover, direct instruction of metacognition also has positive benefits for motivational constructs such as self-efficacy, valuing academic tasks and setting mastery achievement goals (Zepeda et al., 2015), and we suspect it will underwrite the motivational aspects of virtuous intellectual inquiry as well.

Science identity

We argued that science identification is central to self-understanding and provides the phronetic blueprint that gives a motivational push to the enactment of intellectual virtues. But identity internalization could vary along a continuum of autonomy as conceptualized by SDT (Krettenauer, 2020). Two literatures provide insight on how moral identity—and by extension, science identity—can be better aligned with more autonomous regulatory styles. One literature arises from moral psychology (Lapsley & Yeager, 2013), the second from SDT itself (Ryan & Deci, 2017). As Figure 1 illustrates, these literatures underscore the importance of learning contexts characterized by relational support and autonomy support for internalization of values.

Moral psychology

The moral psychology literature suggests that moral integrity and the pursuit of moral goals are deeply relational. For example, Kochanska (2002) traces the development of conscience and moral self to the "mutually responsive orientation" that characterizes early secure attachment between caregivers and infants (Kochanska, 2002). Her model moves from security of attachment to committed compliance to moral internalization. Social influence was also the decisive mechanism that drove the extraordinary moral commitment of exemplars studied by Colby and Damon (1992). Indeed, the communal and relational context of moral formation is a common theme in moral-character education (Lapsley & Yeager, 2013), and we suspect that it is also implicated in the findings on mentoring noted earlier (Abrami et al., 2015). Here it was shown that mentoring had a "catalyzing effect" on instructional strategies for critical thinking dispositions. It is likely that what is catalyzed within the nexus of mentorship is not simply the acquisition of critical reasoning skills but also internalization of values and identity commitments.

Self-determination theory

Internalization is "the process of taking in values, beliefs and behavioral regulations from external sources and transforming them into one's own" (Ryan & Deci, 2017, p. 182). These values, beliefs and regulations can be integrated within the self to a varying degree, and if fully internalized "will largely be in harmony or congruence with other aspects of one's values and personality, and enacting it will be experienced as autonomous" (p. 182). We propose that internalization of science virtues follows this model. Within the context of instruction, mentorship and practice, these virtues are internalized along a continuum of autonomy to the point where these values anchor the sense of self-identity, at which point "identity can be a powerful motivator of identity-consistent behavior" (Ryan & Deci, 2017, p. 387).

Meeting the basic psychological needs of relatedness, competence, and autonomy are crucial to internalization (Deci et al., 1994). For example, as in moral education, SDT underscores the importance of meeting relational needs for trust and connection, attachment and belonging in setting the conditions for internalization. When relational needs for belonging and connection are met, when there is caring and trust, children are motivated to internalize the behavioral norms of parents (Kochanska, 2002), students are motivated to internalize school regulations (Ryan et al., 1994) and pursue socially responsible goals (Wentzel, 2003).

Support for competence and autonomy also facilitates internalization. Competence is a strong intrinsic drive toward efficacy that is functionally important to the extent

that it motivates mastery of culturally-adaptive skills. But it is also "nourishes people's selves" when actions are perceived to result from one's own agency, from internal sources autonomously initiated (Ryan & Deci, 2017, p. 95). Moreover, it is only within autonomy-supportive contexts that one can come to feel competent and relationally connected (Ryan & Deci, 2000). In order to integrate regulatory norms "people must grasp its meaning and synthesize that meaning with respect to their other goals and values" (p. 74). Put differently, regulations must be assimilated into an identity framework that gives it meaning. This identification "is facilitated by a sense of choice, volition and freedom from excessive pressure towards behaving or thinking a certain way" and in this way "support for autonomy allows individuals to actively transform values into their own" (Ryan & Deci, 2000, p. 74).

A study by Williams and Deci (1996) is illustrative. This project examined the extent to which medical students came to embrace a set of values (the "biopsychosocial model") for how best to interact with patients. It was premised on the SDT view that internalization is more likely in autonomy-supportive contexts. Across two studies, Williams and Deci (1996) showed that perception of autonomy-support from instructors (e.g., "I feel that my instructor provides me options and choices") promoted students' autonomous self-regulated learning, their sense of competence, and later internalization of beliefs and values imparted during their classwork. Put differently, students were more likely to embrace the biopsychosocial values of doctor-patient interaction, and later adopt them in actual practice, when instructors were perceived to support student autonomy. Presumably the internalization of other values, including intellectual values such as open-mindedness, humility, honesty, among others, is an extension of this perspective. Intellectual virtues are likely to be internalized, and later enacted, when explicit instruction takes place in learning contexts that are perceived by students to be autonomy-supportive.

How to promote internalization of science values has implication for the educational response to post-truth. Of course, science education (indeed, all education) should help students nurture a motivation to value knowledge and truth for its own sake, as a "good internal to practice" (following MacIntyre, 1984). Developing intellectual virtues is key to this objective. The challenge is how to understand the motivational part of intellectual virtues, the part that requires desiring, caring about, and loving epistemic goods for their own sake. How do we get students who have spent their entire academic careers chasing transcript values, that is, grades, awards, class points and class rank—goods external to the practice of learning certainly—to desire knowledge and truth as a foundational pursuit for its own sake and out of a deep personal desire?

We suggested that moral psychology and SDT literature provide guidance on how to support the internalization of intellectual virtues. Instruction in intellectual virtues will ideally take place in learning contexts that provide relational and autonomy-support (Figure 1). These contexts are conducive to internalization to such an extent that intellectual virtues become constitutive of one's self-identity. We care about these values, are motivated to pursue them, and to love epistemic goods for their own sake, when they are central, essential, and important to self-understanding, to our very identity as a person. A science identity so constituted should moderate the influence of post-truth on inquiry and evidence appraisal.

Conclusions and future direction

We argued that deficiency of intellectual character puts one at greater epistemic risk to the facets that promote post-truth. To break free of epistemic bubbles and echo chambers, and replace the identity-protective cognitive mechanisms that guard them, will require a suite of intellectual virtues. We understand intellectual virtues as cognitive excellences or habits of mind that underwrite the scientific attitude to belief appraisal. The deployment of intellectual virtues requires metacognitive planning, evaluation and control. It also requires metacognitive knowledge about which virtues are best suited for addressing specific epistemic aims. In addition, we appealed to science identity to provide the motivational blueprint to guide the exercise of phronesis and epistemic metacognition. What we termed "science identity" is the degree to which intellectual virtues are central, important and essential to self-understanding. We assume, following SDT, that internalization of science virtues can be modeled along a continuum of increasing self-determination where the exercise of intrinsically motivated intellectual inquiry emanates from the autonomous self. As Moshman (2009, p. 156) put it, "Identities provide self-constructed and enduring reasons for action and thus enhance autonomy and, potentially, rationality."

Our educational response to post-truth was directed to showing how intellectual virtues can be inculcated by use of Aristotelian-inspired virtue pedagogy, metacognitive instructional strategies, and strategies for promoting internalization of science identity. Internalizing a science identity was further illustrated by appeal to the moral education and SDT literature. Although teaching for intellectual character will require explicit, intentional focus as a target of instruction, many of the strategies discussed here already are part of best practice instruction in other learning domains, including cognitive strategy instruction, metacognitive instruction, critical thinking, and moral education.

There is still much to learn about intellectual virtues and their relationship to inquiry and post-truth. Some have expressed doubts about whether virtues can be measured (Curren & Kotzee, 2014) or whether intellectual exemplars provide a guide for action (Kotzee et al., 2019). The latter concern is aimed at Zagzebski's (2017) exemplarist moral theory that draws attention to "supremely excellent" moral exemplars as a source of motivation. The critique that moral exemplarism fails to provide guidance at the proper level of decision-making may well be correct. We noted a similar concern with the way science textbooks hold out world-historical figures as exemplars of science. Yet, students may still

need to see examples of how virtues (and vises) play out in concrete life circumstances of inquiry not only to build the proper mental model of the virtuous inquirer, but also to make the aspiration seem possible "for someone like me." We think there is a role for exemplars in motivating these aspirations.

The measurement of virtues is a challenge particularly if the touchstone of success is the operationalization of virtues as understood in the rich detail of philosophical inquiry. As noted earlier, translating philosophically rich concepts like virtue, character, and phronesis into psychological constructs will give rise to ongoing debate about meaning, scope, and coverage of the domain. Yet, there is promising work on the assessment front. New assessments of virtuous character (Ng et al., 2018) and phronesis (Kristjánsson et al., 2020) have appeared. Intellectual humility has attracted several attempts at assessment (e.g., Alfano et al., 2017; Haggard et al., 2018; Hoyle et al., 2016; Krumrei-Mancuso & Rouse, 2016), as has epistemic curiosity (e.g., Litman & Mussel, 2013; Piotrowski et al., 2014). This trend will excite useful debate in education, educational psychology and science education, and between the empirical and philosophical wings of moral psychology, but it also invites ongoing research on the role of intellectual virtues in counteracting the facets of post-truth.

One limitation of the present analysis is that our conception of how to break free of epistemic bubbles and echo chambers, and to defeat post-truth more generally, is located at the individual level. It refers to the psychological specification of intellectual character as a possession of virtuous inquirers. As Longino (2002) has shown, however, this cognitive individualism is one-sided and ignores the important role of social forces in securing rationally-grounded knowledge. The cognitive and the social, on her account, are not epistemic strangers. Although there are elements of our analysis that underscore the social dimensions of intellectual character (e.g., exemplars, autonomy-supporting learning contexts, the relational support for internalization), it is still an open question how the social structure of inquiry interfaces with the dispositional qualities of inquirers (Burbules, 2019).

Certainly, post-truth culture is a challenge to rational consideration of urgent policy debates and for democratic deliberation more generally. The apparent ease with which individuals are swept up into epistemic bubbles and the ferocity with which ideological bunkers are defended is cause for concern. Our approach has been to focus on intellectual character and the development of science identity as part of an educational response. We conclude that one way to defeat post-truth tendencies is to make intellectual virtue an explicit aim of science education and to consider science education a special form of character education.

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