

# Chapter 12 1

## Toward a Self-Cultivation Approach 2

### to Engineering Education: A Confucian 3

### Perspective 4

Qin Zhu and Yixiang Shawn Sun 5

**Abstract** This chapter serves as an initial endeavor to investigate the potential utility of the idea of self-cultivation in constructing an alternative approach to prevalent approaches in engineering education, which predominantly concentrate on the development of employable skills for individual engineers. To achieve this goal, this chapter first conceptualizes a challenge central to dominant approaches to engineering education which is the lack of the self-dimension. It then provides a brief introduction to the Confucian theory of self-cultivation by comparing it with the Western concept of *Bildung*. Finally, this chapter discusses the implications of this self-cultivation theory for engineering education practice and research. It explores how teaching, learning, and assessment in engineering education can be defined and implemented differently. This chapter is expected to be of particular interest to engineering educators, administrators, and policymakers who are unsatisfied with dominant approaches to engineering education that focus on the attainment of measurable technical knowledge and skills. 6-19

**Keywords** Engineering education · Self-cultivation · Confucian ethics · *Bildung* · Educational theory 20-21

## 12.1 Introduction 22

Philosophers and engineering educators have recently criticized that dominant approaches to the professional formation of engineers lack self-critical and self-reflective dimensions (Karwat et al., 2015; Karwat, 2019; Mitcham, 2014). While engineering students are taught to comply with professional codes of ethics and be aware of the social and ethical implications of technology (Herkert, 2000), rare 23-27

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28 opportunities can be found in the curriculum that allow them to reflect on some  
29 fundamental and self-reflective questions for the engineering profession such as  
30 why they are engineers, for whose benefit they work, and what kinds of engineers  
31 they want to become (Zhu, 2021). By drawing on the theories in Confucian ethics (a  
32 philosophical tradition known for its emphasis on the value of self-cultivation for  
33 human development and social governance), this chapter aims to develop an outline  
34 for the self-cultivation approach to engineering education practice and research.

35 Such a process encompasses two components. First, this chapter conceptualizes  
36 a challenge central to dominant approaches to engineering education which is the  
37 lack of the self-dimension. Second, it will briefly introduce the Confucian theory of  
38 self-cultivation by comparing it with the Western concept of *Bildung*. Conducting  
39 such a cross-cultural comparison is meaningful in at least two different ways. First,  
40 such a comparison allows readers to develop a much deeper and critical understand-  
41 ing of Confucian self-cultivation including its underlying values, commitments, and  
42 limitations. Second, doing so will also be helpful for further augmenting Confucian  
43 self-cultivation by integrating insights from the Western interpretations of *Bildung*.  
44 Therefore, a self-cultivation theory developed in this way will be more responsive  
45 to diverse cultures. Even though such a theory was derived from the Confucian tra-  
46 dition, it has been critically examined and expanded in its comparison with the  
47 Western concept *Bildung*.

48 Finally, this chapter will discuss the implications of this self-cultivation theory  
49 for engineering education practice and research. It explores how teaching, learning,  
50 and assessment in engineering can be defined and implemented differently. Doing  
51 so generates insights that can be potentially useful for designing instructional activi-  
52 ties that invite students to reflect on (1) the values that drive their personal and  
53 professional decision-making; and (2) how their participation in engineering trans-  
54 forms their professional identities and the values and rituals in communities they  
55 serve. By taking the lens of self-cultivation, this chapter also critically examines the  
56 typical learning outcomes in engineering. It analyzes how these learning outcomes  
57 and the ways in which they are assessed in educational practices may potentially  
58 undermine the development of self-cultivation in students. It will also explore how  
59 these learning outcomes can be rewritten to include space for students' self-  
60 cultivation. This chapter is expected to be of particular interest to engineering edu-  
61 cators, administrators, and policymakers who are unsatisfied with dominant  
62 approaches to engineering education that focus on the attainment of measurable  
63 technical knowledge and skills.

## 12.2 The Self: A Missing Dimension in Engineering Education

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Dominant ideologies in engineering education have persistently been criticized by humanists and social scientists for lacking the self or the critical dimensions. There is a widespread ideology “normative holism” in engineering education that equates “the technical contents of engineering practices with material advancements across the planet for human benefit” (Downey, 2012, p. 233). Partly what this ideology leads to is that engineers do not feel obligated to critically examine the actual consequences of their work including their *unique role* (both positive and negative) in shaping or governing these consequences.

Engineering is widely perceived as a *profession of solving problems* and thus engineers and engineering students are proud of themselves being *problem-solvers* (Jonassen, 2014; Zhu, 2021). There are certain problems that are global in nature and transcend national boundaries, requiring collaborative efforts between engineers and non-engineers. The National Academy of Engineering (NAE) in the United States call these global concerns “Grand Challenges,” highlighting the need for engineers to collaborate across borders and disciplines, drawing upon their creativity, imagination, and expertise from all engineers. However, philosopher Carl Mitcham argues that what is missing in engineering education is more than simply technical abilities to address these grand challenges (Mitcham, 2014). There is a more fundamental challenge encountered by engineering educators and engineering students, the “self-knowledge” challenge, which refers to the ability to “think reflectively and critically about the kind of world we wish to design, construct, and inhabit in and through our technologies” (Mitcham, 2014).

From Mitcham’s perspective, what distinguishes between his approach and NAE’s Grand Challenges is essentially the *nature and scope* of these challenges. In other words, are the problems confronted by engineering educators more of global technical problems as indicated in NAE’s Grand Challenges which are expected to be solved by expertise and innovation provided by engineers? Or, do engineering educators have a more pressing moral obligation to address the challenges concerning themselves or the lack of self-knowledge in the profession? Even for highly complex questions such as Global Challenges, is engineering the only and always the best way to approach these issues? Karwat et al. (2015) argue that what is more important for addressing questions such as climate change is more of a cultural change within the engineering profession rather than engineering expertise or engineering solutions *per se*. Thus, it is crucial to educate engineering students to examine some bigger questions concerning the purposes of their work and who and whose benefits they serve (Karwat, 2019). These questions are meant to help engineers develop a self-critical consciousness and help them better understand the motivations for doing engineering work and the implications for their work. All these questions are concerned about their *moral project* not simply the engineering project. Some example questions include:

- 106 • Why am I an engineer?
- 107 • For whose benefit do I work?
- 108 • What is the full measure of my moral and social responsibility (Karwat, 2019,
- 109 p. 1329)?

110 Readers who are familiar with engineering education research (EER) as a field in  
111 the United States may argue that most recent scholarship in EER does emphasize  
112 certain concepts that seem to have a self-dimension such as self-efficacy and self-  
113 concept (Dirisina & Shehab, 2023). It is true that these concepts do touch on how  
114 engineering students perceive or evaluate themselves. However, we would argue  
115 that discussions on these concepts miss certain engagement opportunities for stu-  
116 dents. For instance, scholarship in EER often considers the *instrumental* value of  
117 these concepts for pursuing or persisting in engineering as their career pathway.  
118 Exploring these self-related concepts in EER is mainly to understand the psycho-  
119 logical mechanisms for engineering learning. Doing so will help to improve stu-  
120 dents' efficiency in grasping technical concepts and skills and thus help them better  
121 at solving technical problems. The *moral* value of these concepts is not addressed in  
122 these efforts. In other words, if my own values are not aligned with how I see or  
123 experience engineering, is engineering a career path I should pursue? Or if there are  
124 values or assumptions embedded in engineering practice that are questionable? If I  
125 continue to pursue engineering, what do I learn and grow as an engineer?

126 The discussions on these self-related concepts in EER often does not take engi-  
127 neering or technology seriously, including their impacts on social and human devel-  
128 opment. For instance, by participating in a particular engineering field, whose  
129 interests do I serve and what kind of society and societal values do I build? The  
130 more I participate in these engineering projects, what kind of person will I become?  
131 Is that kind of life as an engineer worth pursuing? Therefore, the term self is not  
132 merely considered as a psychological or learning science concept (in other words,  
133 understanding the self is essential for learning more efficiently). Instead, it is more  
134 of an ontological or moral concept, and it is valuable not *only* for the sake of learn-  
135 ing successes (e.g., good self-concept skills predict academic outcomes) but also for  
136 some ontological issues such as who we are as engineers and who we want to  
137 become. Therefore, our major goal in this chapter is to leverage resources from  
138 Confucian ethics and explore how these resources can help us conceive an alterna-  
139 tive approach to engineering education that focuses on self-cultivation.

### 140 **12.3 Confucian Theory of Self-Cultivation:** 141 **A Comparative Perspective**

142 To integrate the self-critical dimension into engineering education research and  
143 practice, we aim to leverage holistic approaches to education in both the East and  
144 West traditions. More specifically, our discussions hinge on a central concept in  
145 Confucianism self-cultivation (*xiusheng*, 修身) and compare it with a similar

concept *Bildung* derived from the European tradition. We expect that adopting such a comparative perspective will enhance our ability to engage in a meaningful discussion about an alternative approach to engineering education that prioritizes critical self-cultivation.

As a central concept and practice in Confucianism, self-cultivation needs to be examined within its rich historical context. As a philosophical tradition, Confucianism emerged during the Spring and Autumn Period (*chunqiu shiqi*, 春秋时期) (770 BC–476 BC). This historical period witnessed a decline in the central authority of the Zhou dynasty (1046 BC–256 BC), leading to increased political autonomy among regional lords who governed their own territories as independent states. This era witnessed the emergence and active participation of the *shi* (scholar, 士) class, or “scholar-officials” (Li, 2018), marked by a significant degree of academic freedom and diverse and yet competing intellectual traditions. During such a period marked by warfare and social upheaval, scholars gave rise to various schools of thought, seeking to provide solutions. In this era, a notable phenomenon known as the “*baijia zhengming*” (contention of hundred schools of thought, 百家争鸣) showcased academic freedom. Influential philosophers such as Laozi, Mozi, and, notably, Confucius played pivotal roles in shaping the intellectual landscape during that period.

Amidst such societal upheaval, a central question concerning all schools of thought was how society could reach social harmony. The solution that Confucius offered was through the practice of self-cultivation. Specifically, according to the Confucian perspective, a primary aim of self-cultivation is to attain the status of a *junzi* (morally exemplary person, 君子). Originally, the term *junzi* referred to a lord’s son, but Confucius expanded the term to represent a “morally exemplary person.” Central to this process of self-cultivation is the cultivation of virtues (or virtuous tendencies) which is expected to lead to ethical conduct, with a notable assumption that achieving this noble goal does not depend on one’s social background. Therefore, ideally anyone has the potential to become a *junzi* through learning (Gardner, 2014). The ultimate aspiration becoming a *junzi* is to become a person whose behaviors in their interactions with others demonstrate the highest moral integrity, guided by cardinal virtues such as *ren* (benevolence, 仁), *yi* (righteousness, 义), *li* (ritual propriety, 礼), *zhi* (wisdom, 智), and *xin* (trustworthiness, 信). In general, self-cultivation serves as the foundation for governing larger spheres such as one’s family and their state, as laid out in *Daxue* (大学).

Building on the three-dimensional model of Confucian self-cultivation proposed by Lai (2003) and the Confucian notion of self as inherently relational (Wong, 2004), we argue that self-cultivation in Confucianism covers three key elements: the self, relationships, and knowledge: (1) the process of self-cultivation involves deep self-reflection to refine one’s character; (2) the practice of virtues and refinement of moral character are conducted in one’s social interactions with others; and (3) lifelong pursuit of knowledge and continuous self-improvement constitute the *epistemological* basis for self-cultivation. On the basis of the three elements, the Confucian approach to self-cultivation also recognizes the evolving nature of the self, underscoring the importance of lifelong learning and self-improvement to attain the true

191 essence of *ren* and maintain virtuous behavior throughout one's life (Zhu, 2021).  
 192 For example, according to the idea of "examining oneself three times a day" (*san*  
 193 *xing wu shen*, 三省吾身) proposed by Zengzi (曾子), one needs to examine whether  
 194 they are faithful in their endeavors, trustworthy in their friendships, and committed  
 195 to continuous learning on a daily basis. Further, self-cultivation is also exemplified  
 196 by the concept of *neixing bujiu* ("when self-reflection reveals that nothing goes  
 197 wrong, then there is nothing to be anxious about", 内省不疚), advocated by Yan  
 198 Yuan (颜渊), Confucius' most favorite disciple.

199 *Bildung*, a philosophical concept derived from the Western context, has been  
 200 observed to exhibit resonance with the practice of Confucian self-cultivation by  
 201 scholars. *Bildung* has its European tradition and cultural roots during the  
 202 Enlightenment that ushered the era of secularization in an emerging civil society  
 203 (Biesta, 2002). Situated in that historical context, *Bildung* demonstrates a transfor-  
 204 mative concept of humanity with a progressive ethos: "a being who can and should  
 205 take responsibility for itself and its world" (Gjesdal, 2015). As noted in Sjöström  
 206 et al. (2017), two core elements are included in the concept of *Bildung*: an idealized  
 207 representation of desirable knowledge and skills, coupled with processes of free and  
 208 self-directed learning. It should also be noted that the concept of *Bildung* is primar-  
 209 ily associated with intellectual and educational traditions in Germany, and still  
 210 remains a contested concept ever since (or, an "empty concept", see Reichenbach  
 211 (2014)).

212 *Bildung* could also be understood through its connection with the German liter-  
 213 ary genre known as *Bildungsroman* (*Bildung* + *sroman* (novel)), which delves into  
 214 the mental and moral development of the protagonist, typically within the context of  
 215 their coming-of-age journey. Hence, in a *Bildungsroman*, a central aim is the pro-  
 216 cess in which the protagonist achieves maturity, and this transformation is usually  
 217 portrayed as a challenging process that the protagonist encounters. For instance, in  
 218 Johann Wolfgang von Goethe's *Wilhelm Meister's Apprenticeship*, Wilhelm Meister  
 219 grapples with various conflicts, such as those between familial expectations and  
 220 societal norms when embarking on different apprenticeships in fields like the the-  
 221 ater, literature, and business, and eventually he has changed from an aimless, young  
 222 dreamer to a mature, self-aware, and well-rounded adult (Moretti, 2000).

223 Throughout history, much like the diverse interpretations of Confucian self-  
 224 cultivation, *Bildung* has been subject to varied perspectives and understandings. For  
 225 instance, thinkers such as Johann Gottfried Herder, Friedrich Schiller, and Wilhelm  
 226 von Humboldt considered *Bildung* as a secular phenomenon, connecting it to the  
 227 emotional, moral, and intellectual growth of a person, their educational experiences  
 228 and even their process of becoming a responsible citizen. For example, University  
 229 of Berlin could be seen as an embodiment of the Humboldtian initiative toward a  
 230 *Bildung* education during the Prussian reforms (Nybom, 2003). A Hegelian  
 231 approach, in contrast, seeks to disrupt the mere dichotomy between the subjective  
 232 and the objective with a dialectical approach, resulting in *Bildung* internalizing "the  
 233 public or objective sphere (that is, the world in its historical development)" in "the  
 234 individual, who is thus (in virtue of the dialectical method) led from subjective  
 235 belief to objective knowledge or wisdom" (Nordenbo, 2002, p. 350).



Overall, *Bildung* places a strong emphasis on the significance of knowledge as a means to achieve individual freedom or a more holistic self (Gjesdal, 2015). One should also be aware that *Bildung* as an idea of general education was firstly directed mainly towards the emerging middle class, individuals who did not enjoy the privileges of the clergy and the aristocracy, with less attention given to peasants or workers. But as time went by, *Bildung* had also been applied to a broader use in the educational setting (Ringer, 1989; Løvlie & Standish, 2002). Even in a more contemporary context, where *Bildung* was misused and criticized as merely a commodity or value (Reichenbach, 2014), or where debates persist regarding the necessity of *Bildung* education (see, e.g., Masschelein & Ricken, 2003), proponents like the European Union continue to argue that the sustainability of democracy hinges on citizens with *Bildung* (Andersen, 2021), or a more proactive call for rethinking *Bildung* from a posthumanist approach (Taylor, 2017).

As mentioned above, Confucian self-cultivation and *Bildung* both aimed to help individuals navigate the shifts in their societies during certain periods of time, whether those transitions were a result of wartime disruptions or secularization. Both also underscored the importance of education for the individual. Educational scholars have recently systematically compared Confucian self-cultivation with *Bildung*. According to Yang (2022), the two concepts share at least two similarities. The following paragraphs mainly summarize Yang's (2022) work on how Confucian self-cultivation and *Bildung* share both similarities and differences in certain aspects.

First, both the two concepts emphasize the critical role of individual effort and agency in moral development. Confucian self-cultivation underscores the inherent equal potential within every individual to attain the status of a *junzi*, or morally exemplary person. The fact everyone is born with similar moral potential invites us to stay true to ourselves. Therefore, the path to becoming a *junzi* lies in actively exercising one's agency and freedom in everyday life, engaging in thoughtful observation and reflection on both others' and one's own moral choices. This introspective process should be used to inform and enrich one's future decisions. The practice of integrating reflective insights into decision-making not only aids in evaluating the plausibility of these insights but also enhances one's ability to continually observe and reflect on the moral choices made by others and themselves. Such an iterative process motivated by one's agency is central to Confucian self-cultivation. From the perspective of *Bildung*, one has the agency and freedom to train one's reasoning ability including the freedom to understand all available options and thus make informed choices based on such knowledge.

Second, both Confucian self-cultivation and *Bildung* underscore the connection between individual growth and development and the broader social and communal harmony. In Confucian ethics, we know that individual self-cultivation is fundamental for managing family (*qijia*, 齐家), governing the country (*zhiguo*, 治国), and ensuring security all under heaven (*pingtianxia*, 平天下). Similarly, in the context of *Bildung*, one aspires to become a responsible citizen, encompassing the notion that individuals, through their education and personal development, should be inclined to actively engage in public life and contribute to the welfare and

281 progress of their community and society. Therefore, so-called “public-spirited indi-  
282 viduals” are motivated by a sense of civic duty to promote the common good through  
283 participating in civic activities, advocating for social progress, and working towards  
284 collective well-being.

285 While there are similarities between Confucian self-cultivation and *Bildung*, it is  
286 also critical to recognize that these two concepts exhibit certain differences. First,  
287 they demonstrate different worldviews. Confucian self-cultivation finds its roots  
288 within the context of the *tianxia* (天下) worldview, which seeks to attain a profound  
289 state of harmony between the individual and the cosmos. This worldview is mani-  
290 fested on multiple levels, encompassing the self, the family, the state, and ultimately  
291 the concept of *tianxia*. In contrast, a Humboldtian, tradition approach to *Bildung*  
292 revolves around the dichotomy of I and non-I, wherein the broader community,  
293 society, and even the cosmos is categorized as “non-I.” The primary emphasis of  
294 *Bildung* is therefore on individual development and self-cultivation, with the soci-  
295 etal or even cosmic connection viewed as supplementary to the overarching goal of  
296 personal growth.

297 Second, Confucian self-cultivation and *Bildung* adopt different approaches to  
298 conceptualizing personality and natural tendency of human beings. Confucian eth-  
299 ics considers that all persons are born with comparable human tendencies or moral  
300 potential for becoming good persons. Therefore, everyone is almost equal in terms  
301 of the potential to become a morally developed person or a *junzi*. In comparison,  
302 *Bildung* emphasizes the diverse attributes humans are born with. It places impor-  
303 tance on recognizing and nurturing the varied qualities and characteristics inherent  
304 in individuals from birth. In this context, *Bildung* implies a recognition of the inher-  
305 ent diversity among people, encompassing a range of innate talents, qualities, and  
306 potentials that contribute to their unique identities. Such an emphasis on diversity  
307 underscores the idea that education and personal development should take into  
308 account and value the multifaceted nature of individuals from the outset of their lives.

309 Third, while both Confucian self-cultivation and *Bildung* underscore the role of  
310 environment in shaping one’s process of becoming a good person, they diverge in  
311 their focal points. Self-cultivation puts more emphasis on a person’s own determina-  
312 tion or agency in developing and perfecting one’s moral self through reflective  
313 engagements with others. However, *Bildung* highlights the value of environmental  
314 diversity, which provides diverse opportunities for individuals with distinct person-  
315 alities, as central to one’s moral growth.

316 Finally, in this section, readers may concern that our discussion and attempt to  
317 compare the two concepts may fall short in addressing broader societal or structural  
318 factors that influence individuals, thereby advocating for an individualistic moral-  
319 ism. In other words, when contemplating one’s inner self or focusing on personality  
320 development, there is a risk of overlooking how individuals are inherently con-  
321 nected to a larger social structure. Nevertheless, we did mention earlier in this sec-  
322 tion, both the two traditions do emphasize the connection between individual growth  
323 and development and the broader communal harmony and social order. Moreover,  
324 at least in the Confucian tradition, the virtue of *yi* (义, appropriateness) is compa-  
325 rable to the Western concept of justice at least in the Aristotelian sense (Sim, 2010).



Acting in accordance with the virtue of *yi* can ensure the alignment of personal conduct with broader social moral principles and help cultivate the moral sensitivity among people toward the underlying social and structural factors that affect personal growth.

In the next section, we will synthesize the similarities and differences between Confucian self-cultivation and *Bildung* and utilize this comparative perspective to formulate an approach to engineering education grounded in self-cultivation.

## 12.4 Toward a Self-Cultivation Approach to Engineering Education

Based on a comparative review of the Confucian concept of self-cultivation, this section explores how such a concept can provide implications for constructing an alternative approach to engineering education that focuses on the self-dimension of the professional formation of engineers.

A first step toward such a goal is to critically examine the learning outcomes often found prevalent in engineering education, including how they are often formulated, what they often entail, and how they influence curriculum priorities, assessment, and pedagogy. Learning outcomes are arguably the most fundamental component in the American approach to engineering education. Historically, a critical move to turn engineering education into a field informed by educational sciences and evidence was to adopt the outcome-based or backward design approach (Wiggins & McTighe, 2005). Such a philosophy has been integrated into both accreditation policies and classroom practices.

More specifically, effective design of learning activities in engineering starts with a *pragmatic* question concerning learning outcomes: what do we expect students to achieve after they complete a specific learning activity? Given that engineering education is informed by the outcome-based, backward design approach, what engineering educators are supposed to care about would only be to what extent students achieve these learning outcomes after they participate in a particular learning activity. It does not matter much what instructional methods are employed to achieve these outcomes insofar as they achieve these outcomes. It provides freedom to both instructors and students and allow them to achieve these goals through diverse ways. This raises the crucial question: how can we *empirically* verify that students have indeed attained these outcomes? Engineering educators thus need to ensure that good learning outcomes are supposed to be supported by observable, empirical (either quantitative or qualitative) evidence of students' learning achievements (Davis & Beyerlein, 2006). Therefore, good learning outcomes thus typically manifest as either knowledge or skills. Nevertheless, it is worth noting that it is not easy to collect empirical assessment data for all learning outcomes.

364 Consider, for instance, the widely recognized engineering learning outcomes,  
 365 such as the ABET student learning outcomes. The most recent version of student  
 366 learning outcomes for accrediting engineering programs include:

- 367 1. an ability to identify, formulate, and solve complex engineering problems by  
 368 applying principles of engineering, science, and mathematics;
- 369 2. an ability to apply engineering design to produce solutions that meet specified  
 370 needs with consideration of public health, safety, and welfare, as well as global,  
 371 cultural, social, environmental, and economic factors;
- 372 3. an ability to communicate effectively with a range of audiences;
- 373 4. an ability to recognize ethical and professional responsibilities in engineering  
 374 situations and make informed judgments, which must consider the impact of  
 375 engineering solutions in global, economic, environmental, and societal contexts;
- 376 5. an ability to function effectively on a team whose members together provide  
 377 leadership, create a collaborative and inclusive environment, establish goals,  
 378 plan tasks, and meet objectives;
- 379 6. an ability to develop and conduct appropriate experimentation, analyze and  
 380 interpret data, and use engineering judgment to draw conclusions;
- 381 7. an ability to acquire and apply new knowledge as needed, using appropriate  
 382 learning strategies (ABET, 2000).

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383 It is evident that most these learning outcomes are formulated based on either technical  
 384 knowledge (e.g., principles of engineering, science, and mathematics) or skills  
 385 (e.g., solutions that meet specified needs with consideration of public health, safety,  
 386 and welfare, as well as global, cultural, social, environmental, and economic factors)  
 387 (even ethics is considered as an instrumental skill for engineering design).  
 388 These learning outcomes largely assume that developing these practical abilities is  
 389 central to the formation of competent engineers and it is critical for “solving complex  
 390 engineering problems” (as seen in Objective 1) and transforming the society.  
 391 As previously noted, gathering empirical assessment evidence for all learning outcomes  
 392 can be challenging or impractical. This challenge typically leads to two outcomes:  
 393 First, certain learning objectives, such as ethics, may be simplified, reducing  
 394 them to technical skills, such as selecting the “best” solution from multiple pre-  
 395 determined options. Second, some learning outcomes may be discarded altogether due  
 396 to their difficulty to measure accurately. Hence, existing engineering accreditation  
 397 criteria may overlook certain essential outcomes.

398 For instance, what is missing in the learning outcomes in existing engineering  
 399 accreditation criteria is to what extent students can develop an ability to critically  
 400 examine the *broader impacts of engineering work on themselves*. Instead of solely  
 401 emphasizing how engineering expertise can solve technical problems and transform  
 402 the world, can we envision an alternative learning outcome centered on students’  
 403 capacity to evaluate *how their engagement in engineering shapes and is shaped by  
 404 their self-knowledge, values, and beliefs?*

405 Considering the pivotal role of reflective learning in both Confucian self-  
 406 cultivation and *Bildung*, an additional learning outcome might be articulated as follows:  
 407 Engineering students demonstrate the ability to critically observe the practices

of participants in the engineering community, including not only their peers but also various stakeholders such as managers, investors, and workers. They adeptly integrate insights acquired from reflective observations into their own work, and eventually lead to continuous improvement of themselves. In other words, assessing the quality of engineering education hinges on the extent to which students are capable of competently developing technical solutions but also on their capacity to cultivate an awareness of continuous self-improvement through reflective learning in professional settings.

From a more holistic perspective, another challenge with most learning outcomes in engineering today is that they do not explicitly address the fact that engineering students may come to engineering with diverse backgrounds. Confucianism does emphasize the argument that every person is born with the same potential for development especially moral growth. However, when students start their undergraduate engineering programs, there have already been variations among them due to different learning experiences they have each encountered since they were born. In comparison, *Bildung* emphasizes the diverse attributes humans are born with. It places importance on recognizing and nurturing the varied qualities and characteristics inherent in individuals from birth. *Bildung* implies a recognition of the inherent diversity among people, encompassing a range of innate talents, qualities, and potentials that contribute to their unique identities. Such an emphasis on diversity underscores the idea that education and personal development should take into account and value the multifaceted nature of individuals. When engineering educators formulate and implement learning outcomes, they need to keep in mind that students all come with different qualities and therefore these learning outcomes may mean differently to them. An overarching objective for engineering educators involves effectively engaging with individual students, adeptly tailoring learning outcomes to suit diverse situations. This approach aims to enhance learning experiences by aligning them more closely with the distinctive needs, values, and career aspirations of each student.

Finally, engineering education extends beyond the realm of individual professional and moral growth. Both Confucian self-cultivation and *Bildung* advocate for the connection between the growth of individual engineers and the broader social harmony or progress. A major limitation with the current form of engineering learning outcomes is that these outcomes only focus on *individual development within engineering*. Engineering educators should strive to educate their students to critically examine how their expertise can be socially relevant by serving the needs of people in various communities. Engineering students are thus invited to critically reflect on how their expertise is (or should be) used in the workplace, whose interests their work serve, what values their work contributes to, and if and how these values help promote the wellbeing of the public. The lead author of this chapter used to employ various engaged pedagogies such as ethics autobiographies and personal ethics statements to cultivate students' capacity to reflect on the relationship between their daily, "mundane decisions" and the implications for broader social structures (Snieder & Zhu, 2020; Zhu & Woodson, 2020).

452 Both Confucian self-cultivation and *Bildung* acknowledge that various human  
453 (personal) and organizational resources present in the environment can facilitate the  
454 self-improvement of engineers. Earlier in this section we already articulated the  
455 value of engagement with others in professional settings for engineers' self-  
456 improvement. Moreover, certain forms of organizational or structural resources can  
457 also be helpful for engineers' growth. For instance, choosing a company that values  
458 responsible innovation and corporate social responsibility (CSR) is beneficial for  
459 engineers' cultivation of moral character (Smith et al., 2021). Therefore, educating  
460 engineering students to be cognizant of the ethical dimension of career choices is  
461 critical for engineering educators. In addition, engineering students need to be  
462 aware that different values and moral tendencies can be potentially cultivated while  
463 they are assigned to work with individuals and organizations from diverse back-  
464 grounds. Collaborating with individuals solely focused on the profitability of their  
465 products may cultivate different values and moral tendencies compared to working  
466 with people from underserved communities, where basic human needs are  
467 barely met.

468 While the concept of self-cultivation offers valuable insights for engineering  
469 education, it is important to recognize that it may present challenges and limita-  
470 tions, particularly when applied across diverse cultural contexts. To effectively  
471 implement this approach in engineering education, at least two key factors are  
472 essential. First, there must be a *philosophical foundation* that supports efforts to  
473 cultivate the moral self of students, especially considering that Western engineering  
474 education tends to focus heavily on individualistic, employable skills. Second, even  
475 with a philosophical foundation for the self-cultivation approach, there needs to be  
476 an *infrastructure* within engineering education to translate this mindset into con-  
477 crete practices. This includes classroom pedagogy, university policies, curriculum  
478 design, and student support programs. Unfortunately, changes in these two factors  
479 require large-scale institutional transformations, which can be particularly challeng-  
480 ing in Western contexts due to the democratic governance structures prevalent in  
481 higher education. These structures often involve extensive consultation and  
482 consensus-building processes among diverse stakeholders, including faculty,  
483 administrators, and students, which can slow down the process of implementing  
484 substantial changes in curriculum and instructional practices.

485 In summary, this chapter does not aim to formulate a comprehensive framework  
486 for engineering education centered on the concept of self-cultivation. Instead, it  
487 should be viewed as an initial endeavor to investigate the potential utility of the idea  
488 of self-cultivation in crafting an alternative approach to prevalent methods in engi-  
489 neering education, which predominantly concentrate on the development of *employ-*  
490 *able* skills for individual engineers. Future research is needed to discuss how the  
491 idea of self-cultivation can help design engaged learning activities and assessment  
492 strategies that promote self-cultivation, continuous self-improvement, and ulti-  
493 mately a flourishing life for engineers.

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