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Susan Kenyon

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Conceive-design-implement-operate: pedagogical innovation to enhance attainment, engagement, satisfaction and employability in political science

Susan Kenyon

Canterbury Christ Church University

ABSTRACT

This paper introduces a new pedagogic approach to the teaching of political science. In engineering education, the Conceive-Design-Implement-Operate (CDIO) pedagogy provides an active, experiential learning experience, structuring learning around four key phases in product development. Applied to the undergraduate Politics and International Relations (IR) classroom, this pedagogical innovation in learning, teaching and assessment is adapted to *policy* development. This design-build-test pedagogical approach has been highly successful in engineering education, supporting students to be "industry-ready engineers" on graduation. Results across 3 cohorts suggest that this pedagogical innovation is also highly successful when transferred to Politics and IR, supporting political science students develop "society-ready" attitudes, attributes and skills, greatly enhancing the student experience and increasing their attainment, engagement, inclusion and wider graduate outcomes. Civic engagement and the ability to understand and respond to a range of stakeholders are also improved. This paper presents the pedagogy and the module to which it was applied as a case study, before highlighting opportunities for political science educators to transfer the pedagogy to their own teaching context.

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Introduction

This paper is informed by a core concern to readers of this journal: how can we do better at ensuring that our students have a positive student experience, which engages them with our subject and provides the knowledge, understanding and skills that will equip them for success, in their own personal aspirations and in their wider contributions to civil society, post-graduation?

Scholars of teaching and learning believe that we achieve this not only through *what* we teach, but also *how* we teach; not only through curriculum *content*, but also through curriculum *process* and *praxis* (Craig 2014; Friere 2017).

CONTACT Susan Kenyon Susan.Kenyon@Canterbury.ac.uk School of Law, Politics and Social Sciences, Canterbury Christ Church University, Canterbury, United Kingdom.

In the decade since Isacoff (2014) called for a rethinking of the purpose and methods of political science education, multiple papers have been published that support this claim. A consensus has emerged, amongst scholars of teaching and learning in political science education, that changing how we teach, to include teaching practices that encourage learning through active participation in real-world political practices, focused on real-world problems, we can enhance student engagement, experience and outcomes. Such methods include client-focused research (Glazier and Bowman 2021; Solop et al. 2022), debating (McMonagle and Savitz 2023), internships (Glover et al. 2021), service learning (Lamb, Perry, and Steinberg 2023; Reynolds 2023) and simulations (Baranowski and Weir 2015; Bradberry and De Maio 2019; Rinfret and Pautz 2015; West and Halvorson 2021). Dionne (2023) considers project-based learning, introducing design thinking into political science education; Mitchell (2019) integrates classroom learning with the real-time, real-world of political campaigning; and Hosman and Jacobs (2018) explore the benefits of interdisciplinary collaboration between political science and engineering students in overseas fieldwork projects. Research also suggests that such active, experiential learning can address employers' needs for political science graduates who are employability-ready (Biswas and Haufler 2020).

This paper seeks to contribute to and advance this literature. The paper introduces a pedagogical approach, the Conceive-Design-Implement-Operate (CDIO) pedagogy, which has been highly successful in engineering education since its inception in 2001 (Crawley et al. 2007).

The global success of this active, experiential, team-based pedagogy, which simulates the workplace and engages students in designing, building and testing real-world solutions for real-world problems, has led a number of authors to experiment with its adaptation in other disciplines. For example, Malmqvist et al. (2016) highlight application in business, chemistry, education, food science and music. Tangkijviwat, Sunthorn, and Meeusah (2018) consider advertising, cinematography, design, media, photography, public relations. Tholler and Rian (2020) review application to digital media, hotel management, health & beauty and Thai traditional medicine courses. Further papers consider CDIO in accounting (En et al. 2022), events management (Ng and Tan 2022), sustainability (Cheah, Lim, and Chao 2022) and teacher education (Bang et al. 2022).

However, there are no documented applications to Political Science, Political Theory and International Relations (IR). As such, this paper reports the first known adaptation to Politics/IR.

Applied to the undergraduate Politics and IR classrooms, this pedagogical innovation in learning, teaching and assessment is adapted to *policy* development. Results across three cohorts suggest that it is highly successful when transferred to Politics and IR, supporting political science students develop "society-ready" attitudes, attributes and skills, greatly enhancing the student experience and increasing their attainment, engagement, inclusion and wider graduate outcomes. Civic engagement and the ability to understand and respond to a range of stakeholders are also improved.

This paper proceeds through the following sections. First, the CDIO pedagogy is discussed in detail, considering its rationale, development and implementation. It will be shown that, whilst individual elements of the pedagogy have been implemented in Political Science education, CDIO represents an innovation because it combines multiple individual pedagogical elements into a whole systems approach. Details of the

adaptation of CDIO to the Transport: Politics and Society module and an evaluation of this follow. Finally, opportunities for political science educators to transfer the pedagogy to their own teaching context are considered.

Conceive, design, implement, operate: a pedagogy to develop "industry-ready engineers"

At the turn of the century, a consensus emerged that engineering education and real-world demands on engineers had drifted apart (Crawley et al. 2007). In response to the rapid progression of scientific and technical knowledge in the 20th century, engineering education had evolved into the teaching of engineering science, at the expense of engineering practice. As a result, graduates were entering the workplace with in-depth theoretical knowledge, but without the professional, personal and technical attitudes and skills and the broader societal knowledge needed to be an effective engineer in practice.

To resolve this tension, academics, industry and government came together to reassess the purpose of engineering education. The conclusion was that the purpose of engineering education was to develop graduates who are "industry-ready": able to conceive, design, implement and operate systems, products, processes and projects, working within an interdisciplinary team to identify, understand and respond to complex societal needs (Crawley et al. 2007).

In 2000, the CDIO project began, to answer two key questions.

1. What is the full set of knowledge, skills and attitudes that engineering students should possess as they leave the university, and at what level of proficiency?
2. How can we do better at ensuring that students learn these skills? (Crawley et al. 2007, 85).

In response to the first question, the CDIO Syllabus was launched—a set of programme learning outcomes, covering technical knowledge, professional, personal and interpersonal skills, aptitudes and attitudes, which engineering students should learn to prepare for engineering practice.

The second question is answered by the CDIO Standards—12 principles that govern the delivery of engineering programmes (CDIO.org. n.d.a). The Standards express the philosophical underpinnings of the pedagogy and the best practices that underlie its implementation. These largely focus on learning, teaching and assessment (LTA) principles that readers of this journal will be familiar with, including:

- An integrated curriculum and integrated learning;
- A spiral curriculum, where practical experience provides the foundation for theoretical knowledge;
- Constant evaluation and embedded student feedback;
- The importance of learning spaces and the wider learning environment;
- Active, experiential, problem-based learning;
- Constructive alignment, with a range of assessment methods; and
- The importance of continuing professional development for educators, to build subject and LTA competence.

These principles are embodied in the design-build-test pedagogical approach. Design-build-test projects are the key feature of CDIO programmes. Students *conceive* a societal problem, which must be solved. They seek to understand the problem, before *designing* an engineering solution (a product, process or system) that they believe will address the problem. Students *implement* their design, building it and testing it, before *operating* their solution and evaluating the impact. This is illustrated in Table 1, below, which applies the process to a hypothetical research question, developed for the purposes of this paper and inspired by Environmental Audit Committee (2018), Kulkarni, Patil, and Pawar (2020), Lauritsen (2011) and Wedel, Goodhew, and Malmqvist (2007).

Whilst not prescriptive, the CDIO Syllabus and Standards guide the development and delivery of engineering programmes at 196 Universities, across the globe (CDIO.org. n.d.b). Together, they ensure that engineering educators provide active, experiential learning, with knowledge and skills taught through engineering practice, as students learn through participation in industry-designed projects, in teams designed to replicate the modern workplace.

There is a wealth of evaluation of the pedagogy, including 1,349 double-blind peer-reviewed conference papers, presented at 19 Annual conferences and publicly available via www.cdio.org. Taken together, this body of work illustrates the success of the approach in developing deep learning of technical knowledge, alongside the simultaneous development of a range of personal, interpersonal and professional skills, in an engaging, inclusive learning environment. The Worldwide CDIO Organization continue to adapt and refresh the Syllabus and Standards, in response to evaluation and cultural, economic, political and social change (Kenyon, 2023; Malmqvist et al. 2022). The research discussed in this paper is based upon Syllabus and Standards 3.0 (CDIO.org. n.d.a).

As mentioned, the global success of CDIO in engineering education has led a number of authors to experiment with its adaptation in other disciplines. However, there are no documented applications to Politics/IR. Whilst some individual elements that comprise the CDIO process have been implemented and evaluated in political science education, including those highlighted above, CDIO is distinct, innovative and novel because it brings these elements together and introduces new elements, less common to political science education, to create a single, comprehensive approach to education.

The following section presents the first known adaptation of the CDIO approach within a Politics and International Relations programme.

Table 1. Example of the CDIO process, with reference to a hypothetical project.

Paper cups damage our environment, in their production, use and disposal, through pollution, resource use and waste. 2.5bn are used in the UK each year. Most are not recycled; most cannot be recycled. Is there an alternative?	
Conceive	Understand the problem. Identify customer/market need. Consider a range of solutions, including materials and environmental impacts across every step of the produce lifecycle, plus user acceptability. Develop the concept. Develop project plan.
Design	Develop a detailed design, including components, drawings, materials, modeling, manufacturing process, as appropriate.
Implement	Create the prototype, including manufacturing, testing and validating in the workshop environment.
Operate	Test the prototype in a real-life situation. Evaluate efficacy, considering every step of the product lifecycle.

Transport: politics and society

CDIO has been highly successful in engineering education at Canterbury Christ Church University (CCCU), enhancing engagement, attainment, satisfaction and employability by enabling students to learn engineering *science* through engineering *practice* (Imam, Joyce, and Nortcliffe 2023; Manna, Joyce, and Nortcliffe 2023). The author aimed to achieve similar outcomes in *political* science, through *political* practice. This inspired the creation of a new module, Transport: Politics and Society, with the Politics and IR framework of degrees.

This paper now turns to describe the module curriculum, considering content, learning outcomes and pedagogy.

Content

The starting premise of the module is that we are a society that needs to move. In the UK and many countries across the globe, we live in a built environment in which physical mobility is both necessary and expected to participate in activities. Economic, planning, social and transport policies have resulted in living environments and activities that are dispersed across large, ever-increasing distances. Our society and culture, our biology and psychology, act to reinforce this mobility dependence in our hypermobile societies.

As a result, to participate in the activities that we need to take part in to be included in the society in which we live—including education, employment, leisure, shopping, social networks—we need to be able to travel, usually by motorized mobility. However, a substantial proportion of us are not able to travel as much as we need to, to take part in the activities that enable us to be included in the society in which we live (Kenyon, Lyons, and Rafferty 2002; Lucas 2019). This results in mobility-related social exclusion.

The link between mobility and social exclusion is well-established. Across the globe,[1] studies have confirmed the existence, experience and effects of mobility-related exclusion (MRE):

> The process by which people are prevented from participating in the economic, political and social life of the[ir] community, because of reduced accessibility to opportunities, services and social networks, due in whole or in part to insufficient mobility in a society and environment built around the assumption of high mobility. (Kenyon, Lyons, and Rafferty 2002, 210–211)[2]

This is experienced most keenly by those who experience disadvantage, inequality and/or exclusion in other ways: children; disabled people; non-drivers; people of color and other minority ethnic groups; people with a low income; older people; women.

In this sense, some have *too little mobility*, which results in exclusion from activities, including education, employment, healthcare, family and friends, leisure, shopping and other activities that are critical to social development (Kenyon 2015).

But the solution to the problems caused by too little mobility cannot be to increase mobility, for two key reasons.

First, studies suggest that when we increase mobility, we decrease accessibility (Kenyon 2015), to the extent that mobility and accessibility are described by Ross (2000, 13) as "the yin and yang of planning."

Second, increasing mobility is environmentally problematic. Transport is a primary contributor to climate change and environmental harm. Transport accounts for around 16% of global Greenhouse Gas (GHG) emissions (Ritchie, Roser, and Rosado 2020). In the UK, approximately a quarter of GHG emissions are estimated to be from the transport sector (DBEIS 2022). Transport has more far-reaching implications for the environment, causing environmental harms including: airborne particulates and other air pollutants; community bifurcation and isolation; ecosystem damage; land take; noise pollution; resource use; visual pollution; and water pollution.

In this sense, we have *too much mobility*. Increasing mobility to tackle the problem of too little mobility will worsen the problem, in the longer term.

So, what do we do, when policies conflict in this way? Do we tackle exclusion, or environment? Who do we prioritize? Why? Do we prioritize the short term, or the long term? How? These debates lie at the core of the module learning outcomes, given in Figure 1 and the pedagogy, to which this paper now turns.

Pedagogy

The module introduces students to the complexity of real world policy practice, through an approximation of a design-build-test project, over ten weeks.

Conceive (weeks 1–4)

Students uncover the problem of transport-related social exclusion first-hand, by taking a walkabout around Canterbury city center in the UK. Through this mini-ethnography, students observe key features in the urban environment, including a pedestrian crossing, a bus stop, a car park and an underpass. Students are prompted to consider, for example, who they can see and who they can't see in these locations; to count how long pedestrians have to cross at a pedestrian crossing; to feel how welcoming the environments are.

Teamwork begins at this first task: students explore in pairs, matched with someone who has different characteristics to themselves. This helps to illuminate the experience of transport exclusion, but it also encourages students to accept, include and value different perspectives in their "workplace": an invaluable, real-world, employability skill.

After seeing the problem for themselves, students return to class to discuss their findings. They apply their observations, to conceive the problem of too little mobility as it affects them, or their local community.

1. Demonstrate a detailed knowledge and understanding of the problem of too little and too much mobility, in UK society.
2. Systematically gather, organise, synthesise and analyse information from appropriate primary and secondary sources.
3. Critically appraise the benefits and disbenefits of policy responses, through the lens of the problem of mobility-related social exclusion.

Figure 1. Learning outcomes.

All further learning is focused on understanding the specific problem that they would like to resolve. Individualized readings are selected for each student, based on their transport problem. Every student must report back on their reading, every week, to enable other students to learn about the problem of transport exclusion more deeply and theoretically. This develops invaluable professional skills, including communication, confidence, note-taking and reliability; and teamworking builds learning community.

Design (weeks 5 and 6)

At this stage, students design a potential solution to the problem of too little mobility in their community. They select the decision maker that they need to influence to resolve their problem and present a 5-minute verbal briefing, designed to appeal to their specific decision maker. This is the culmination of their learning about too little mobility and is 50% of their assessment.

Based on government guidance for briefing Ministers (Jary 2015) and consultations with civil servants and industry, this authentic assessment (Kenyon et al., 2021) is highly employability focused, developing communication skills relevant to all manner of industries, not just in the political sphere, but also business, consultancy, civil service, local government. In combination with the second assessment, it is designed to develop industry-ready graduates, who have built employability skills through this form of work-related experience.

The assessment also shows graduates they belong in the workplace. Graduates are more employable, because they are work-ready; and they are valued and included in the workplace, because they are more able to assimilate into the workplace community.

Implement (weeks 7–10)

It is not possible for students to implement changes to the transport system. To approximate this, students critically reflect upon their proposed solution, by introducing policy conflicts. This, combined with consistent formative feedback on the proposed implementation of their solution, from the tutor and their peers, students consider what may happen if they implemented their proposed solution. First, they consider the potential negative effects of increasing mobility, considering who may be harmed by their proposal—other demographics, the environment—and the negative impact on other policies—economic, health. Second, they consider who may oppose the implementation of their solution and how they may overcome this opposition, through conflict or compromise, to influence implementation.

Operate (assessment)

Finally, students operationalize their learning, by delivering their recommendations in the form of an options and recommendations paper (Jary 2015), targeted to meet the needs of and to influence the decision-making process of their specific decision-maker.

Through the lens of their transport problem, political decisions are brought to life: the complexity; the compromises; the consequences; the contradictions.

Outcomes

The approach has been very successful.

- 100% first-time pass rate for three cohorts (equivalent modules: 66%).
- Average mark 70% (equivalent modules: 59%).
- Substantially higher attendance, engagement and attainment, relative to other modules.
- Universal satisfaction (measured in module evaluations).
- All module graduates were in graduate employment/further study 6 months after graduating.

In addition, students' studies have been shared with stakeholders and presented at conferences, highlighting the potential for students' work to have real-world influence and impact.

The topics chosen and investigated by students are deeply rooted in their local communities, enabling and fostering civic engagement. These include:

- The impact of lack of transport on Covid-19 uptake in deprived communities;
- Necessary changes to street lighting, to enable active mobility for women;
- A business case for the provision of free transport home from a student nightclub;
- The impact of lack of transport on visitors to a care home;
- The impact of lack of transport on widening participation to Higher Education;
- Measures to enhance safety for LGBTQ + travelers on public transport.

Conclusions, limitations and next steps

The success of the TPS module provides proof of concept that the CDIO pedagogy is adaptable to Politics and International Relations courses. Results support and extend findings reported by Franco (2020) and Perry and Robichaud (2020), suggesting that integrating practice into political science and political theory modules is not only possible, but also effective, in enhancing engagement, experience and outcomes, at university and after graduation.

The approach could be transferred to multiple other contexts, in Politics and International Relations, including the subjects considered in the literature outlined above. Research methods (RM) teaching, which is well represented in the political science education literature reviewed above, would be particularly adaptable to CDIO, extending the active, experiential learning that these authors have proven to be successful. Distinct from traditional RM research project, a CDIO approach would incorporate greater experimentation and reflection, for example, encouraging students not to produce a single, exemplary research project, but instead to explore the efficacy and impacts of multiple methods in answering the same question—implementing and operating different methodologies, reflecting on findings, redesigning and repeating the process.

The next steps for this research are to adapt, implement and evaluate the use of CDIO with a larger cohort, in a different module. This core module, "Insight for

Impact," considers different approaches to making practical change to policy. Employers are increasingly demanding graduates who not only know and understand information, but who also have the ability to transform information into usable insights, which are relevant and useful in real world situations. With this in mind, students will select a policy with meaning to them and their local community. They will learn techniques, drawn from the political and business sectors, to understand their decision makers' needs, before identifying and extracting the insights that their decision makers need to (be persuaded to) make the necessary changes.

With a focus on developing a "product"—a briefing that will influence their stakeholder—based upon a deep understanding of user needs, alongside developing the skills and behaviors needed to influence and to overcome barriers to influence, this module provides the perfect opportunity to apply the CDIO pedagogy.

This said, the applicability and potential benefits of incorporating the pedagogy are, at this stage, speculative. Success to date is proven on a single module, with 3 small cohorts ($n = $ c.15 per cohort), at a single University. As such, generalizability to other contexts is not proven. Further research into the applicability of this pedagogy is essential, not only in the above module, but also in different programs at different institutions, with different cohorts in terms of size, demographics and prior attainment. In addition, further research into the impact of the module on students' awareness and understanding of the skills that they are developing and how to enhance these—for example, how to further skills in team working, how to develop understanding of group dynamics, how to extend their abilities in professional communication—is important, particularly in the context of whether or not the full benefits of this pedagogy can be realized in a single module, or if the pedagogy needs to be repeated in every year, as it is in engineering education.

Finally, in his 2014 paper, Craig raises the question of whether or not teaching in political science is distinctive, vis-à-vis teaching in other disciplines. It is not the intention of this paper to mask the differences between political science and engineering science. In particular, the traditional culture of engineering science, characterized as an ethically and morally neutral endeavor, operating in a value-less space to benignly benefit a society that it oversees but neither influences nor is influenced by, could be considered to be in conflict with the culture of political science, which challenges this sociotechnical divide and recognizes (the existence and value of) multiple discourses and perspectives (Cooper, Liote, and Colomer 2023; Martin, Conlon, and Bowe 2021). That these cultures conflict and that they transfer to *traditional* educational approaches, creating tensions and potentially limiting the transferability of these engineering pedagogies to political science education, is not in doubt. However, the CDIO pedagogy is not a traditional engineering education approach. It has been explicitly designed to decrease the sociotechnical divide, to introduce debate, to encourage and learn from failure, which is expected and reflected upon during the implementation and operation phases. In the hands of political science educators, the value of the pedagogy in encouraging criticality, exploration of implicit values and reflection on the real-world impacts of our policies can only be enhanced.

This said, differences in subject content, philosophy, aims, learning outcomes and student profiles are important considerations when we adapt pedagogies across

disciplines. This paper has sought to draw out similarities and to adapt to differences, tailoring the approach to the needs of the author's subject and students.

As with all methods of learning, teaching and assessment, success is dependent on adaptation to the individual classroom. Those who are tempted to trial CDIO in their own teaching are urged to apply the CDIO process to their LTA design, following the process outlined in Table 1 to ensure that student needs are both understood and fully met.

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Notes

1. Knowles (2019) and Lucas (2019) provide an overview of the growth in the field of study since 1993, largely in the UK and USA. To illustrate global reach, in the first 6 months of 2022 alone, the literature has expanded to include 17 papers on transport and social exclusion, reporting studies from every inhabited continent: Africa (Castro, Sandoval, and Odamtten 2022); Asia (B. Wang, Liu, and Zhang 2022); Australasia (Shaw and Tiatia-Seath 2022); Europe (van Dülmen, Šimon, and Klärner 2022); North America (Cooper and Vanoutrive 2022); South America (Ospina et al. 2022).
2. Whilst this definition has been expanded in recent years to include consideration of the unequal impact of negative transport externalities (Kenyon 2015), this paper focuses on MRE as a *lack of access to participation*, as defined above.

Notes on contributor

Dr Susan Kenyon is a Principal Lecturer in Politics in the Faculty of Science, Engineering and Social Sciences at Canterbury Christ Church University. Dr Kenyon has more than 20 years' experience in travel behavior science, in academia and industry. Dr Kenyon was Faculty Director of Learning and Teaching 2017–2021. Her tenure included the establishment of the School of Engineering, during which time she coordinated both the integration of CDIO into all Engineering and Computing courses and CCCU's successful bid for membership of the CDIO Initiative. Dr Kenyon holds a BSc Hons Politics (York), MA Dist. Environmental Politics (Keele), PhD (Southampton), PGCHE (Kent).

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