International Journal of Engineering Education Vol. 32, No. 2(A), pp. 695–711, 2016
Printed in Great Britain
0949-149X/91 $3.00+0.00

The Influence of External Forces, Institutional Forces, and Academics' Characteristics on the Adoption of Positive Teaching Practices across Australian Undergraduate Engineering*

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This study investigates how academics' personal beliefs, perspectives on institutional forces, and perspectives on external influences relate to their teaching and learning decision-making.

Using a national-level survey of Australian engineering academics (n = 591; 16% of Australia's engineering academics), analyses investigate (1) how influences external and internal to the university environment vary across characteristics of academics, and (2) how academics' characteristics, organizational features, and external drivers relate to issues informing academics' teaching and their actual teaching practices. External and internal influences differed across academics based on their individual characteristics and university contexts, and academics' individual characteristics explained the greatest variability in their teaching considerations and practices. For external influences (e.g., accreditation), promoting awareness of educational goals for undergraduate engineering—as opposed to forcing outcomes into course planning—relates to more desirable teaching and learning practices. No internal institutional policy driver related to teaching practice variables. This study points to informed, professional development that seeks to capitalize on academics' personal interests and characteristics and assists in helping them understand how curricula and outcomes may better align to help student learning. Findings support working from a bottom-up model of change to improve the teaching and learning culture within engineering programs.

Keywords: teaching and learning; change; organizational influences

1. Introduction

Preparing graduates for success in the workforce is an important objective of undergraduate engineering programs. Within Australia, members of the university community, industry, and the governmental sectors have come together to identify a set of graduate attributes that students should develop during their time in their university studies so that they can have recognized entry into the engineering profession [1]. A challenge for engineering programs is to create educational environments and facilitate learning practices that help reach these goals. It is well-documented that undergraduate engineering tends to be comprised of a highly technical curriculum with an emphasis on didactic theory-focused courses with few examples of integrated theory and practice. Such curricular emphases and structures tend not to promote the real-world, interdisciplinary thinking, contextually aware engineers for which members of industry and governments around the world have been calling [2–6]. With many engineering institutions weighing research more heavily than teaching in reward structures for determining promotion and tenure [7], the task of changing teaching practices to support the development of such student outcomes becomes even more challenging.

Because educational environments are created largely by academics, administrators, and organizational supporting mechanisms [8], the objective of this study is to investigate how academics' personal characteristics and beliefs (e.g., demographics, experience, drivers of personal priorities), perspectives on internal institutional forces (e.g., institutional context, promotion and tenure policies), and perspectives on external influences (e.g., accreditation bodies) relate to their teaching and learning decision-making. Using a national-level data set of Australian engineering academics, we determine

* Accepted 24 December 2015.

how characteristics of academics, organizational features, and external drivers relate to the adoption of educationally sound teaching and learning practices. Empirically advancing such understanding within the Australian engineering context might allow programs to identify new strategies that they could follow to promote desired student learning outcomes. This in-depth investigation of the Australian context joins international research on change strategies for engineering education as a whole [9] and illuminates the generalizability of findings from such global studies. Furthermore, this research recommends specific strategies that other engineering programs or external accreditation bodies around the globe might consider as they seek ways to change the engineering education system.

2. Literature review and conceptual framework

The Academic Plan model (Fig. 1) conceptually organizes this study; it describes an array of influences on academics' teaching and learning strategies (which include considering the student outcomes the class seeks to develop), which ultimately influence those student outcomes once the class is carried out [10]. This model builds on the observation by Toombs and Tierney that a curriculum is "an intentional design for learning negotiated by faculty [academics] in light of their specialized knowledge and in the context of social expectations and students' needs" [11, p. 183]. Toombs and Tierney identified three essential parts of a curriculum design process: (1) the content that is to be taught, (2) the context in which the curricular design is developed, and (3) the form that results from the design decisions made. Two empirical studies conducted by the National Center for Research in Postsecondary Teaching and Learning that focused on academics' course planning also inform the Academic Plan model. The first study, *Reflections on Course Planning*, included interviews with a cross section of academics to generate a conceptual framework for studying course planning decisions [12]. *Planning Introductory College Courses*, a follow-on study, used survey methodology to validate and modify the first study's conceptual framework [13]. These studies defined the content dimension as including the factors that academics bring to the table when they plan a course: their background characteristics and experiences, their views of their academic field, and their beliefs about the purposes of education. These experiences and beliefs inform one another but also shape their perceptions of the institutional environment—or the context—in which they plan courses. The form of the course consists of decisions about course content, curricular sequence, instructional methods, and assessments [12].

Taking into account more recent scholarship on teaching and learning, the Academic Plan model builds on these foundational works in an expanded conceptualization of factors, both internal and external to academics and institutions, which shape course and program curricula. In the context of this study, this framework is useful because it frames teaching decisions as the result of a variety of complex interrelated forces. In addition, the model is heuristic in nature; rather than specifying a set of factors that will operate in all postsecondary settings and circumstances, it provides examples of relevant factors (in each of the boxed elements in Fig. 1) to alert researchers to the kinds of influences that might be salient for the academics and curriculum under study.

Importantly, the Academic Plan assumes that academics have a key role in determining strategies for teaching; their final curricular plans, however, are also influenced by a variety of forces both internal and external to their institution. Forces *external* to the institution, such as student demand and the expectations of accreditation agencies, employers, and industry groups, all influence teaching and learning plans and strategies; calls for major reforms in engineering education around the globe have come primarily from external forces [7, 14]. Following implementation of new outcomes-focused accreditation criteria in the United States, for example, engineering programs showed less variation in curricular and instructional emphases and a greater use of educationally sound practices [15]. Within Australia, the accrediting professional agency, Engineers Australia, has developed a set of competencies with which students should graduate following their university studies in engineering. Programs must demonstrate progress and efforts towards helping students develop these competencies every five years for accreditation visits. Though Engineers Australia does not mandate certain objectives or content, it expects programs to demonstrate the attainment of learning outcomes by enrolled students and establish a process for continual program improvement based on those measured outcomes. Such an influence on an academic plan is an example of a force *external* to the institution.

Internal forces within institutions also influence academic plans and the adoption of teaching and learning strategies. An institution's mission, leadership, resources, and policies all may play important roles [10]. For example, reward systems for promotion and tenure or merit salary increases provide incentives, motivations, and reinforcements on aca-

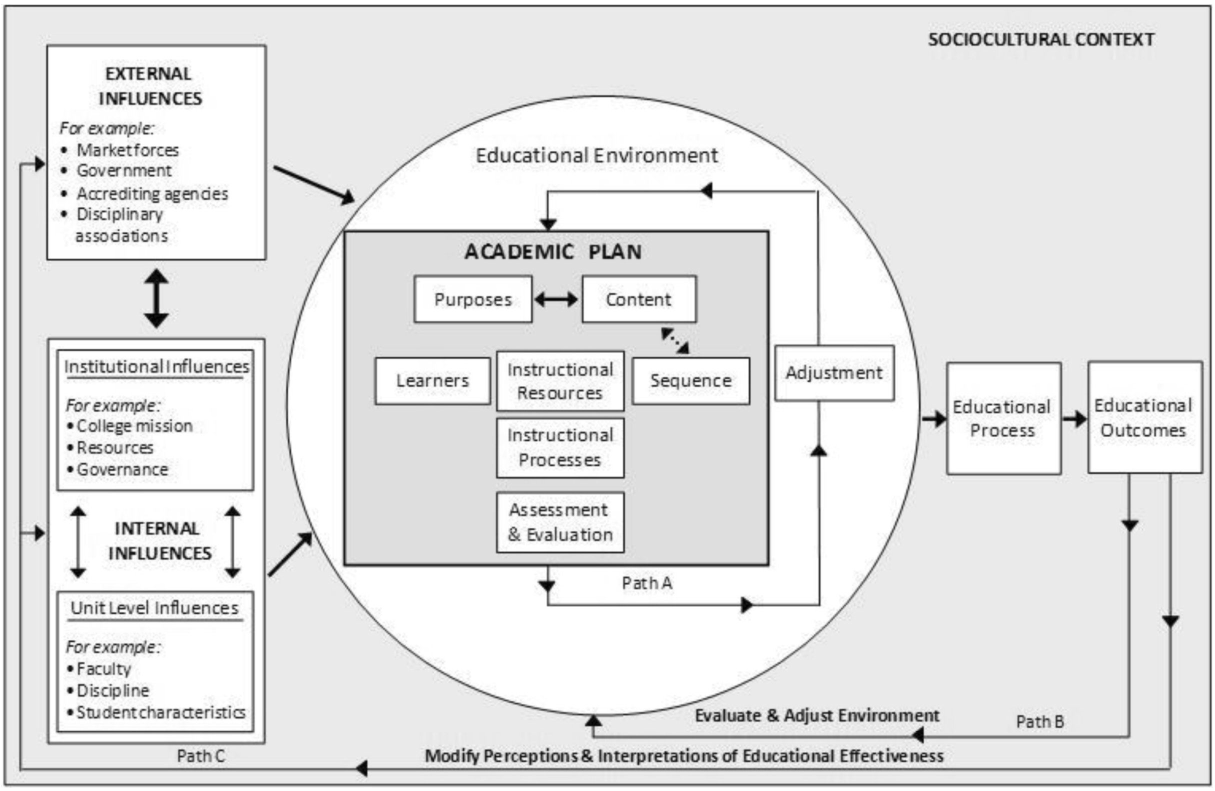

Fig. 1. Academic Plan in Sociocultural Context [10].

demics' decisions on how to prioritize research, teaching, and service activities [16–19]. Fairweather [20] showed that such reward systems have historically favored research activities over teaching, regardless of institutional type. Thus, policies and conditions at the institutional level must enter the conversation when trying to understand whether academics are likely to adopt various teaching and learning practices.

The backgrounds and personal beliefs of academics (e.g., educational experiences, gender, views of fields, beliefs about education) may also affect teaching and learning designs at both the course and program levels [10, 13, 21, 22]. In a broad study of curricular choices made by academics, the top two responses to a question on the first steps taken in planning courses were selecting course content and drawing on their own background and experiences—students enrolled in the course were only considered first by 15% of respondents [13]. A strong body of evidence indicates that academic discipline is one of the strongest influences on academics' attitudes and behaviors [23, 24]. Though most of these previous studies have focused on research activities [24], there is considerable evidence that disciplines also influence views of teaching [25, 26] and curriculum [10, 21, 27–31]. As academic markets, disciplines offer a standard approach with respect to methodology and content for new studies [32], and younger academics often have limited room to experiment with approaches that move beyond the disciplinary paradigm [33]. In addition to disciplinary cultures, academics with professional work experience outside the university setting tend to bridge theory and practice differently than academics who have spent their careers in academia [34], which could lead to varying approaches to teaching and learning strategies. Thus, in accordance to the Academic Plan model, studies of teaching and learning must also take into account the backgrounds and beliefs of academics.

In summary, this conceptual framework and related literature on academics' behavior emphasizes a variety of external and internal factors that influence academic plans and ultimately how students can learn within their classes and programs. Researchers typically overlook features such as academics' cultures, internal and structural organizational characteristics, and institutional policies when considering students' learning [35, 36]. Because organizations are social constructions, however, it is also important to consider organizational features as a collection of individual behaviors and perceptions [37, 38]. Individual academics are responsible for directly affecting students' teaching and learning experiences [35], and those academics rely on both self-assessments and their understandings of their institution's values and rewards as they make choices about activities to pursue [17]. Thus, researchers should operationalize both the external and internal influences on academic plans as well as explore how variations in academics' views and backgrounds may determine the teaching and learning strategies that are ultimately adopted in classrooms.

3. Data and methods

3.1 Data set and sample

This study draws on archival survey data collected from engineering academics across the Australian engineering education landscape by the Australian Learning and Teaching Council (ALTC) Discipline Scholars for Engineering and Information and Communications Technology (ICT) [39]. The project's objective was to develop an understanding of academic demography and views around research, teaching, and learning as well as their attitudes toward a wide range of personal and institutional factors. Initial survey questions were developed under a series of sub-headings that included: (1) demographic and academic roles; (2) experience in commercial and/or industrial environments; (3) educational challenges, changes and attitudes to teaching; and (4) higher education teaching and learning practice. Following multiple survey reviews by senior academics and a member of the Australian Council of Engineering Deans to ensure survey items would be understood by respondents, the survey received ethical approval from the review process of a large, research-intensive institution in Australia.

The survey was deployed via SurveyMonkey and open to all engineering related staff at the 38 Australian universities with engineering programs; academics' participation was strictly voluntary. Executive Deans at each university were asked to email the survey's web link to their academic staff members twice over a period of six months from 2010–2011. Project co-investigators also promoted the survey to academics across Australia at a series of workshops and conferences to urge wide participation. Following data cleaning and the removal of 22 responses containing no usable information, the final sample consisted of 591 engineering academics from 30 institutions. According to the Australian Council of Engineering Deans [40], the entire Australian university system is comprised of 3,696 engineering academics. Thus, this data set contains information from 16% of the entire nation's engineering academics. Because it is unclear whether or not Executive Deans circulated the survey to every academic staff member (i.e., to the entire population), this value should not be misinterpreted as a "response rate." Without knowing the exact number of academics who were sent the survey (i.e., the sampling frame), the response rate cannot be calculated, and thus we instead report the number of responses as a fraction of the overall population of academics. Such comprehensive data coverage of a national system of higher education is rare.

Table 1 displays descriptive statistics for the full sample (n = 591). 84% of the sample respondents were male, and 16% were female, which is comparable to total engineering academic population figures calculated by the Australian Council of Engineering Deans [40], which reported a population that was 81% male. Given this consistency, analyses are conducted on unweighted data. Nearly two-thirds of the sample spoke English as a first language, and over half of the sample was between the ages of 31–50. Two-thirds of respondents had at most five years of experience industry (respondents could list up to three industry jobs, past or current, and this industry experience variable represents the total time working over those three jobs). Disciplines shown in Table 1 represent aggregates of finer sub-disciplines that respondents selected; for example, electrical engineering and computer and software engineering sub-disciplines were grouped together because they typically are housed within the same departmental or School organizational unit within universities. Sub-disciplines comprising less than 3% of the sample that did not neatly fit with another sub-discipline were categorized as "Other Engineering." The "Other Non-Engineering" category consists of academics who categorized themselves as members of science, mathematics, statistics, and education fields despite being asked to provide their principal area in engineering.

To account for differences attributable to institutional type or mission, respondents' institutions were grouped according to their institutional partner networks. Over half of the sample worked at Group of 8 (Go8) institutions, the eight major research-intensive universities in Australia. 16% worked at Australian Technology Network (ATN) institutions, an alliance of five universities that strategically link research with industry and government partnerships, and another 12% worked at Innovative Research Universities (IRU), a partnership of seven comprehensive research universities. 4% worked at the six institutions comprising the Regional Universities Network (RUN), which aim to play a transformational role in their non-metropolitan regions, and the remaining 16% worked at other institutions across Australia. In the context of this paper, we investigated differences across these institutional groupings because they all have differ-

Table 1. Descriptive statistics (n = 591 for full sample)[1]

Variable	Subset	Sample
Gender	Male	84%
	Female	16%
Age	20-30	13%
	31-40	28%
	41-50	25%
	51-60	22%
	61+	12%
English as a Second Language	No	62%
	Yes	38%
Industry Experience	0-5 Years	66%
	6-10 Years	17%
	11-15 Years	8%
	16-20 Years	4%
	21 Years +	5%
Discipline	Aeronautical/Aerospace	3%
	Biological/Biomedical	4%
	Chemical	11%
	Civil	17%
	Electrical/Computer	25%
	Environmental	4%
	Materials	5%
	Mechanical	18%
	Mining	3%
	Other Engineering	7%
	Other Non-Engineering	5%
Institutional Network[2]	Group of 8 (Go8)	52%
	Australian Technology Network (ATN)	16%
	Innovative Research Universities (IRU)	12%
	Regional Universities Network (RUN)	4%
	Other	16%

[1] Percentages reflect proportions of individuals who responded to each question. Sums within each variable may not add up to 100% because of rounding.
[2] Go8: eight major research-intensive universities in Australia; ATN: alliance of five universities that strategically link research with industry and government partnerships; IRU: partnership of seven comprehensive research universities; RUN: aim to play a transformational role in their non-metropolitan regions.

ent missions and points of emphases, which may play an important role in determining academics' views on teaching (or how they focus their time more generally) and in turn their decisions for their classrooms.

3.2 Variables and operationalization of the academic plan elements

Because the current paper draws on archival survey data collected for other purposes, the survey was not designed intentionally to map onto the Academic Plan model. Rather, the research team for the current paper mapped relevant items that were collected on that broader survey to different parts of the model. The available survey items enable the analyses shown in Fig. 2, which comprise and operationalize different elements of the Academic Plan model. Each variable is described in greater detail in the subsequent sections.

3.2.1 Independent variables

As depicted in the Academic Plan model, forces *external* to the institution can influence an academic plan. Three survey items serve as variables representing external forces in this study (Table 2), two asking academics to consider the learning outcomes set forth by the accrediting board, Engineers Australia, and one asking about the influence of external drivers on their own priorities.

Four variables represent potential *internal* influences on academic plans at the *institution* level. In addition to the type of institution in which an academic works, these items include the importance of formal recognition/reward and promotion policies for teaching and learning, and an item specifically asking academics the extent to which institutional priorities drive their own personal priorities.

Finally, several variables represent potential *internal* influences on academic plans at the *unit* level—the "unit" level on the Academic Plan refers to *academics' background and beliefs*. These items include academics' gender, age, length of industry experience, primary language, and discipline, as well as whether or not they ever attained an educational qualification. In addition, academics reported on the extent to which their priorities are driven by their own personal needs or student satisfaction with their educational programs.

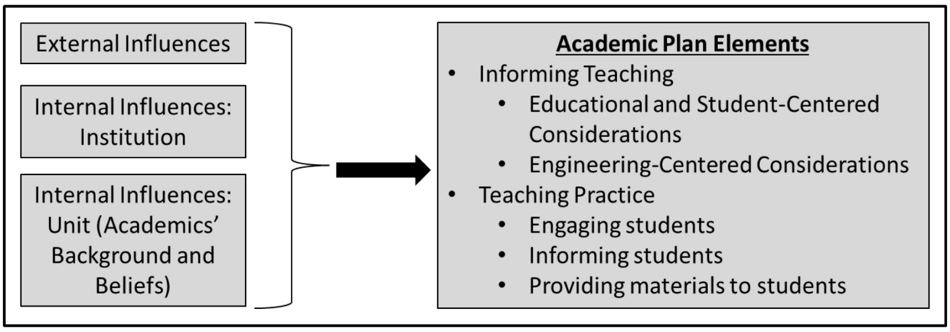

Fig. 2. Analytical model based on available data.

Table 2. List of independent variables

External Influences	How familiar are you with the Engineers Australia Stage 1 Competency Statements?[1]
	In course design, how often do you believe Engineers Australia learning outcomes are expressed as desired goals?[2]
	What are the main drivers determining your priorities: External drivers such as Excellence in Research for Australia Initiative[3] *[note: one of multiple provided options]*
Internal Influences: *Institution*	Institutional Network
	How important do you consider formal recognition/reward for your teaching and learning achievement inside or outside your institution?[3]
	How important do you think your institution regards teaching and learning performance for promotion purposes?[3]
	What are the main drivers determining your priorities: Organizational/institutional priority[3]
Internal Influences: *Unit (Academics' Background and Beliefs)*	Gender
	Age
	Industry experience
	English as a second language
	Discipline
	Educational qualification
	What are the main drivers determining your priorities: My own personal needs[3] *[note: one of multiple provided options]*
	What are the main drivers determining your priorities: Student satisfaction with their education program[3] *[note: one of multiple provided options]*

[1] 1: Unfamiliar; 2: Know they exist; 3: Some knowledge; 4: Good understanding; 5: Very familiar.
[2] 1: Never; 2: Sometimes; 3: About half the time; 4: Frequently; 5: Always.
[3] 1: Unimportant; 2: Not very important; 3: Unsure; 4: Important; 5: Very important.

3.2.2 Dependent variables

Respondents also answered several questions related to their teaching and learning practices (see Table 3), which fall within the "Academic Plan" box of the Academic Plan model (see Figs. 1 and 2). Because several survey items gathered information about related ideas, principal axis analysis (Oblimin with Kaiser Normalization rotation) was used to identify items that exhibit similar tendencies [41]. This statistical procedure does not require a dependent variable, but rather seeks to determine the degree of correlation between multiple items. Highly correlated items that vary together and are ideally measuring the same construct can be combined to form a single scale; this procedure is useful for reducing the number of variables required for subsequent statistical tests. Following the principal axis analysis, each item was assigned to a scale based on the magnitude of the factor analysis loading, the effect of keeping or discarding the item on the scale's internal consistency reliability, and professional judgment. Five scales were formed by taking the average of a respondent's scores on the component items, as recommended by Armor [42], which comprise the dependent variables.

One section of the survey focused on elements that inform academics' approaches to their teaching and learning roles. The factor analytic techniques and scale development collapsed these 13 items into two scales (see Table 3): (1) Educational and Student-Centered Considerations (i.e., the degree to which teachers consider their students and relevant educational developments), and (2) Engineering-Centered Considerations (i.e., the importance of certain curricular elements, including design, and the balance between theory and practice). A separate section of the survey asked academics to report on their approaches to teaching and learning. These 16 items were reduced to three scales: (1) Engaging Students (i.e., inviting active student participation that encourages critical thinking), (2) Informing Students (i.e., focusing on the transmission and coverage of information), and (3) Providing Materials to Students (i.e., consolidating information for students into exactly what students need to know). Table 3 displays the Cronbach's alpha for each scale, which is a measure of internal consistency—the Providing Materials to Students scale has the lowest reliability (alpha = 0.63), so caution should be taken when interpreting findings for this scale.

3.3 Analyses

First, a series of analyses of variance (ANOVA) with post-hoc tests investigated how external and internal influences vary across characteristics of academics. These analyses explored how other independent variables varied by participants' gender, age, first language, educational qualification, industry experience, discipline, and institutional network. Second, multiple linear regression investigated how independent variables related to issues informing academics' teaching as well as their actual approaches to teaching (the dependent variables shown in the Fig. 2 analytical model). Separate regressions were run for each dependent variable in a blocked manner—external influences were entered separately from internal institutional influences, separately from internal unit-level aca-

Table 3. List of dependent variables

	Scale	Survey Items
Informing Teaching	**Educational and Student-Centered Considerations**[1] (alpha = 0.73)	How important do you rate the following issues in informing approaches to your teaching and learning role? • The need for subject and curriculum renewal to take advantage of pedagogical developments • Familiarity with the engineering education literature dealing with pedagogy, assessment, innovations, and underpinning research • Understanding and developing the graduate attributes needed when they leave the higher education sector • Understanding the key characteristics of Generation-Y students • Understanding the capabilities of students entering the engineering program • Moving students towards self-directed learning • Developing and exercising critical thinking skills in students
	Engineering-Centered Considerations[1] (alpha = 0.73)	How important do you rate the following issues in informing approaches to your teaching and learning role? • The role of design in engineering • The role of modelling, simulation, and visualisation • The role of 'systems thinking' in engineering activities • Situating learning in real world contexts • The importance of content transmission to students • The need to balance theory and practice in the engineering curriculum
Teaching Practice	**Engaging Students**[2] (alpha = 0.78)	Approaches to teaching: • Make available opportunities for students in a subject to discuss their changing understanding of the subject • A lot of teaching time in a subject should be used to question students' ideas • Encourage students to restructure their existing knowledge in terms of the new way of thinking about the subject that they will develop • Use difficult or undefined examples to provoke debate • Set aside some teaching time so that the students can discuss, among themselves, the difficulties that they have encountered studying a subject • Assessment in subjects should be an opportunity for students to reveal their changed conceptual understanding of the subject • In interactions with students, try to develop a conversation with them about the topics studied • It is better for students in a subject to generate their own notes rather than always copy teacher's
	Informing Students[2] (alpha = 0.65)	Approaches to teaching: • It is important to present a lot of information to students so that they know what they have to learn in a subject • Concentrate on covering the information that might be available from a good textbook • Teacher should know the answers to any questions that students may put to him/her during a subject • Design teaching with the assumption that most of the students have very little useful knowledge of the topics to be covered • It is important that the subject should be completely described in terms of specific objectives relating to what students have to know for formal assessment items
	Providing Materials to Students[2] (alpha = 0.63)	Approaches to teaching: • An important reason for running teaching sessions in a subject is to give students a good set of notes • Only provide the students with the information they will need to pass the formal assessments • Structure subjects to help students pass the formal assessment items

[1] 1: Unimportant; 2: Not very important; 3: Unsure; 4: Important; 5: Very important.
[2] 1: Only rarely; 2: Sometimes; 3: About half the time; 4: Frequently; 5: Always.

demics' background and beliefs variables. By following this approach and changing the order of entry, results identify the proportion of the variance in the dependent variable(s) explained by each set of independent variables. Standardized coefficients are reported for the statistically significant relationships; the standardized coefficient allows for comparisons across variables with different scales.

4. Results and discussion

4.1 Variation across characteristics of academics

Analyses of variance demonstrated that external and internal influences were different across academics based on their individual characteristics (Table 4). With only one exception, disciplinary differences were not observed, so those results are not included in the table.

4.1.1 External influences

On average, respondents pointed to a fairly weak familiarity with or importance of external influences. For example, respondents in aggregate indicated that they only had minimal knowledge about the competency statements set forth by Engineers Australia (2.64 out of 5). Within this knowledge

Table 4. External and internal influences across characteristics of academics (mean response for each subset is shown for each variable)

		External Influences			**Internal Influences: Institution**			**Internal Influences: Unit (Academics)**	
	Subset	Familiarity with competency statements[1]	Accreditation outcomes expressed as desired goals[2]	Priority Setter: External drivers[3]	Recognition Reward[3]	Promotion[3]	Priority Setter: Org.[3]	Priority Setter: Personal interests[3]	Priority Setter: Student satisfaction[3]
Gender	Male	2.61	2.86[a]	3.06	3.86[a]	3.20[a]	3.92[a]	4.46	4.24[a]
	Female	2.86	3.22[b]	3.31	4.24[b]	3.64[b]	4.19[b]	4.40	4.45[b]
Age	20-30	2.14[a]	2.68	3.13	4.09	3.43	4.00	4.51	4.14
	31-40	2.22[a]	2.80	3.32[b]	3.90	3.37	4.08	4.53	4.16
	41-50	2.79[b]	3.05	3.01	3.83	3.29	3.95	4.45	4.32
	51-60	3.00[b]	2.94	3.12	4.01	3.22	3.95	4.35	4.35
	61+	2.81[b]	2.88	2.66[a]	3.83	2.98	3.68	4.41	4.38
English 2nd Language	No	2.74	2.90	2.83[a]	3.91	3.01[a]	3.83[a]	4.37[a]	4.28
	Yes	2.49	2.98	3.55[b]	3.91	3.71[b]	4.19[b]	4.60[b]	4.27
Education Qualification	No	2.55[a]	2.89	3.04	3.82[a]	3.22	3.93	4.42	4.24
	Yes	2.91[b]	3.00	3.30	4.18[b]	3.38	4.07	4.54	4.39
Industry experience	0-5	2.44[a]	2.90	3.12	3.91	3.35[b]	3.98	4.47	4.23[a]
	6-10	3.01[b]	2.81	3.23	3.84	3.22[b]	3.98	4.51	4.18[a]
	11-15	3.03	3.15	3.03	4.11	3.26[b]	3.95	4.34	4.43
	16-20	3.11	3.00	2.72	3.68	2.32[a]	3.81	4.14	4.68[b]
	21 +	2.88	2.88	2.65	4.24	3.18	3.91	4.50	4.68[b]
Institutional Network	Go8	2.39[a]	2.81	2.93[a]	3.84	3.04	3.94	4.46	4.19[a]
	ATN	2.86	3.05	3.29	3.97	3.38	3.90	4.51	4.22[a]
	IRU	2.95[b]	2.95	3.24	3.89	3.39	3.89	4.36	4.39
	RUN	3.73[b]	3.27	2.94	4.18	3.27	4.00	4.32	4.65[b]
	Other	2.81	3.19	3.43[b]	3.98	3.74	4.23	4.40	4.36

[1] 1: Unfamiliar; 2: Know they exist; 3: Some knowledge; 4: Good understanding; 5: Very familiar.
[2] 1: Never; 2: Sometimes; 3: About half the time; 4: Frequently; 5: Always.
[3] 1: Unimportant; 2: Not very important; 3: Unsure; 4: Important; 5: Very important.
[a/b]: Statistically distinct subsets within each variable (p<.05), according to ANOVA and posthoc analyses.

variable, however, there were differences across academics' demographics. There was a generational divide for this external influence variable, as younger academics (20–40 years old) were significantly less familiar with the statements than older academics (older than 40 years). Potentially related to this finding, academics with only 0–5 years of industry experience were less familiar than those with 6–10 years industry experience (note: only 17% of respondents answering this question had greater than 10 years of industry experience). Institutions could investigate their onboarding processes for new academics to ensure they receive an introduction to outcomes-based education as articulated by accrediting bodies. Academics with an education qualification (e.g., a certificate in higher education or teaching and learning) were more familiar with competency statements than those who did not, which suggests that professional development in teaching may help academics, at the very least, become more aware of accreditors' educational objectives. Finally, academics at the research-intensive Group of 8 institutions were significantly less familiar with the statements than those who worked at Innovative Research Universities or those in the Regional Universities Network. Thus, in accordance with the Academic Plan model, this finding suggests that an academic's institutional context—and what it most values—relates to the potential influence of education-related external forces. It is possible that the IRU and RUN institutions emphasize to their academics the competency statements and a teaching focus to a greater degree than the Go8 institutions. Alternatively, it is possible that academics' set of values differ when they decide to seek employment at one institutional type over another—perhaps those who are attracted to a Go8 institution are inherently less inclined to pay attention to or be influenced by teaching-related information from external sources.

When designing courses, academics on average expressed Engineers Australia accreditation outcomes as desired goals for the course less than half the time (2.91); females linked accreditation outcomes to course goals significantly more frequently than males. Respondents overall were unsure (3.11) when asked about the importance of external drivers in setting their priorities. As was the case for the familiarity with accreditation outcomes, external drivers were less of an influence on academics working at research-intensive universities than those at other universities. For this variable, however, younger academics were driven significantly more by these external forces than the oldest academics (although this item is not specifically related to educational-focused drivers). Unique to this external influence variable, academics for whom English was a second language relied on external drivers to set their priorities far more than those who first spoke the native language.

In combination, these results suggest that work by Engineers Australia to identify a set of outcomes may not yet be effectively communicated to—nor taken up by—academics. Because data indicate that external influences are not very likely to influence priorities of academic staff, perhaps expanding communication efforts broadly from this external mechanism across all academics would be a poor use of time and resources. Rather, targeting communication efforts toward younger academics, who may be more malleable by external forces, might be a more successful approach. Additionally, perhaps the burden of communicating and integrating strategies must be taken up by individual institutions as opposed to relying on external forces. Indeed, this internal approach has been followed by many institutions [43], which might also explain why respondents did not report high levels of influence by external forces; they may be more familiar with internal forces.

4.1.2 Internal influences: institution

For institutional internal influences, academics in aggregate indicated that formal recognition/reward was important (3.92) for their teaching and learning achievement but noted that their institutions thought teaching and learning performance was less important for promotion purposes (3.26). Female academics cited higher importance than males for both of these, and academics for which English is a second language thought the importance of teaching and learning performance for promotion was significantly higher than their colleagues with English as their native language. Similarly, academics with less industry experience thought teaching and learning performance was more important for promotion than staff with more years of industry experience. Such findings demand further investigation, as it is problematic that academics may differentially understand what their institutions value for the promotion and rewards system in a systematic manner by demographics. Clarifying institutional expectations with respect to teaching and learning is an important implication from these observations. As supported by many years of research on academics' work [16–19], such organizational policy levers help academics prioritize how they should spend their time. Clearly communicating priorities would help academics more closely align with their organizations' overarching missions and goals.

A more specific complicating matter is the observation that the institution's priorities are more important to how female and non-native language speakers set their own priorities than they are to other subpopulations. When administrators set institutional policies related to teaching and learning, they should be mindful that those policies—or at least perceptions of those policies—may differentially influence their academics' behaviors. Indeed, data from the United States, for example, have shown that engineering programs tend to rely on female academics much more than their male colleagues for advancing institutional priorities, even though activities such as student recruitment or advising are not valued in promotion and tenure decisions [44]. This observation becomes even more problematic if written institutional policies do not correspond to what is valued in practice. For example, if teaching and learning objectives are listed in policies but not valued as highly as research during actual decision-making processes, as has been the case historically [20], female and non-native language speaking academics could be at a disadvantage in positioning themselves for promotions if they pay closer attention to institutional influences than their colleagues.

4.1.3 Internal influences: unit (academics)

Relative to external and institutional influences, in aggregate, academics' personal interests (4.45), especially for non-native speakers, were more important drivers of their own priorities, supporting previous research that indicates intrinsic motivation is more important than extrinsic motivation for good teaching practices [45]. Institutions should take note of this finding of the importance of unit-level influences when developing effective change strategies with respect to teaching and learning initiatives. Though Graham's [9] report on curricular change in engineering education cited the importance of organizational structures and the leadership of the department head, a key finding from that report was that trust must be in place between academics and their department head as they experimented with and implemented curricular change. Thus, informal dimensions of academic-administrator relationships must be considered in determining the success of teaching and learning initiatives because such relationships largely drive how an organization operates [46]. Barnard [47] describes a managerial authority that is bottom-up rather than top-down—leaders must work to expand their authority by obtaining consent from those governed. A way to build this consent and organizational buy-in is to work hard on building informal relationships with constituents over time.

Following this logic, Selznick [48] describes institutionalization as an infusion of a set of values into an organization. The main role of leaders is to guide this process of defining their organizations' cultures; it takes a substantial amount of time to develop a common set of values shared by many within the organization. In higher education settings, effective administrators recognize the importance of the informal organization and the need to collaborate with academics to guide proposed changes [49]. Rapidly forcing a cultural change upon an organization without first generating buy-in among academics is highly likely to be an ineffective approach [50]. Administrators can build trust over time, and organizational change can successfully occur if that is in place [51–54].

Taking this organizational change literature into account when interpreting the findings about academics' personal interests, therefore, suggests that institutions and administrators should appeal to academics' interests and seek to expand upon those interests to include teaching and learning. Such a bottom-up strategy of leadership likely will find more long-term, sustainable success in changing the teaching and learning culture among academics than a top-down management strategy, as institutional policies and priorities were of less importance to academics than their individual priorities.

Finally, students' satisfaction with their educational programs was also an important driver of priorities of academics (4.27), in particular for females as well as for academics with over 16 years of industry experience relative to those with less than 10 years. Several aspects of this result merit further investigation. On one hand, taking into account students' satisfaction levels is a hallmark of student-centered teaching. As summarized by Eccles and Wigfield [55], as interest within a class increases, students tend to become more primed for learning [56, 57]. Thus, it might be encouraging that academics reported such a high average value for this driver of priorities. Alternatively, this finding could point to the notion that institutional policies stressing the importance of student course evaluations in annual review considerations may influence academics to find ways to enhance their student evaluations without actually improving teaching or learning environments. Further research also should explore why student satisfaction is a more important priority for women and academics with industry experience relative to their colleagues. We are limited by the available survey data to be able to draw any definite conclusions; follow-on qualitative research could explore this finding in greater detail.

Finally, student satisfaction drove priorities of academics who taught at RUN institutions to a greater extent than those teaching at Go8 and ATN institutions. The latter institutional types have a more extensive research mission, and so academics' time, priorities, and incentives for their annual reviews likely were driven more by research-related activities and less by teaching-related metrics, such as student satisfaction evaluations. Similar results showing differences across institutional types that have different missions have been uncovered in studies of undergraduate engineering education within the U.S. context [58]. Additionally, although similar proportions of academics at all institutional types had greater than 10 years of industry experience, the RUN academics were nearly balanced between the 0–5 and 6–10 year categories. Go8 and ATN institutions, however, had over three times as many academics in the 0–5 year category than the 6–10 year category. Thus, in concert with our previous finding, we suggest that additional research should more closely examine why industry experience seemingly relates to academics' consideration of students.

4.2 Influences on teaching and learning

In this section we present results of regression analyses linking the external and internal influences described in the previous section to reports of teaching and learning practices (shown in Fig. 2). Although the Academic Plan model asserts that these variables are linked causally, we present our results as relational and stop short of claiming causality because of the cross-sectional nature of our research design. We instead allow the reader to determine the appropriateness of making causal inferences based on the combination of the presented prior literature and the evidence from these regression models. Results from these models are presented in two sections based on the nature of the dependent variables: (1) Informing Teaching, which consists of Educational and Student-Centered Considerations as well as Engineering-Centered Considerations dependent variables, and (2) Teaching Practice, which consists of Engaging Students, Informing Students, and Providing Materials to Students dependent variables.

4.2.1 Informing teaching

On average, respondents indicated that they found both Educational and Student-Centered Considerations as well as Engineering-Centered Considerations important aspects of their approaches to teaching and learning (4.1 and 4.2, respectively). The suite of independent variables in the regression analyses explained approximately a quarter of the variability in both scales (Table 5). Such explanatory power is substantial for social science research, especially because this survey did not obtain information such as academics' attitudes toward teach-

Table 5. Regression results relating internal and external influence variables to informing teaching and teaching practice variables. Values indicate statistically significant standardized coefficients ($p < 0.05$)

	Independent Variables	**Informing Teaching**		**Teaching Practice**		
		Educational and Student-Centered Considerations	Engineering-Centered Considerations	Engaging Students	Informing Students	Providing Materials to Students
External Influences	Familiarity with competency statements	0.25	0.12	0.13	-0.13	
	Accreditations outcomes expressed as desired course goals		0.11	0.13	0.11	
	Priority setter: External drivers	0.13	0.16		0.14	
Internal Influences: Institutional	Group of 8					
	Australian Technology Network					
	Innovative Research Universities				0.20	
	Regional Universities Network					
	Recognition/Reward					
	Promotion					
	Priority setter: Organization					
Internal Influences: Unit (Academics)	Female					
	20-30 Years Old					
	31-40 Years Old					
	51-60 Years Old					
	61+ Years Old			0.14		
	Educational Qualification					
	English as a Second Language				0.28	
	Industry Experience	0.14	0.12			
	Aeronautical/Aerospace					
	Biological/Biomedical					
	Chemical					
	Civil					
	Environmental					
	Materials				0.16	
	Mechanical					
	Mining					
	Other Engineering					
	Other Non-Engineering		-0.13			
	Priority setter: Personal interests	0.13				
	Priority setter: Student satisfaction	0.20	0.17	0.18		
	Adjusted R-squared	0.24	0.21	0.13	0.18	0.04

ing, beliefs about undergraduate education, or nature of their teaching histories.

Familiarity with Engineers Australia's competency statements was the strongest predictor of Educational and Student-Centered Considerations, which is logical since the scale contains items related to awareness of educational issues. Those competencies represent the general aims for undergraduate engineering in Australia, with specific emphases interpreted by various disciplines. When student satisfaction was more important to academics' own priorities, they considered their students in their approaches to teaching more than their colleagues who reported that student satisfaction was less of a personal priority. External drivers, personal interests, and industry experience each had approximately the same positive relationship with this scale.

Coupled with the finding presented in the previous section relating industry experience to academics' attention to student satisfaction, it is noteworthy that industry experience significantly related to Educational and Student-Centered Considerations in the regression model. Kirschenbaum [59] noted that professional experience could improve instruction, as academics with professional experience may be more capable of modeling what professional practice should resemble, and our data may be substantiating that claim. Given the different considerations made by academics with prior industry experiences, professional development practitioners may want to make it a priority to engage those individuals in the development of teaching improvement workshops. Doing so may help create workshops that reflect on and consider different visions of good teaching.

Comparisons of the different blocked regression analyses (Table 6) show that unit-level (academic) internal influences explained more variability than external influences, which explained more variability than institutional influences. At the time of this survey, the proportion of the variability in the Educational and Student-Centered Considerations scale that was independently explained by the Institutional internal influences variability was only 10%. This finding suggests that institutions still have room for improvement if they want their policies related to teaching and learning to translate into decision-making and behavior on the part of academics.

The full model explained 21% of the variability in Engineering-Centered Considerations. As was the case for Educational and Student-Centered Considerations, the greatest variability in this scale similarly was explained by external influences and internal unit-level (academic) influences (Table 6). Familiarity with competency statements and external drivers of priorities significantly related to items containing engineering-specific considerations (Table 5). Unlike the previous scale, however, expressing accreditation outcomes as desired course goals also related significantly to Engineering-Centered Considerations. This finding provides some evidence that outcomes-based assessment in Australia might have an influence on how academics consider organizing their courses; further research should explore how academics actually use outcomes-based assessment in course development.

For unit-level (academic) influences, the extent to which student satisfaction sets a teacher's priorities also positively related to Engineering-Centered Considerations. Similarly, experience in industry related to greater values on this scale, a finding that is consistent with prior research. Lattuca, Knight, and Bergom's [60] study of U.S. engineering teachers demonstrated that academics who worked in industry tended to use effective teaching practices of active learning and provided frequent and detailed feedback to students more often than their colleagues with less industry experience. Although additional research is required within the Australian context to substantiate this claim, it appears as if programs should explore why their academics with more industry experience consider such a wide variety of issues when they approach their teaching and learning roles and how these examples could be leveraged to spark change throughout the ranks.

4.2.2 *Teaching practice*

For the approaches to teaching scales, Engaging Students consists of items that are most positive from an educational perspective. Informing Students as well as Providing Materials to Students scales consist of less educationally sound

Table 6. Adjusted R-squared values for blocked regression analyses

	Informing Teaching		Teaching Practice		
	Educational and Student-Centered Considerations	Engineering-Centered Considerations	Engaging Students	Informing Students	Providing Materials to Students
External Influences	0.12	0.09	0.08	0.08	0.03
Internal Influences: Institutional	0.10	0.05	0.02	0.04	0.04
Internal Influences: Unit (Academic)	0.14	0.11	0.10	0.11	0.02
External Influences + Internal Influences: Institutional	0.18	0.13	0.08	0.10	0.04
External Influences + Internal Influences: Unit (Academic)	0.23	0.18	0.14	0.16	0.04
Internal Influences: Institutional + Internal Influences: Unit (Academic)	0.18	0.16	0.09	0.15	0.04
External Influences + Internal Influences: Institutional + Internal Influences: Unit (Academic)	0.24	0.21	0.13	0.18	0.04

approaches that do not encourage students to be as actively engaged in the learning process or that resemble lecture-style approaches. Encouragingly, academics reported Engaging Students over half the time (3.2), Informing Students about half the time (3.0) and Providing Materials to students only sometimes (2.2). The independent variables in this analysis only explained 4% of the variability in the Providing Materials to Students scale (Table 5). The scale's low mean, a skewed distribution, being comprised of only three items, and the lowest internal consistency made it less useable for this analysis, so discussion is limited.

Regression analyses explained 13% and 18% of the variability in the other two scales, notably lower than the explanatory power for the dependent variables related to how teaching is informed. Thus, there appears to be a disconnect between influences on what *informs* teaching practice and influences on what *actually happens* in classrooms. This finding aligns with prior work on curriculum in higher education in general by Toombs and Tierney [11] as well as Stark et al.'s Contextual Filters model [12]. That research stated that the context of a course significantly influences the planned content and form of a course, and thus what is *intended* and what is *delivered* are two distinct items. Variables such as time constraints, space allocation, and insufficient tutor allocation, for example, could all explain the disconnect that we observed in our data; omission of such variables from our analyses is a limitation of the data set.

Institutional internal influences explained very little variability in Engaging Students and Informing Students scales (Table 6). It is troubling that the institutional policy drivers captured in this survey were not related to what actually happens in classrooms, despite the fact that academics view teaching as being important for reward structures and, to a lesser extent, promotion, as mentioned previously. Although most institutions tout their support for teaching and learning, these findings question their effectiveness and suggest the need to identify methods to better align organizational policies and priorities with academics' teaching activities. As Sloan [61], Boyer [62], Gmelch et al. [63], and Felder et al. [45] all suggest, strategically and effectively using reward and recognition could provide the needed support and reinforcement required to sustain intrinsic motivation towards effective teaching. These data show that Australian engineering programs do not seem to have found that balance in their institutional policies.

Academics' reports on the educationally sound Engaging Students scale increased as academics were older, were more familiar with accreditation competencies, as those outcomes were expressed more often as desired course goals, and for academics who placed an importance on student satisfaction for setting their own priorities (Table 5). Expressing outcomes as course goals as well as the importance of external factors on academics' priorities also positively related to the Informing Students scale. A negative relationship was observed, however, between familiarity with the competencies and the less educationally sound Informing Students scale. Coupled with findings presented previously, patterns related to external influences continue to emerge in these analyses. It appears that promoting *awareness* of different educational goals for undergraduate engineering may result in more desirable teaching and learning practices. We find mixed results, however, when accreditation outcomes and external drivers might be forced into course planning and academics' priorities, which may relate to a more content-driven and potentially less engaging scenario.

Thus, these findings support the notion of providing educational materials to academics to enhance their awareness of curriculum alignment goals, perhaps in a targeted manner as previously noted, without necessarily applying a mandate for implementation. What may be more effective, however, would be continual professional development that could help academics begin to incorporate educational ideas organically as opposed to a top-down approach that may actually result in less engaged classes. Such professional development would require a commitment on the part of institutions to build in appropriate time for academics to engage in such activities or to build strategic partnerships between academics so that they could help one another enhance the curricular alignment of their courses so that educational environments support intended learning outcomes.

An additional unit-level (academic) result is noteworthy from the regression analysis. Academics for whom English was a second language used the Informing Students approach more than their colleagues. Language barriers, or potentially a different academic training context if this variable is a proxy for international status, may have led them to prefer providing information *to* students rather than leading discussions of concepts *with* students. Institutions should investigate whether or not these academics have received sufficient professional development to lead classes in the active and engaging manner that is becoming the gold standard for many higher education systems, including Australia.

Two final observations of non-significant relationships merit discussion. First, academics' discipline was a poor predictor of each teaching and learning scale, which is not consistent with previous work conducted on engineering education in the United States. Lattuca et al. [64] identified subgroupings of engineering disciplines categorized by Holland type (i.e., groups of subdisciplines categorized by the overarching socializing environments related to personality types) and found variations in the degrees to which academics placed an emphasis on professional and social contexts and in the use of active learning pedagogies. Further investigations could compare disciplinary subcultures between international contexts. The shared university governance model of the U.S system in which academics maintain an important voice in institutional decision-making sets it apart from the more top-down Australian model. Although departments may rely on the College or institution to fund academic hiring lines in the United States, for example, they maintain autonomy on most other issues. Thus, loyalty of U.S. academics in making decisions tends to be first to their disciplines and secondly to their institutions [65–67]. Though Australian academics may similarly have greater loyalty to their disciplines, perhaps the difference in academics' *authority* makes the disciplines in the United States more distinct from one another on a variety of issues, including ones related to teaching and learning practices.

Second, whether or not an academic held an educational qualification was not related to these scales. It is especially troubling that those who received explicit training in teaching and learning were no more likely to demonstrate higher scores on the Educational and Student-Centered Considerations scale or the Engaging Students scale. Programs should investigate whether such professional development activities are considered separate, "add-on credentials" that are not supported by the culture of engineering programs. As indicated by Stes et al. [68], such educational qualification activities tend to only be sustainable if academics' home programs value teaching and learning improvements. The current result highlights an apparent missed opportunity by engineering programs with academics who sought to enhance their teaching and learning knowledge.

5. Implications

In addition to illuminating an area which merits additional research to explain *why* we observed differences across academics' characteristics, these results identified several implications for practice and policy. First, programs may want to consider tailoring professional development efforts based on academics' characteristics. Those with industry experience, for example, may be more likely to adopt new student-centered teaching strategies and can be leveraged as potential "gatekeepers" to their colleagues. Second, we recommend that institutions clarify institutional policy with respect to teaching and learning because we observed differences across academics' characteristics—in particular by gender and non-native language—in their reports of what is valued in promotion and tenure decisions. Third, rather than following a top-down approach to spur improved teaching and learning through institutional policies, a more organic approach to change from the bottom-up might be more successful and a better use of resources. Institutional policies and priorities were of less importance to academics than were their individual priorities, which aligns with findings from previous research that engineering academics' own desire to change teaching practices [69] and their beliefs about learning [22] directly related to their teaching decisions. In particular, our study points to informed and resource-supported professional development for academics that (1) seeks to capitalize on their personal interests and characteristics, and (2) assists in helping them understand *how* curricula and outcomes may better align to help student learning.

6. Conclusion

Using a comprehensive survey data set of Australian engineering academics, we investigated how characteristics and beliefs of academics, institutional features, and external drivers relate to the adoption of educationally sound teaching and learning practices. Our data showed that external and internal influences differed across academics based on their characteristics and contexts, as we illuminated differences in influences by age, gender, industry experience, native language, and institutional type. Thus, in applying the Academic Plan model to the Australian engineering context, our analyses reinforced its central principle—sociocultural context matters, and considering unit-level (academic) influences alongside internal institutional and external influences in investigations of teaching and learning drivers is essential. Internal unit-level (academic) influences explained the greatest variability in academics' considerations and practices for teaching, which provides additional support for a bottom-up strategy for changing the culture around teaching and learning. For external influences, our results suggest that promoting *awareness* of different educational goals for undergraduate engineering relates to more desirable teaching and learning practices. Forcing accreditation outcomes and external drivers into course planning may lead to a more content-driven and potentially less engaging curricula. Thus, programs should be deliberate in the ways they require alignment between curricula and accreditation outcomes—an approach that makes explicit *how* the educational environment promotes the development of students' learning for each outcome would likely be more effective than a curriculum-outcome mapping exercise.

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