The Future of Engineering Education
2024 Annual Conference & Exposition
Oregon Convention Center
Portland, OR . June 23 - 26, 2024
Paper ID #43120

An Exploratory Analysis of an Electrical Engineering Technology Curriculum Using Bernstein's Instructional Discourse

Dr. Ashish Agrawal, Rochester Institute of Technology

Ashish Agrawal (he/they) is an Assistant Professor in the College of Engineering Technology at Rochester Institute of Technology. His research interests include exploring the intricacies of STEM curricula, studying the influence of curricular features on students' experiences, and designing equitable interventions and assessing their influence on student learning. He has taught several introductory engineering courses using student-centric approaches such as project-based learning and flipped classroom.

An Exploratory Analysis of an Electrical Engineering Technology Curriculum using Bernstein's Instructional Discourse

Abstract

This paper analyzes the undergraduate electrical engineering technology curriculum at an engineering technology college at a private R2 (based on Carnegie Classification) university in the USA. The purpose of this analysis is to identify key elements of the curriculum being studied including selection, sequencing, pacing of the course content, and evaluation criteria. Data for this work include the undergraduate plan of study, course outlines, and course syllabi for the required discipline-specific courses at the research site. Data analysis was guided by the theory of the pedagogic device developed by the British sociologist Basil Bernstein. Bernstein notes that disciplinary knowledge is recontextualized into the curriculum through the pedagogic discourse. The framing element of recontextualization focuses on the process through which the disciplinary knowledge is transformed into the disciplinary curriculum. Framing involves both regulative discourse (related to social order and relation between actors) and instructional discourse (related to the content and delivery). Data were analyzed using Bernstein's concept of instructional discourse to highlight the selection, sequencing, and pacing of the course content, and its evaluation criteria in the curriculum under study. Findings highlight how curricular requirements are distributed across major vs. general education courses and required vs. elective courses; how major-specific required courses are sequenced and paced across semesters; and how course requirements expect students to demonstrate their learning. These exploratory findings point to the need for future studies to better understand how different aspects of the curriculum came into being and how they shape students' learning experiences, academic success, and development as future professionals.

1. Introduction

One of the key reasons for the genesis of Engineering Technology (ET) degrees in the United States (US) is the geopolitical developments post World War II. The need for military development and space exploration during the Cold War era fueled a marked shift in the nature of engineering degrees with a heavy engineering science component [1], [2]. As the engineering programs became more science-heavy, ET programs started being established to prepare professionals who were trained in specific domains of technology and could fill the need for "skilled crafts and the highly scientific professions" (Smith and Lipsett, 1956, as cited in [1]).

As a result, one significant aspect of the ET degree is its emphasis on practical and laboratory-based instruction and relatively less focus on advanced mathematics. As a report by the National Academy of Engineering notes, "the pedigree of ET is rooted in application-focused and hands-on learning, perhaps to a greater extent than in engineering" [1, p. 167]. As a result, the ET curricula incorporate more laboratory-based courses. While the ET curricula also contain courses in engineering sciences, these courses are redesigned with an application focus in mind to teach students how concepts from engineering sciences are applied in practice [1].

Although there are differences in the training of engineering technology graduates as compared to that of their engineering counterparts, there is a significant overlap in the career trajectories of the two degrees. The Engineering Technology Council of the American Society for Engineering Education notes in its goals that while "the degree is engineering technology, the career is engineering"™ [3, p. 3]. This goal is also supported by the nature of employment of engineering technology graduates. A report by the American Society of Manufacturing Engineers notes that there is a large number of jobs such as product engineering, manufacturing, component design, company management, test, development, evaluation, and system integration that are performed by both engineering and engineering technology graduates [1]. Moreover, over time, an increasing number of engineering technology graduates have entered the workforce as "engineers" [1].

These similarities and differences in engineering and engineering technology degrees are also reflected in the accreditation criteria used by ABET. Overall, the criteria used for assessing the engineering and engineering technology programs look very similar. Both sets of criteria require the graduates to solve engineering problems using the knowledge of math, science, and engineering; solve engineering problems through design; conduct experiments to analyze and interpret data to draw conclusions; consider ethical and professional responsibilities and public health and safety while assessing the impact of the proposed engineering solutions by situating them in the current local, societal, and global contexts; effectively communicate on technical and non-technical environments; and contribute to teamwork [4], [5]. The only marked difference lies in the nature of problem solving or design that the graduates from the two degrees are expected to learn. While the engineering graduates are expected to identify, formulate, and solve complex engineering problems [4], engineering technology graduates should be competent in solving "broadly defined engineering problems" [5].

1.1 Purpose of this study

Given the similarity of student outcomes, nature of jobs, and intent of the degree, one point that can be argued with certainty is that curricula in both engineering and engineering technology degrees largely draw from the same body of knowledge in math and science. The primary difference between the two programs lies in how this disciplinary knowledge is delivered to students through the curricula. While the knowledge in math and science is converted into a more theory-oriented curriculum in engineering programs, it is transformed into an application-heavy curriculum in engineering technology degrees.

However, this is not to suggest that there is a clear demarcation between engineering and engineering technology curricula in terms of their theory vs. application focus. Engineering curricula include several application-based elements in the form of laboratory courses, course projects, and capstones. Similarly, engineering technology curricula include several theory-based courses such as calculus and physics. The difference lies in the fact that engineering curricula generally tend to be more toward the engineering science side of the application vs. theory spectrum, and engineering technology curricula tend to me more on the application end. The extent to which each curriculum tilts toward application or theory greatly varies across the universities and programs.

Because there is a relative continuum of theoretical density (or application density) across engineering and engineering technology programs, the purpose of this paper is not to compare engineering and engineering technology curricula, which would create significantly different outcomes based on which specific programs are chosen. The objective, rather, is to understand how disciplinary knowledge is recontextualized into an application-oriented curriculum in one electrical engineering technology program at one US university. Analysis is done using Bernstein's theory of the pedagogic device [6], [7] to explore the selection, sequencing, pacing, and evaluation criteria of the course content. Selection refers to what constitutes part of the curricular knowledge delivered to students and the process of choosing what curricular knowledge is included. Sequencing refers to the order in which the curricular knowledge is presented to students, pacing refers to the rate at which students are expected to learn the content, and evaluation criteria refer to how the student learning is assessed. The research question guiding this study is:

> ***How is the disciplinary knowledge recontextualized into an electrical engineering technology curriculum in terms of the selection, sequencing, and pacing of the course content, and its evaluation criteria?***

While prior work comparing engineering and engineering technology degrees has shown that engineering technology degrees have more laboratory-based and application-oriented courses, this comparison has been limited to the overall curricular level [1]. This paper extends our understanding of engineering technology curricula by analyzing the curriculum under study at the level of course syllabi. This is achieved by focusing on the selection, sequencing, and pacing of curricular content, and the associated evaluation criteria.

The findings for this work have implications for both engineering technology and engineering educators. For engineering technology educators, these insights will provide insights into the skills and dispositions that graduates with ET degrees obtain. These insights will help ascertain "the extent to which the supply of those with ET degrees does–or does not–meet the needs of employers" [1, p. 12]. This knowledge is significant as engineering technology programs play a key role in supplying the technical workforce in the United States [3]. For engineering educators, these findings provide ways to make engineering curricula more hands-on, which aligns with the recent push to develop engineering curricula that are more experiential [8].

2. Theory of the Pedagogic Device

British sociologist Basil Bernstein notes that disciplinary knowledge is transformed into the educational curricula through the pedagogic device. The pedagogic device is the set of rules that produces the pedagogic discourse (i.e., teachable material or the educational version of disciplinary knowledge) through a set of three interrelated rules: distributive rules, recontextualization rules, and evaluative rules [6], [7]. In a very broad sense, the distributive rules govern the institutional practices, the recontextualization rules govern the transformation of school subjects or students, and the evaluation rules govern the pedagogical practice [9].

2.1 Distributive rules

Distributive rules regulate knowledge [10] by regulating the institutional practices. They determine "who may transmit what to whom, and under what conditions" [7, p. 183]. In terms of understanding the teaching and learning practices in higher education, the distributive rules relate to "*what* can legitimately be taught in universities, *who* may legitimately take on the role of a 'teacher' or 'learner', and the conditions under which teaching–learning processes take place" [11, p. 91, *italics* in original]. Thus, distribution rules put a bound on what constitutes legitimate knowledge that can be taught in universities and other educational institutions.

2.2 Recontextualizing rules

Recontextualizing rules create pedagogic discourse, i.e., the specific course content along with the ways to deliver it. In other words, recontextualizing rules "govern the process by which knowledge is removed from its original site of production and turned into something else: the educational subject (or school) version of that knowledge—the pedagogic discourse" [10, p. 216].

Bernstein [6], [7] notes that pedagogic discourse consists of two discourses: instructional discourse and regulative discourse. The instructional discourse refers to the selection, sequencing, pacing, and evaluation criteria of the knowledge. Thus, the instructional discourse is "a discourse of the skills of various kinds and their relations to each other" [6, pp. 31–32]. It creates tangible skills and knowledge within particular academic disciplines [10]. The regulative discourse creates rules for conduct, character, and manner [6]. Thus, the regulative discourse controls "relations between all actors, creating social order and constructing identities" [10, p. 217]. Hoadley equates the regulative discourse to the hidden curriculum, which refers to the norms, beliefs, and values enacted in the classroom and educational settings [12]. Agrawal et al. argue that the regulative discourse can also include aspects of the curricula such as curricular rigidity, the number of scheduled contact hours for lectures and labs, and the structuring of the degree in terms of when discipline-specific content is introduced to students [13].

2.3 Evaluative rules

Evaluative rules are concerned with specific pedagogic practices [6]. They regulate "what counts as valid acquisition of instructional (curricular content) and regulative (social conduct, character and manner) texts" [14, p. 573]. It is based on the evaluative rules that various actors (i.e., the state, institutions, professional bodies, and academics) determine the specific set of evaluative criteria to assess the attainment of the instructional and regulative discourses. In other words, evaluative rules determine what is valuable knowledge to learn for students [10].

2.4 Classification and Framing

Two elements are crucial to recontextualization of disciplinary knowledge: classification and framing [6], [11]. Classification refers to the extent to which disciplinary knowledge maintains its own voice while being recontextualized into pedagogic discourse (i.e., curriculum) at an institution of learning. Bernstein notes that in cases where classification is strong, the pedagogic discourse is classified as singulars. In singulars, disciplinary knowledge is transmitted independent of knowledge from other disciplines. On the other hand, if the classification is weak, the pedagogic discourse is classified as regions where the disciplinary knowledge is transmitted in relationship with knowledge in other singulars [6]. For example, physics or chemistry or biology can be seen as singulars whereas biochemistry (a combination of biology and chemistry) or biomechanics (a combination of biology and physics) or nanomaterials (a combination of chemistry and physics) can be seen as regions. Engineering, including electrical engineering, which draws from a variety of disciplines including math, natural sciences, humanities, and social sciences [15], is classified as a region [6]. Finally, Bernstein notes that when the classification is extremely weak, disciplinary knowledge can be recontextualized into generics, which respond to the changing demands of the market and the society [6].

Framing of the disciplinary knowledge refers to how the disciplinary knowledge is recontextualized into the disciplinary curriculum [11]. An important aspect of framing deals with the question of "who controls what" [6]. Framing involves both regulative and instructional discourses. As noted above, the instructional discourse concerns itself with the selection, sequencing, pacing, and evaluation criteria. Thus, framing is also concerned with these aspects of the instructional discourse.

Framing can be both external and internal. External framing is related to control outside the teaching context or the classroom [16]. More specifically, external framing is a site for struggle between different actors including the state, employers, disciplinary and professional bodies, institutions, departments, and the academics in determining the specifics of the pedagogic discourse [11]. For example, engineering curricula in the US and other Washington Accord countries are governed by ABET and similar regulatory bodies [17]. Case et al. note how engineering curricula in three different countries are influenced by the national requirements and are regulated through the state [18]. Agrawal et al. show how the institutional and the departmental culture in different engineering disciplines can impact students' approaches to learning, teaching approaches, and the overall learning environments [19], elements that are regulative aspects of the pedagogic discourse.

Internal framing relates to control within the teaching context or the classroom [16]. It represents the degree of control that instructors and students have over selection, sequencing, pacing, evaluation criteria, and rules of engagement between the students and the instructors [12]. A strong framing is when instructors have a greater control over these aspects while a weak framing is when students have a greater perceived or apparent control over these aspects. Murray equates this weak framing to student autonomy in charting their educational experiences [20], which can have significant influence on students' learning and success [21].

2.5 Value of the theory of the pedagogic device

At a macro level, Bernstein's theory of the pedagogic device provides insights into social relations, power, and control. As he notes, the "rules of relation, selection, sequencing, and pacing (the rate of expected acquisition of the sequencing rules) … are social, not logical facts [7, p. 185]." Expanding on this idea, Clark argues the pedagogic device helps us analyze and understand how the education system becomes a tool for social reproduction in any society:

> Bernstein proposes that the pedagogic device makes the transformation of power into differently specialised subjects possible through the distribution and regulation of "knowledges" and the discourses such knowledges presuppose…. Rather than act as an

> agent of change, the education system, therefore – including the curriculum taught within – becomes a site of cultural reproduction that aims to reproduce the society within which it is located. [9, p. 36]

At the micro level, the selection, sequencing, pacing, and evaluation of a curriculum (an engineering technology curriculum in this case) has important implications for how both instructors and students experience the curriculum. As Ashwin notes:

> [T]he pedagogic device highlights that the ways in which different disciplinary knowledge practices are recontextualized can be very different depending on the institutional location of each set of rules…. It seems possible that the level of control and ownership that academics have of the recontextualization of disciplinary knowledge practices into curriculum is highly significant in shaping academics' and students' experiences of teaching–learning interactions in higher education. [11, p. 103]

Prior studies provide strong evidence for this argument. For example, Agrawal and colleagues argue that the ability to select elective courses and specialization areas (i.e., a weaker framing) can have significant influence on students' learning experiences and subsequent formation as engineers [13], [22]. Specifically, they highlight how the ability to choose electives and specializations within the degree can allow students to diversify their skills and broaden their worldviews. On the other hand, Ulriksen et al. note that STEM programs with a strong framing provide limited avenues to reflect and make sense of what they are doing, especially in the initial years of the degree [16]. Similarly, Pausigere argues that strong sequencing and pacing (i.e., a stronger framing) can impede learning of primary math concepts for poorer and working class children [23]. Thus, the framing aspect of recontextualization has considerable effects on student experiences and success in academic settings.

Thus, it is undeniable that Bernstein's theory of the pedagogic device including the framing rules can provide important insights into understanding students' learning experiences. Hence, this study uses this theoretical framework to understand how knowledge derived from different disciplines is recontextualized in an electrical engineering technology curriculum.

3. Methods

3.1 Research site

To address the research goal, data were from an undergraduate program at a Carnegie Classification R2 (high research activity) university in the United States. The research site offers undergraduate and master's degrees in engineering technology in different disciplines including electrical, computer, mechanical, robotics, manufacturing, and civil. The university has both a college of engineering and a college of engineering technology, with the engineering technology programs relatively more hands-on and less theoretical in nature. The college of engineering technology has been admitting 350-450 incoming first-year students over the past few years out of which 20-25 generally pursue an undergraduate degree in electrical engineering technology. One of the distinguishing features of the undergraduate programs in both colleges is the cooperative education (co-op) requirement. Both colleges require undergraduate students to complete a total of one year of co-op. This engineering work experience typically occurs over two semesters and two summers and is interspersed with academic semesters. To accommodate for the year spent working in an industrial setting, the academic programs are 5 years in duration. Students are employed full-time and do not pay tuition while on co-op.

3.2 Data sources

The data for this study include the official course documents that represent the academic requirements for an undergraduate degree in electrical engineering technology at the research site. These documents included 1) the plan of study outline for the degree, 2) course outlines for the major-specific courses, and 3) syllabi for the major-specific courses. These documents were obtained from either the university website, or course instructors (the department chair served as a liaison in obtaining these documents). The need for IRB approval was waived for this work by the Human Subjects Research Office at the research site as the data collected only includes official university documents.

The electrical engineering technology program was chosen as a convenience sample for conducting this study. It was easier for the author to obtain the course outlines and syllabi due to acquaintances in the college and the department. Additionally, the author also holds undergraduate and master's degrees in electrical engineering, making it convenient for them to understand the course topics and learning outcomes while analyzing the course documents.

3.3 Data analysis

The first step in data analysis included building up a plan of study based on the outline available to all students. To this end, the various courses along with the possible set of options that students had for each semester were identified. The second step involved obtaining the course outlines and the syllabi for all major-specific courses that were required for the program and analyzing these documents for identifying the pre- and co-requisites for each course, and understanding the learning outcomes for the course and how student learning was assessed within the course.

4. Findings

This section presents the findings of the data analysis in terms of the four elements of the instructional discourse: selection, sequencing, pacing, and evaluation criteria.

4.1 Selection

Selection refers to what counts as curricular knowledge. For this analysis, selection is measured at the level of the entire curriculum in terms of the courses that students are required to take for the degree.

The plan of study divides the credits required for the degree into three categories: major-specific requirements, general education requirements, and open electives. Based on the plan of study, the undergraduate degree under study requires students to obtain a total of 127 credits. Out of these, 55 credits are from major-specific courses, 60 credits are to be obtained from general education requirements, and the remaining 12 come from open electives.

For the 55 major-specific credits, students are required to take 22 courses. These courses are either 1, 2, 3, or 4 credits each. Generally, a 1-credit course is a laboratory course associated with a theory course with the same name. Additionally, students take one 1-credit course that prepares them for their co-op training by introducing them to the resources at the university and key considerations during the job search and co-op training process. A 2- or 3-credit course is usually a course focused on theory. A 4-credit course is a combination of theory and laboratory work.

Course credits are connected to seat time with lecture-style classes assigned one credit for every 50 minutes and laboratory-style courses assigned one credit for every 100 minutes. Active learning pedagogies, if implemented, are considered lecture-style courses. Using this assignment strategy, 2-credit courses generally meet for 100 minutes per week, 3-credit courses meet for 150-200 minutes per week. Some 3-credit courses may meet for 100 minutes per week in lecture and the same time per week in laboratory. Four-credit courses typically meet for 150 minutes per week in lecture and 100 minutes per week in laboratory.

In addition to the credit bearing courses, students also must complete five 0-credit courses. One of these introduces students to the university community and helps them build connections across the campus. The remaining four require students to successfully complete their cooperative education work requirement and complete an oral presentation on their experience.

Table 1 presents the list of major-specific courses with credits associated with them. Note that the nomenclature present in the tables is slightly modified (without losing the essence of the course) to preserve anonymity of the research site. As can be seen from Table 1, most of the technical course requirements (49 of 55 credits) are compulsory for all students. The only flexibility allowed to students is in terms of two technical electives for 3 credits each that allow students to pick from a specified set of engineering courses based on their interests. Additionally, students have 12 credits of open electives that may be used for any courses (technical or non-technical) within the university.

Table 1: Major-specific course and credit requirements

Courses (separated by a semi-colon)	***Credit for Each Course***	***Total Credits***
Co-op Presentation (2); Introduction to the University Community	0	0
Co-op Preparation; Lab for Circuit I; Lab for Circuit II; Lab for Signals and Systems; Lab for Electrical Machines	1	5
Electrical Machines	2	2
Engineering Fundamentals; Introduction to Digital and Microcontroller Systems; Circuits I; Circuits II; Digital Systems Design; Electronic Devices; Microcontroller Systems; Signals and Systems; Communication Electronics; Power Transmission	3	30
Advanced Electronics; Digital Signal Processing; Control Systems	4	12
Technical Electives	3	6
Total		**55**

The second category of courses that students need to take constitutes the general education requirements. As noted above, the general education requirements form a significant portion of the undergraduate program (60 of 127 credits). There are several areas in which students are required to take courses to meet these general education requirements. These areas include math requirements, scientific principles requirements, first-year writing, natural science inquiry perspective, computational problem solving, statistics, artistic perspective, ethical perspective, global perspective, social perspective, immersion, and elective. Out of these, students need to take specific courses for math (which are primarily calculus courses), scientific principles and computational problem solving requirements. Students, however, do have some flexibility in choosing their math requirements based on their math placement results before the start of the first semester. For the perspectives, students need to take one course from a list of courses that fall under that specific perspective. For immersion, students need to take 3 more courses (9 credits) from a particular perspective area of their choice. The elective requirements can be fulfilled by taking a course from the list of general education electives.

Table 2 presents the distribution of the courses and credits that students need to take for their general requirements. Within Table 2, the program specifies which courses students must complete to fulfill math, scientific principles, first-year writing, computational problem solving, and statistics requirements. Students are free to choose other courses based on their interest as long as they fall within the required category.

Table 2: Courses and credits for general education requirements

Courses	***Credit for Each Course***	***Total Credits***
Math Requirement (3 courses)	3	9
Scientific Principles (1 course)	4	4
First-year Writing (1 course)	3	3
Natural Science Inquiry Perspective (1 course)	4	4
Computational Problem Solving (1 course)	3	3
Statistics (1 course)	3	3
Artistic Perspective (1 course)	3	3
Ethical Perspective (1 course)	3	3
Global Perspective (1 course)	3	3
Social Perspective (1 course)	3	3
Immersion (3 courses)	3	9
General Education - Elective (2 courses)	3	6
General Education - Elective (1 course)	4	4
Math/Science Elective (1 Course)	3	3
Total		**60**

The plan of study requires students to take three writing-intensive courses during the program. These are courses with at least 25% of the grading requirement associated with significant writing assignments. Two of these courses are specified in the plan of study – one being the first-year writing course and the second a program-specific course. Students are free to choose a third writing-intensive course in the degree. Additionally, students are also required to complete two non-credit-bearing wellness courses.

The third type of course that students are required to complete falls under the open elective category. As noted earlier, to meet these course requirements, students can choose any of the four courses (technical or non-technical) offered at the university. Each of these courses should be at least a 3-credit hour course.

In addition to pursuing a major in electrical engineering technology, this course selection scheme along with the plan of study and university policies allow students to pursue specializations and minors. Students can obtain specialization in telecommunication or audio engineering if they complete the required set of courses for each specialization. Some of these courses are, at times, required by the degree and some are to be taken by students as technical or open electives. Students may use elective and sometimes immersion courses to select from over 100 minors offered by the university. A minor requires the completion of at least 15 credit hours in a specialized area, at least nine of which are not required by the student's major.

4.2 Sequencing

For this paper, sequencing is measured in terms of the courses that are required by students as pre- and co-requisites. Since there is a very large number of general elective courses, sequencing here is measured only for the major-specific courses. Also, as the data used for this analysis included only documents that list topics within a course, the rationale for why pre-requisites were specified or for topic-sequencing within individual courses was not investigated. Table 3 lists the different courses that have a pre-requisite along with the pre-requisites. In addition, all laboratory courses are co-requisites with their theory counterparts, e.g., the Electrical Machines theory course has the Electrical Machines laboratory course as its co-requisite.

Table 3: Major-specific courses along with their pre-requisites

Course	***Pre-requisite***
Power Transmission	Signals and Systems including Lab
Co-op Education	Advanced Electronics; Microcontroller Systems; Career Orientation
Control Systems	Multivariate Calculus & Differential Equations; Microcontroller Systems (Introduction or Advanced)
Digital Signal Processing	Signal and Systems including Lab; Introduction to Statistics
Communication Electronics	Advanced Electronics
Electrical Machines including Lab	Circuits I including Lab
Signals and Systems including Lab	Circuits II including Lab; Multivariate Calculus & Differential Equations
Advanced Electronics	Introduction to Digital and Microcontroller System; Electronic Devices
Electronic Devices	Circuits I including Lab; Calculus
Microcontroller Systems	Computational Problem Solving; Introduction to Digital and Microcontroller System
Digital Systems Design	Introduction to Digital and Microcontroller System
Circuits II including Lab	Circuits I including Lab
Circuits I including Lab	Pre-calculus (from High School)

4.3 Pacing

For this paper, pacing is defined as the number of major-specific and non-major specific (i.e., general education courses and open electives) credits students need to complete in each academic semester. While a large number of electives allows students to build their own semester-wise schedule for their degree, the requirements of co-requisites and pre-requisites constrain this freedom. As a result, students are required to take some major-specific courses in each semester of their degree along with general education and elective credits. Table 4 presents the number of major-specific and non-major courses and credit hours that students need to complete each semester of the degree. Note that semesters are numbered 1 through 8, and the semesters when students are on co-op training are not counted. Additionally, students can elect to complete some courses during the summer terms.

Table 4: Major and non-major specific course and credit requirements

Semester No.	***Major-specific Courses***	***Major-specific Credits***	***Non-major specific Courses***	***Non-major specific Credits***
1	3	6	3	9
2	2	4	4	12
3	3	7	3	10
4	3	7	3	10
5	3	8	3	9
6	3	6	3	9
7	3	11	2	6
8	2	6	2	7

4.4 Evaluation criteria

Evaluative criteria refer to the ways in which the acquisition of knowledge is legitimized within a course. In other words, evaluation criteria refer to the ways in which students can demonstrate their learning.

Discipline-specific course outlines and syllabi were analyzed regarding specific course learning outcomes. This analysis revealed that students are required to demonstrate their learning through the following mechanisms:

- Describe the concepts and theories;
- Apply the concepts and theories to a given hypothetical situation (in the form of close-ended text-book problems or more open-ended projects);
- Analyze a given problem to develop or design a desired solution;
- Demonstrate the application concept and theories in a laboratory setting;
- Communicate the above outcomes, mostly in the written form but sometimes orally.

The modes through which student learning is assessed generally are a combination of examinations, project work culminating into reports and/or presentations, in- or out-of-class assignments, and laboratory demonstration. Except for instances where the syllabi noted dropping an assignment or two, or allowed students to complete work for extra-credit, little flexibility was afforded to students in terms of learning outcomes assessment.

5. Discussion

This paper analyzed an electrical engineering technology curriculum using concepts from Bernstein's idea of instructional discourse, namely selection, sequencing, pacing, and evaluation criteria. In terms of the selection of curricular content, one distinguishing feature of the plan of study is the amount of credit requirements designated as general education requirements. While the program specifies some general education courses as compulsory, students still have a large amount of freedom in selecting the courses they want to pursue, and these courses can be taken from a wide range of academic disciplines. This level of freedom relates to a weak framing of the curriculum [6]. While the framing for discipline-specific courses is strong, it still allows some autonomy to students. They can choose some discipline-specific courses in the form of technical and open electives. Additionally, they can choose one of the two specialization areas within the degree. In terms of choosing a degree path, a large number of electives and minors can allow students to explore diverse subject areas and develop a variety of skills. However, this flexibility can come at a cost of acquiring engineering competency that meets the industry needs [13].

The high number of general education credit requirements aligns with ABET Engineering Technology Accreditation Council's requirements, which assert that the discipline-specific content for engineering technology degrees must be "one-third of the total credit hours for the curriculum but no more than two-thirds of the total credit hours" [5, p. 9]. This high level of non-major components in the curriculum can allow students to develop a diverse worldview, although at the expense of acquiring core technical competency [13].

The curriculum demonstrates a high degree of sequencing in terms of pre- and co-requisites, thus indicating a strong framing. This sequencing is not surprising in an engineering discipline that draws heavily from math and natural sciences. These disciplines have what Bernstein refers to as vertical knowledge structures that "create very general propositions and theories, which integrate knowledge at lower levels" [6, p. 161]. This kind of knowledge structure leads to a pedagogic discourse that is "coherent, explicit and systematically principled structure, hierarchically organized" [6, p. 160].

In terms of pacing, the curriculum being studied demonstrates both a strong and a weak framing based on major-specific and general education requirements. As the major-specific courses are hierarchically linked with one another as pre- and co-requisites, students are expected to complete them at the suggested pace to finish their degrees in five years. However, the general education courses, as they represent a range of academic disciplines, allow students to reduce or increase their credit loads per semester to meet their learning needs. A strong framing in terms of sequencing and pacing of the discipline-specific courses can prevent students to pursue a plan of study that allows them the required time to reflect and make sense of how different discipline-specific courses and content relate to each other [16].

The evaluation criteria as noted in different syllabi and course outlines generally indicates a strong framing while very much aligning with the applied nature of the engineering technology degrees. Students are required to show competence in acquisition of course concepts through homework, exams, and assignments. They also learn how to apply these concepts through laboratory work and course projects. The focus on concepts vs. problems is an area of tension among engineering educators [24]. The ideal is probably to focus on a combination of both, as the curriculum being studied actualizes in practice. That said, the curricular practices being studied do not allow students significant flexibility except for some extra-credit work, which are not mandatory, and dropping of a few assessment points while calculating the final grade.

5.1 Conclusion and future work

Curriculum occupies a key place in the debate on technical education and has the potential to address many issues concerning developing future professionals [8]. This analysis was a first step in unearthing the transformative potential of the curriculum. Overall, the analysis indicates both strong and weak framing in different aspects of the curriculum being studied. The framing is relatively strong when it comes to choosing discipline-specific courses but weak when it comes to general education requirements. Along similar lines, in terms of the sequencing and pacing, the framing is strong for discipline-specific courses and weak for general education requirements. In terms of assessment of student learning, there is relatively strong framing with students having control in terms of only deciding whether to complete extra-credit work or skipping a few assignments if they are dropped from the final grade calculation.

This analysis primarily focuses on the "what" aspect of the curriculum under study. As curricular documents do not shed light into why certain decisions are made at the curricular and the course levels, the process through which this "what" comes into being remains a topic for further exploration. Some of the questions that are of key importance here include:

- How is major vs. general education requirement determined for a curriculum? Which stakeholders influence this process and how?
- How are the topics/courses that are taught as part of the major requirement determined?
- How is the pacing of the topics within a course determined?
- How intentionally are student growth, student success, and engineering identity development considered in the sequencing and pacing of engineering courses?
- How much do pedagogical strategies influence student success within a given sequencing and pacing?
- Why are the assessment criteria the way they are? How do they influence students' development as future professionals?
- How are assessment criteria used to understand and improve student success?
- How are institutional priorities, requirements from the state and the regulatory bodies, and instructors' idiosyncrasies balanced as disciplinary knowledge is delivered through a course offering?
- How does student autonomy related to course selection, sequencing, pacing, and assessment criteria influence student engagement and/or student success? What role do students' backgrounds play in shaping these aspects of their academic experiences?

This paper analyzed a single engineering technology curriculum at a single university while also highlighting the possibilities of Bernstein's conception of instructional discourse as a lens to compare individual programs or even categories of programs, such as engineering and engineering technology. The various elements of the curricula addressed in this paper (i.e., selection, sequencing, pacing, and evaluation criteria) allow us to juxtapose the theoretical and applied aspects of engineering-focused curricula. This juxtaposition can help engineering educators better understand the relationship between curriculum design and implementation and student learning and success.

Acknowledgements

The author would like to thank Dr. Mike Eastman for his support during the various phases of conducting this work, including but not limited to, reading the paper drafts at different stages and providing suggestions to improve it.

References

[1] National Academy of Engineers, "Engineering technology education in the United States," National Academies Press, Washington, DC, 2017.
[2] B. E. Seely, "The other re-engineering of engineering education, 1900-1965," *J. Eng. Educ.*, vol. 88, no. 3, p. 285, 1999.
[3] Engineering Technology Council, "ETC Bylaws," American Society for Engineering Education. [Online]. Available: https://www.asee.org/membership-and-communities/community/Councils/Engineering-Technology-Council
[4] ABET Engineering Accredition Commission, "2023-2024 Crietria for Accrediting Engineering Programs," 2022.
[5] ABET Engineering Technology Accredition Commission, "2023-2024 Crietria for Accrediting Engineering Technology Programs," 2022.
[6] B. Bernstein, *Pedagogy, symbolic control, and identity: Theory, research, critique*, vol. 5. Rowman & Littlefield, 2000.
[7] B. Bernstein, *Class, codes and control: The structuring of pedagogic discourse*, vol. 4. Routledge, 2003.
[8] L. H. Jamieson and J. R. Lohmann, "Innovation with impact: Creating a culture for scholarly and systematic innovation in engineering education," American Society of Engineering Educators, Washington DC, 2012.
[9] U. Clark, "Bernstein's theory of pedagogic discourse: Linguistics, educational policy and practice in the UK English/literacy classroom.," *Engl. Teach. Pract. Crit.*, vol. 4, no. 3, pp. 32–47, 2005.
[10] R. Wright and H. Froehlich, "Basil Bernstein's theory of the pedagogic device and formal music schooling: Putting the theory into practice," *Theory Pract.*, vol. 51, no. 3, pp. 212–220, 2012.
[11] P. Ashwin, "Analysing teaching-learning interactions in higher education," *Anal. Teach.-Learn. Interact. High. Educ.*, pp. 1–176, 2009.
[12] U. Hoadley, "Analysing pedagogy: the problem of framing," *J. Educ.*, vol. 40, no. 1, pp. 15–34, 2006.
[13] A. Agrawal, J. Carroll, M. Blackie, K. Rosewell, and N. Pitterson, "Impact of curricula on student learning: a comparison of six chemical engineering programmes in three Washington Accord countries," *South. J. Eng. Educ.*, vol. 3, no. 1, pp. 1–25, 2024.
[14] P. Singh, "Pedagogising knowledge: Bernstein's theory of the pedagogic device," *Br. J. Sociol. Educ.*, vol. 23, no. 4, pp. 571–582, 2002.
[15] National Society of Professional Engineers, "NSPE Code of Ethics for Engineers."

[16] L. Ulriksen, H. T. Holmegaard, and L. M. Madsen, “Making sense of curriculum—the transition into science and engineering university programmes,” *High. Educ.*, vol. 73, pp. 423–440, 2016.
[17] J. M. Case, “The historical evolution of engineering degrees: competing stakeholders, contestation over ideas, and coherence across national borders,” *Eur. J. Eng. Educ.*, vol. 42, no. 6, pp. 974–986, 2017, doi: https://doi.org/10.1080/03043797.2016.1238446.
[18] J. M. Case, D. M. Fraser, A. Kumar, and A. Itika, “The significance of context for curriculum development in engineering education: a case study across three African countries,” *Eur. J. Eng. Educ.*, vol. 41, no. 3, pp. 279–292, 2016, doi: https://doi.org/10.1080/03043797.2015.1056103.
[19] A. Agrawal, C. J. Groen, A. L. Hermundstad Nave, L. D. McNair, T. L. Martin, and M. C. Paretti, “Overriding tradition?: An initial exploration of the intersection of institutional and disciplinary cultures from the student perspective,” in *2018 ASEE Annual Conference & Exposition*, Salt Lake City, UT: ASEE Conferences, Jun. 2018.
[20] R. Murray, “The Capability Approach, Pedagogic Rights and Course Design: Developing Autonomy and Reflection through Student-Led, Individually Created Courses,” *J. Hum. Dev. Capab.*, pp. 1–20, 2023.
[21] E. A. Patall and J. Zambrano, “Facilitating student outcomes by supporting autonomy: Implications for practice and policy,” *Policy Insights Behav. Brain Sci.*, vol. 6, no. 2, pp. 115–122, 2019.
[22] A. Agrawal, J. Carroll, J. M. Case, and N. P. Pitterson, “A comparative study of curricular differences and their influence on students’ formation as engineers,” in *2020 ASEE Virtual Annual Conference Content Access*, 2020.
[23] P. Pausigere, “On Bernstein’s sociology of pedagogy and how it can inform the pedagogic realisation of poor and working-class children in South African primary maths education,” *Educ. Res. Soc. Change*, vol. 5, no. 1, pp. 41–53, 2016.
[24] D. H. Jonassen, “Engineers as problem solvers,” in *Cambridge handbook of engineering education research*, A. Johri and B. M. Olds, Eds., Cambridge, UK: Cambridge University Press, 2014, pp. 103–118.