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Work in Progress: Toward A Concept Inventory for Illuminating Engineering

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Abstract

Illuminating engineering is an interdisciplinary field taught within undergraduate and graduate architectural engineering programs, as well as in design, architecture, and technical universities and in professional certificate programs worldwide. This study presents progress toward developing an illuminating engineering concept inventory to measure student learning and to guide instructional improvement in foundational lighting courses. Concept inventories are validated instruments developed by discipline-based education researchers to assess student knowledge and misconceptions. The pilot illuminating engineering concept inventory drew from IES Lighting Library concepts and long-standing curriculum content in the University of Colorado Boulder's architectural engineering introductory lighting course. The test included fourteen multiple-choice and short-answer questions assessing student proficiency with the identified technical concepts. The instrument also included 22 Likert-scale questions to measure student attitudes such as awareness, self-confidence, and perceptions of the profession. During Spring 2025, second-year architectural engineering students enrolled in an introductory illumination course completed the pilot concept inventory at the start and end of the semester under IRB-approved human subjects research. Results show that students acquired accurate and working knowledge for half of the technical concepts and demonstrated significant positive shifts in awareness, self-efficacy, and self-confidence regarding illuminating engineering practice. Future work will refine the concept inventory and employ it for ongoing evaluation of active learning strategies in introductory illuminating engineering education.

Introduction

Illuminating engineering is part of a broader professional field often referred to as lighting. Lighting education appears in a variety of academic programs including architecture, interior design, theater, and product design. The focus of this paper is on ABET-accredited engineering programs, in which illuminating engineering is typically taught as part of architectural engineering degree programs, and sometimes as part of interdisciplinary or electrical engineering programs. In architectural engineering programs, illuminating engineering fundamentals courses serve as prerequisites for advanced technical and design electives and typically precede lighting internships.

In lighting, extensive resources exist to support professional practice and continuing education, including textbooks, handbooks, standards documents, and online education. While these resources provide comprehensive coverage of the technical and design aspects of the field, they do not typically offer a conceptual framework designed to guide undergraduate illuminating engineering curriculum development or instructional design. In particular, there is limited guidance for identifying core concepts, distinguishing them from topical issues or ancillary skills, or anticipating misconceptions that are a common part of student learning in the foundational engineering courses.

In engineering education, conceptual understanding is recognized as a critical foundation for learning [1]. Students who develop firm conceptual understanding are better able to transfer knowledge to new contexts, such as integrate prerequisite material into advanced coursework. In contrast, students who rely primarily on topical or procedural knowledge often struggle when problem features change or when problems require synthesis across multiple concepts [2]. As a result, insufficient conceptual understanding can limit both a student's academic progression and their longer-term development as an engineer. This is ever more important as the professional engineer's value shifts toward high-level judgment and verification of artificial intelligence outputs, tasks that are impossible without a robust conceptual understanding. Importantly for teachers of fundamentals courses, conceptual understanding has the potential to improve student attitudes and beliefs about engineering, increase student confidence, and increase retention in engineering.

This paper reports an initial phase of a longer-term effort to formalize core concepts in illuminating engineering and to develop and validate an associated concept inventory for use in undergraduate engineering education. It describes early ideas regarding illuminating engineering concepts, skills, and common misconceptions, and presents the results from a pilot study conducted within an undergraduate fundamentals course. This phase of the work is modeled in part on the scoping process used in the development of the Statics Concept Inventory as described by Steif [3], with adaptations to reflect the interdisciplinary and applied nature of illuminating engineering.

Background

Professional Practice of Lighting. Illuminating engineering practice requires the integration of knowledge of the physical principles of light with architectural design, human factors, and codes and standards to make design decisions in complex, real-world contexts. An example architectural lighting design problem that illustrates this breadth and integration of conceptual understanding is the design of a lighting system for a hospital patient room. In this scenario, the engineering design professional must consider complex visual tasks and visual comfort requirements for patients, health practitioners, and other hospital staff. They must consider the adaptation state and light-related physiological needs of people who might occupy the space; they must consider how light in the space renders skin tone and objects in the space such as medications. The engineering design professional must also consider the control sequence, energy use, cost, and maintainability of the lighting system. As an overarching problem constraint, a successful lighting solution must support the client and architect's goals for the building.

Solving this type of problem relies on conceptual understanding rather than design templates and rote calculation to verify code compliance. The design professional must reason about how light behaves in relationship to materials, how photometric quantities relate to human experience, and how to validate design ideas in relation to the expected lighting system performance. The final solution comes after iteration and collaboration with an interdisciplinary project team.

Illuminating Engineering Education. As the previous example design problem shows, lighting is a specialized and interdisciplinary field concerned with the generation, distribution, measurement and effects of light in the built environment. Professional societies play a critical role in defining and disseminating knowledge in lighting. Organizations such as the Illuminating Engineering Society (IES) and the International Commission on Illumination (CIE) publish standards, technical reports, and recommended practices that shape both practice and education. These documents form an essential reference base for the field, yet they are primarily oriented toward professional application rather than undergraduate learning.

This work is concerned with the specific lighting education pathways of illuminating engineering held within architectural engineering programs. Illuminating engineering is one of the many pathways into the professional practice of lighting that helps students develop the ability to problem-solve within complex systems, a skill that could be transferred to other engineering disciplines. An illuminating engineering course sequence typically includes a first course that teaches foundational concepts and a second course that teaches or reinforces the applied engineering design layer of professional practice. The core concepts taught in the first foundational illuminating engineering course share some similarities with those in Physics II in engineering curriculum. However, illuminating engineering fundamentals differ in important ways that include architectural design and human physiology context, and applied decision-making considering real-world complexity. An additional difference is the domain-specific terms and notations used in lighting. These differences suggest that illuminating engineering presents distinct conceptual challenges that would not be fully addressed by concept inventories or instructional models borrowed from adjacent disciplines.

Concept Inventories in Engineering Education. Concept inventories are instruments used to assess students' conceptual understanding and to identify common misconceptions. Well-known examples include inventories developed in physics [4] and statics [5]. These instruments provide models for the inventory development process, including concept and misconception identification, test question design, iterative testing, and validation. Inventories may be used for high-level program evaluation or course-level instructional design. The intended use should shape decisions about content, format, and interpretation of results [6]. In this work, a concept inventory is envisioned as a research-oriented instrument that can show patterns of student thinking and instructional emphasis, and support illuminating engineering fundamentals course reform.

Threshold Concepts in Engineering Education. Threshold concepts are ideas that are conceptually difficult, transformative once understood, and resistant to change, often requiring students to revise existing schema and mental models [7]. Threshold concepts are particularly relevant for foundational courses where students are expected to transition from novice to more expert-like reasoning [8]. In this work, a concept inventory of threshold concepts is envisioned as the means to ground course reform efforts in the most challenging but necessary concepts for students to learn.

Misconceptions in Engineering Education. Student misconceptions offer a starting point from which course activities can be designed to help students develop new schema and mental models needed to learn threshold concepts. A framework for misconceptions [9] has been used for heat transfer and thermodynamics [10], [11]. Types of misconceptions include false beliefs, flawed mental models, category mistakes, and missing schema. An additional misconception mapping proposed by Zhou et al. [12] is pre-instructional (naive) and sophisticated types, the latter type likely to persist at the end of a course. In this work, a developed concept inventory should be designed to reveal which misconceptions persist at the end of a course.

The following sections describe possible foundational threshold concepts and misconceptions in illuminating engineering and present a pilot concept inventory that informed a subsequent version.

Development of an Illuminating Engineering Concept Inventory

Threshold Concepts and Misconceptions in Illuminating Engineering. An initial framing of four possible threshold concepts relevant to illuminating engineering is provided below. These concepts are paired with a set of common misconceptions for each. The misconceptions include pre-instructional (as measured by a pre-course test) and sophisticated misconceptions (as measured by a mid- or post-course tests). Demonstration of understanding, accounting for both types of misconceptions, should be possible by the end of a course. The initial threshold concepts were derived from long-standing curriculum content of the University of Colorado Bouder (CU Boulder) architectural engineering introductory lighting course and the IES Lighting Library and Handbook concepts [13]. The possible threshold concepts and related misconceptions were further developed with input from expert instructors in the field of illuminating engineering.

<u>Concept 1. Radiant power can create biological, behavioral, and other effects including vision</u>

Misconception 1a: Spectral power distributions (SPDs) show a scale of effect, spatial distribution, or apparent color of the resulting light
Misconception 1b: An action spectrum is like an SPD
Misconception 1c: Luminous flux is the same as radiant flux
Misconception 1d: Effect is a measure of efficient use of radiant power

<u>Concept 2: Light can be modeled as a ray from a point, diverging in space</u>

Misconception 2a: Spatial extent is the same as planar angular extent
Misconception 2b: Luminous flux density has a linear or exponential relationship with distance and receiving surface position
Misconception 2c: Incident light can only be considered on receiving spherical surfaces

<u>Concept 3: Light interacts with materials in a way that amplifies or reduces light on other surfaces based on geometric relationships, and material and source properties</u>

Misconception 3a: Light on a surface is only from the direct contribution from the source
Misconception 3b: Light on a surface is <u>limited by the direct or directly reflected radiation</u>
Misconception 3c: Material property idealizations are binary and can be broadly applied

<u>Concept 4: Aspects of light in an environment can be characterized using physical and perceptual metrics</u>

Misconception 4a: A single metric can be used to fully characterize system behavior
Misconception 4b: All metrics can apply to any light and surface configuration
Misconception 4c: <u>Metrics are direct measures of physical or perceptual information</u>

Evidence for Misconceptions in Illuminating Engineering. Evidence for some of the identified misconceptions was revealed in a pilot concept test. The pilot concept test is described in more detail in the next section. One example misconception mapped to 1d above is shown below; two other examples are included in the Appendix.

Efficacy: Is same as (high) efficiency
Q: "Provide a non-lighting example of efficacy. Please explain your response."
A: "A non-lighting example of efficacy is baking a batch of cookies that is supposed to make 12 cookies and you end up making exactly 12 cookies." (Pre-course test)

Pilot Test Results

The following describes a pilot concept and attitudes test, and shows results that informed the previously presented concept and misconception framing as well as a subsequent version of the concept test. The results are presented to share the approach and lessons learned from the pilot with less emphasis on the student performance and course design implications.

The pilot concept inventory study was conducted in a required undergraduate course in an architectural engineering program. The course is typically taken in the second or third year of the curriculum and enrolls approximately 35-55 students per offering. Prerequisites for the course include Calculus III, Physics II, and a computer programming course. The course is a prerequisite for a second illumination engineering fundamentals course and for advanced technical electives in architectural lighting design, daylighting, lighting controls, and optical design. Historically, the course has been delivered primarily through lecture-based instruction, supplemented by problem sets, projects, and summative examinations. While overall course pass rates are high, course feedback and instructor observations suggest that some students complete the course without developing accurate understanding of some of the core illuminating engineering concepts. These observations motivated a course reform effort using a concept test to evaluate the course design changes.

The study was approved by the IRB at CU Boulder (protocol 24-0837) and involved pre- and post-course tests, with students receiving extra credit for participation. The pilot test included a mix of multiple-choice and written responses designed to test understanding of a range of course concepts and elicit ideas for student misconceptions. The pilot test also included questions on concepts and attitudes, with the latter intended for tracking over time whether performance on the concept proficiency part of the test correlates with attitudes and beliefs about awareness, self-efficacy, and self-confidence; identity and belonging; and perceptions of the nature of engineering.

Students were invited to take the test during the first and last weeks of the semester. The test was administered via Qualtrics and students completed the optional test outside of class time. There were 51 students enrolled in the Spring 2025 semester course; 12 students completed the pre-test and 11 students competed the post-test. However, only 2 of the students took both the pre- and post-test. In general, "higher performing" students took the pre-test (proactive) and "lower performing" students took the post test (reflecting a stronger need for extra credit). The test time averaged 25 minutes for the pre-test and 42 minutes for the post-test.

Performance on the concept questions was evaluated on a 0-2 point scale with 0 representing incorrect responses, 2 representing correct responses, and 1 representing a partially correct response, such as marking one of two correct answers on a multiple-choice question. The results of student performance on individual items from the pilot concept test are shown in Figure 1. Formal non-parametric statistical comparisons of the pre and post scores (appropriate for ordinal data) were conducted, and Table 1 summarizes these Mann-Whitney U test statistics, p values, and Cliff's delta effect sizes. Post-test scores were higher than the pre-test on 10 of 16 items.

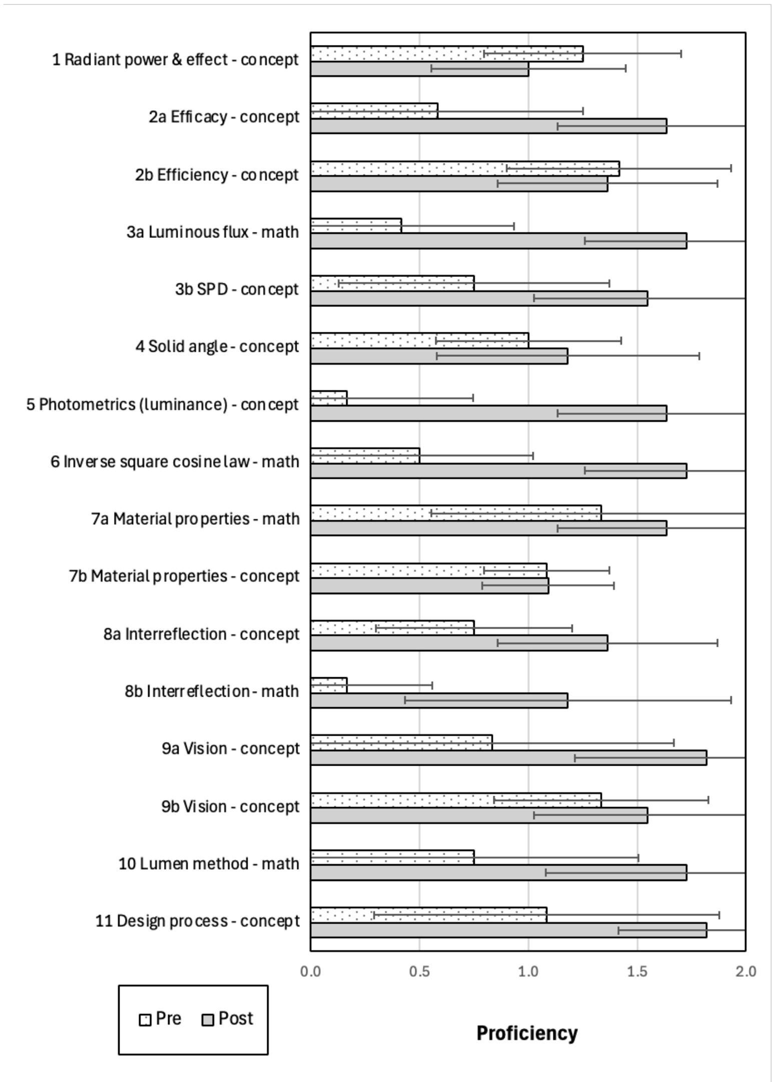

Figure 1. Mean proficiency scores (with standard deviation) on pre and post test

To inform subsequent versions of the concept test, an abbreviated item analysis was conducted. Item analysis typically involves calculating difficulty and discrimination indices to evaluate the quality of individual test questions. These values for the 16 test items are shown in Table 1.

The Difficulty Index indicates the proportion of students who answered an item correctly (only scores of 2 were counted as correct for this analysis). A Difficulty Index closer to 1 suggests an easier item, while a value closer to 0 indicates a more difficult item. Good difficulty values for multiple-choice questions range between 0.2 and 0.8 [6]. Six of the 16 items on the pre-test and 11 items on the post-test fell in this range.

The Discrimination Index measures how well an item differentiates between students with high overall test scores and those with low overall scores. Positive values indicate that higher-scoring students were more likely to answer correctly. Negative values suggest the opposite, implying that the item should be revisited in subsequent versions of the test. For effective discrimination, values should be above 0.2 [6]. Six of the 16 items on the pre-test and 14 of the 16 items on the post test fell into the range.

Table 1. Concept test pilot item analysis (bold notes large effect or values within preferred range)

Test Question (Associated Potential Misconception)	U, p, Δ ^	Difficulty Index		Discrimination Index	
		Pre-Test	Post-Test	Pre-Test	Post-Test
1 Radiant power & effect (1a)	51.0, 0.37, -0.23	**0.25**	0.09	**0.25**	**0.33**
2a Efficacy (1d)	**17, 0.003, -0.73**	0.08	**0.64**	0.00	**0.33**
2b Efficiency (1d)	63, 0.86, -0.05	**0.42**	**0.36**	**0.50**	**0.67**
3a Luminous flux (1c)	**7.5, <.001, -0.89**	0.00	**0.73**	0.00	**0.33**
3b SPD (1a)	**25.5, 0.014, -0.61**	0.08	**0.55**	**0.25**	**0.67**
4 Solid angle (2a)	55.0, 0.52, -0.17	0.08	**0.27**	0.00	**0.67**
5 Photometrics (4b)	**7.5, <.001, -0.89**	0.08	**0.64**	**0.25**	0.00
6 Inv. sq. cosine law (2b,2c)	**9.0, <.001, -0.86**	0.00	**0.73**	0.00	**0.33**
7a Material properties (3c)	53.0, 0.44, -0.20	**0.42**	**0.64**	-0.17	**0.33**
7b Material properties (3c)	65.5, 1, -0.01	0.08	0.09	-0.33	**0.33**
8a Interreflection (3a)	**31.5, 0.04, -0.52**	0.00	**0.36**	0.00	0.00
8b Interreflection (3a)	**19.0, 0.004, -0.71**	0.00	**0.36**	0.00	**0.33**
9a Vision (1b)	**24.5, 0.01, -0.63**	**0.25**	0.91	**0.25**	**0.33**
9b Vision (1b)	52.0, 0.41, -0.21	**0.33**	**0.55**	0.17	**0.33**
10 Lumen method (3a)	**23.0, 0.009, -0.65**	0.17	0.82	**0.50**	**0.67**
11 Design process (4a,4c)	**31.0, 0.034, -0.53**	**0.33**	0.82	0.17	**0.67**

^ $p < 0.05$ interpreted as statistically significant difference; Δ Cliff's delta [14][15] >0.47 large effect, medium 0.33, small 0.15, negligible <0.15; negative sign indicates post test > pre test

Considering both sets of item analysis, and placing emphasis on the post-test results, 7 of the 16 items should be revisited. In practice, all items were revisited for a subsequent version of the concept test to align with the outlined threshold concepts and misconceptions in this paper, and to shift all questions to multiple choice with three or four options and one correct answer.

Example test questions from the pilot version are given below. While these questions are not in ideal form per current test theory that would lead to the clearest interpretation of item results, these items do show useful characteristics such as requiring students to coordinate multiple concepts (Q3b), asking for a conceptual description instead of a numeric result (all), and targeting misconceptions (Q7 and Q11).

Q3b: "Explain the role of integration in the definition of luminous flux. Be clear but brief in your response."
Difficulty Index: Pre(0.08) and Post(0.55); Discrimination Index: Pre(0.25) and Post(0.67)

Q7a: "Select all options from the list below that are true about real architectural surfaces, considering reflectance (r), transmittance (t), and absorptance (a) of radiant power in the visible part of the electromagnetic spectrum: (1) r+t+a = 1 (2) r+t+a < 1 (3) r <= 1, t <=1, a <=1"

Difficulty Index: Pre(0.42) and Post(0.64); Discrimination Index: Pre(-0.17) and Post(0.33)

Q9b: "From the below plot, identify which curve best represents the relationship between the human experience of brightness of a source and the luminance of the source."
Difficulty Index: Pre(0.33) and Post(0.55); Discrimination Index: Pre(0.17) and Post(0.33)

Survey questions related to student attitudes were given after the concept items within the same Qualtrics survey. Responses were given on a 7-point Likert scale. The results from the pilot survey are shown in Figure 2.

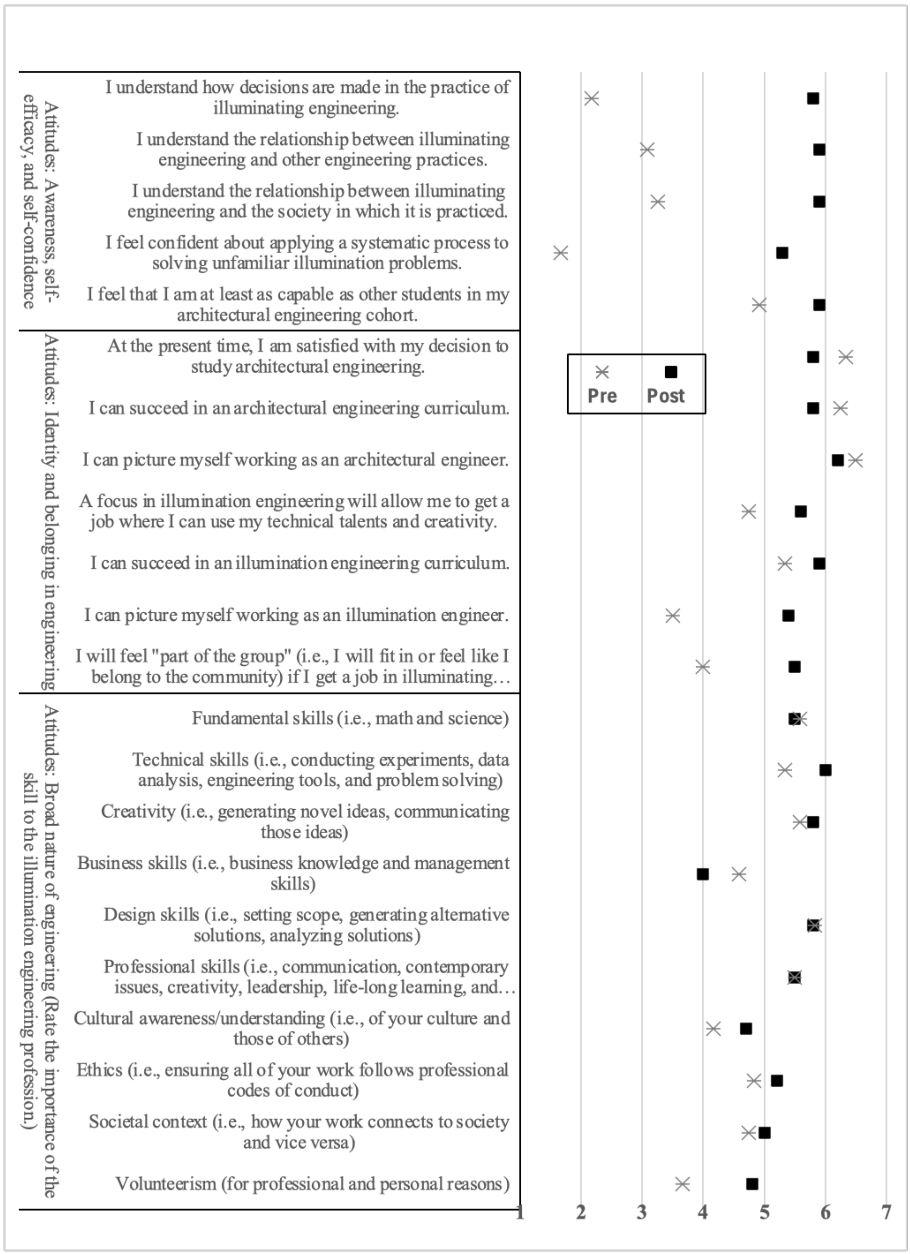

Figure 2. Attitude questions and mean pre and post responses

The attitude responses revealed interesting findings. The largest differences in the post- versus pre-survey averages were in the items "I understand how decisions are made in the practice of illumination engineering" (mean pre 2.1, post 5.4), "I feel confident about applying a systematic process to solving unfamiliar illumination engineering problems" (mean pre 1.9, post 4.9), and "I understand the relationship between illumination engineering and other engineering practices" (mean pre 2.9, post 5.5). There were also some changes in the extent students believed different skills were important to the illumination engineering profession, with stronger importance ratings on the post-survey for technical skills (pre 5.1, post 6.1), cultural awareness / understanding (pre 4.0, post 4.9), ethics (pre 4.6, post 5.4), and societal context (pre 4.5, post 5.2); the perceived importance of business skills was lower on the post survey (pre 4.3, post 3.9).

Discussion

This work represents an initial articulation of foundational threshold concepts and associated misconceptions in illuminating engineering. The proposed threshold concepts emphasize the ontology of light, its transport and material interactions, its modeling and idealizations, and the distinction between physical quantities and human experience.

This work also shares the early development of a concept inventory designed around illuminating engineering threshold concepts. The pilot concept inventory, while not generalizable results due in part to the small sample size, provided early evidence that the identified concepts capture challenging aspects of student learning in foundational illuminating engineering courses. Specifically, pre-test results showed limited conceptual understanding by incoming students across the items, and post-test results showed that instruction supported expert-like conceptual understanding for some students for different items. The data imply that misconceptions persist or instruction did not have a large effect on student outcomes across the semester for approximately half of the tested concepts. These results might be due in part to poor item design for the pilot concept inventory. For example, half of the items that did not show student growth also had either out-of-range difficulty indices or no change in discrimination index from the pre- to post-test, such as radiant power and effects, and interreflection. However, multiple items reveal concepts that warrant further attention in course reform efforts such as solid angle and material properties. Significant positive shifts in student proficiency are seen across the semester indicating that the time a topic is introduced relative to the post-test does not necessarily bias the results since all concepts are reinforced across the semester. Topics associated with project-based coursework versus problem sets map to large effects between the pre- and post-tests.

Overall, post-test results showed an increase in differentiation of student understanding, and a positive shift in student attitudes about illuminating engineering relative to the beginning of the semester. This investigation supports the idea that illuminating engineering concepts are distinct concepts within engineering curriculum and warrants concept-focused instructional design.

Next Steps

Future work will focus on refining the threshold concepts and related student misconceptions, revising and expanding concept inventory items, and exploring validation approaches consistent with established concept inventory development practices [6]. Future analysis will disaggregate data across demographic variables to assess potential differences in conceptual understanding and attitudinal shifts. Results will inform the iterative design of course activities and instruction aimed at supporting student conceptual understanding from diverse perspectives.

Conclusion

This work considers potential threshold concepts and associated misconceptions in illuminating engineering and explores the use of a concept inventory designed to target these concepts. Pilot results of the concept test suggest both areas of student growth and persistent conceptual challenges following a semester-long introductory course in lighting within an architectural engineering program. Although limited by small sample size and preliminary test item design, this study demonstrates the potential of a threshold concept inventory to assess student understanding and inform teaching practice in illuminating engineering. The work establishes a foundation for iterative course reform centered on the most challenging concepts required for developing expert-like understanding and sustained engagement in the field.

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Appendix

The following is an elaboration on foundational concepts and misconceptions, which are described briefly in the Development of an Illuminating Engineering Concept Inventory section of the paper.

<u>Concept 1. Radiant power can create chemical, biological, behavioral, and other effects including vision (light)</u>

Radiant power can be characterized using a spectral power distribution and an effect can be described using an action spectrum. The definition of light uses a specific action spectrum for human vision. Other action spectra can be used to characterize effects such as circadian rhythm entrainment or viral deactivation. The effect needs not to be the result of a direct physical interaction of radiant power; it can also be a downstream event. The concept of efficacy describes the effectiveness of the radiant power for the desired effect.

<u>Misconception 1a: Spectral power distributions (SPDs) show a scale of effect, spatial distribution, or apparent color of the resulting light</u>
It is assumed that a greater numeric value of frequency or wavelength indicates greater effect, often irrespective of electromagnetic radiation (EMR) range, applying the idea of EMR energy to effect. It is assumed that a smoother shape of an SPD implies more uniform spatial distribution or a white appearance of the resulting light.

<u>Misconception 1b: An action spectrum is like an SPD</u>
It is assumed that the action spectrum has physical meaning like an SPD. It is not realized the action spectrum describes the relative potential of an EMR source to produce an effect.

<u>Misconception 1c: Luminous flux is the same as radiant flux</u>
It is assumed that light is the radiant power in the visible part of the electromagnetic spectrum and/or a measured in radiant watts.

<u>Misconception 1d: Effect is a measure of efficient use of radiant power</u>

It is not realized that effect can take many forms and that magnitude of change relative to the radiant watts "in" is efficacy.

Concept 2: Light can be modeled as a ray from a point, diverging in space around the point

A light source, if small enough relative to other objects in a space or if divided appropriately, can be considered an infinitesimally small source emitting light into the spatial sphere around it. The ray of light diverges in proportion to the area of the sphere that grows concentrically around the point. The potential effect of radiant power is only relevant for the aspect of an area that aligns with the sphere and "faces" the point source.

Misconception 2a: Spatial extent is the same as planar angular extent
It is not visualized that spatial extent is a sphere around a point, which can also be considered the origin of an idealized point light source.

Misconception 2b: Luminous flux density has a linear relationship with distance and surface position It is assumed that falls off linearly with distance and/or is not dependent on orientation of the receiving surface. It is not realized that the incident flux on a surface falls off with the square of the distance away from the source and cosine of the orientation of the surface away from the source.

Misconception 2c: Incident light can only be considered on spherical surfaces
It is not realized that coordinate system transformation can allow for the prediction of flux incident on an arbitrary shaped surface in space.

Concept 3: Light interacts with materials in a way that amplifies or reduces light on other surfaces based on geometric relationships, and material and source properties

In a steady state system, the light incident on a surface will include the direct light from a source and the interreflected (multiple "bounces" of) light from other surfaces that "see" each other in a way that is proportional to the project geometry of surfaces and the amount of light reflected from the interacting surfaces. Surface geometry and material idealizations can make this modeling process viable for practitioners of illuminating engineering.

Misconception 3a: Light on a surface is only from the direct contribution from the source
The system of indirect sources, modified light, and interreflected light is not taken into consideration.

Misconception 3b: Light on a surface is limited by the direct or directly reflected radiation
It is assumed that the incident light on a surface cannot exceed the contribution directly from a source or from one reflection from a surface.

Misconception 3c: Material property idealizations are binary and can be broadly applied
It is assumed that a perfectly diffuse surface means that all light is reflected or transmitted, or that transmitted or reflected light disperses from the surface in a completely uniform manner.

Concept 4: Aspects of light in an environment can be characterized using physical and perceptual metrics

A particular frame of reference can be applied to a lighted scene to quantify light in space, interacting with surfaces, or interacting with physical or biological systems. Discipline-specific metrics such as luminous intensity, illuminance, exitance, and luminance allow for characterization of light in a way that matters for a specific analytical process or design question. Some metrics characterize light and space, light and materials, and some metrics characterize potential biological, psychological, or physiological effects of light at a plane of interest. Specific metrics and thresholds should be selected based on their usefulness for informing the results for a given illuminating engineering problem.

Misconception 4a: Using one metric to characterize light instantiates system behavior
It is not realized that calculation of one metric is a characterization but not a definition of the system, and that information can be used to inform a calculation of another, related metric of the physical or other effects of light.

Misconception 4b: All metrics can apply to any light and surface configuration
A prominent example includes applying luminance to a point source and applying ideas from other metrics such as assuming luminance decreases with distance.

Misconception 4c: Metrics are direct measures of physical or perceptual information
Examples include Correlated Color Temperature being interpreted as a measure of actual temperature of light and Color Rendering Index bring a measure of comprehensive color visibility.

Additional Evidence for Misconceptions in Illuminating Engineering.

Interreflection: Is different from direct flux transfer but only one "bounce" happens
Q: "Consider two adjacent, perpendicular surfaces such as a vertical wall and connected flat ceiling. The surfaces can be assumed to be finished with a typical white paint. The wall receives 200 lux of daylight (e.g., from a slot skylight). Select all options from the following list that are true statements about the lighted scene: (1) The ceiling has a non-zero illuminance. (2) The wall has an illuminance of 200 lux. (3) The wall has an illuminance greater than 200 lux. (4) The light distribution is uniform across the wall."
A: Approximately 50% of students marked option 2 but not option 3 as correct (pre- and post-course tests)

Inverse square and interreflection: Is same as (time-related diminishing and non-reciprocal) radioactive decay
Q: "Write, but do not solve, an equation for the final illuminance on the wall (as described in the previous question)."
A: "I do not know what the final illuminance may be given the fact that it would exponentially decay further from the source." (Pre-course test)