LAI 531 Curriculum Prospectus: Fundamentals of Logic, Reasoning, and Argumentation for Public Engagement of Science

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In a report by the American Academy of Arts and Sciences entitled "Perceptions of Science in America (AAAS, 2018)," it was suggested that additional research needs to be conducted, and it should expand upon the definition of science literacy in a manner that emphasizes the importance of understanding the scientific process and the ability to evaluate conflicting scientific evidence. Conflicting scientific evidence abounds, and there exists a plethora of examples in the media of both faulty reasoning and unfounded claims (Diethelm & McKee, 2009).

Despite all of the deficiencies in the Public Understanding of Science (PUS) on display in the media, the nature of the attitudes of the public toward science tends to be positive (AAAS, 2018). In addition, for example, research has demonstrated that although various levels of confidence in science do exist, the majority of people believe that the benefits of science outweigh any potential risks (AAAS, 2018). Moreover, the public thinks that the highest priority for science should be given to improving educational outcomes, reducing poverty, and finding cures for disease and illness (AAAS, 2018).

As admirable as the hopes for, and belief in, science may be, it is vital to understand that the publics' trust or confidence is a function of demographics and the particular issue in question (AAAS, 2018). In fact, not only are members of the public found to have different levels of confidence in science but if asked to explain their understanding of the term "science," one would discover that science means something different to each member (AAAS, 2018). That there exists no consensus concerning the understanding of science as an enterprise should not astonish the reader because the state in which we find ourselves is a logical consequence of the notion of a public that I argue may be responsible for the issues that everyone, including students, has to face.

Fractal Public and Its Logical Consequence

The dictionary defines "public" as people or community (OUP, 2018). Additionally, synonyms for the word public according to the same source include "citizens, subjects, the general public, electors, electorate, voters, taxpayers, ratepayers, residents, inhabitants, citizenry, population, populace, society, country, nation, and world" (OUP, 2018). If we are to accept the definition of the word public as true on authoritative grounds, then, according to the analysis of the synonyms, interpretation of the definition, and understanding of the word, what makes a public is a group of *people* who have *at least one thing in common*. With a clear understanding of the word public, we must consider the notion of logical consequence, as it pertains to such a notion as the public. Something that is said to be a logical consequence of another just in case it is impossible for the former to be true without the latter being the case (Barker-Plummer, Barwise, & Etchemendy, 2011). What concerns us now is how the lack of uniform agreement is a. logical consequence of the notion of public.

The primary issue is that it tends to be somewhat misleading when considering the stance on science and related issues while referring collectively to a group of *different* individuals as members of the *same* public. In addition, relying on this understanding of public as a starting point to refer to the people as such exposes the conceptually inherent flaw of internal inconsistency or self-contradiction. As a result of the contradiction, anything may be derived or proven, which is to be avoided at all costs. Therefore, to avoid such a logical contradiction, we ought to abandon the traditional notion of public and declare that there can be no singular public; there are only multiple publics (AAAS, 2018). Philosophically speaking, the notion of public that I hold would be best understood by referring to "myself watching this video of myself watching this video." As it so happens, similar to a fractal conceptually in which each abstract figure, pattern, or phenomenon comprises progressively smaller versions of itself (OUP, 2018), publics by definition must be made of smaller publics.

If I construct an argument to support the claim that there are many publics as mentioned and begin with the fact, there is a lack of consensus among the public, and then it may be more convincing to the reader. For example, borrowing just one potential scientific issue of contention among the public in which there may only be two possible positions for members comprising a public to adopt, either everyone agrees, or they do not. So, unless there was complete unanimity (i.e., 100% agreement), then the people could be designated according to the position they supported, which results in two groups. However, if each of the *groups* consisted of *people* who share a *common* position, then, according to the definition provided previously, each group would be considered its own *public*. In other words, we have discovered that the original public comprises two distinct publics. Continuing along this same line of reasoning would result in each public containing yet others, and so on.

The takeaway message from this thought experiment is that there exists more than one public. Furthermore, the existence of multiple publics is consistent with the reality of varying interpretations of science as well as confidence in science. Also, given the differences as mentioned above in confidence and meaning of science, it may be concluded that the relationship between them is one of cause-and-effect (Machi & McEvoy, 2016). In other words, it is not that levels of confidence in science cause various meanings of science; I argue that *the differing* *levels of confidence in science can be attributed to the different meanings that science has to different people.*

If there is to be any hope of society moving beyond behavior in the form of flawed reasoning, we must strive for, and engage in, rational discussion. And, if rational discussion requires there to exist a possibility to establish inference-warrants, then all parties involved in the engagement must be clear about the sort of problem or issue at hand (Toulmin, 2003). Such clarity concerning a particular problem may only be achieved if there can be improvements made in the Public Understanding of Science (PUS). Thus, the process of improving PUS must begin with a concerted effort to remediate the faulty reasoning and unsubstantiated claims that have become the norm.

Despite the legitimacy of science and overwhelming evidence supporting climate change and anthropogenic global warming (AGW), many of the American public remain either skeptical or in complete denial of its truth (Dunlap, 2013). The degree of skepticism is much higher in segments of the public on the lower end of SES and educational achievement concerning the purported benefits of science and research and the astounding rate at which technological advancement occurs (AAAS, 2018). Nevertheless, given that skepticism is a qualitative characteristic that is both native and necessary for science (Dunlap, 2013), in the face of existing evidence, complete denial is not.

That the public can remain in denial suggests a lack of appropriate knowledge, skill, and attitude for making judgments regarding such issues of scientific concern. Whether skeptical but willing to accept evidence, or skeptical and unwilling to accept any evidence, in order to legitimately claim improvements in the PUS have been accomplished, all members of the public ought to be equipped with basic scientific skills requisite for evaluating issues of concern. Thusly equipped with improvements concerning the PUS, there would genuinely exist a *competent* public comprised of informed individuals each of who are more likely to *participate* fulfilling the role of citizen scientists (Mejlgaard & Stares, 2009).

Public engagement with science (PES) refers to opportunities for mutual learning and growth that comes about when scientists and members of the public meaningfully and deliberately interact (AAAS, 2018). That notwithstanding, PUS is a prerequisite for PES. Therefore, to remediate the deficiencies in knowledge (i.e., PUS) concerning the basic principles of logic, reasoning, and argumentation necessary for participation in rational discussion (i.e., PES), I have designed a course curriculum addressing them. By availing the public of a seminar entitled "Fundamentals of Logic, Reasoning, and Argumentation for Public Engagement with Science (PES)," individuals who enroll and successfully complete my course will acquire the acumen, ability, and attitude that are essential to contributing to decision-making related to issues of scientific concern. It is through the acquisition of such essential tools that, not only will learners possess what is needed in order to evaluate issues of scientific interest, they will be capable of forming their own opinions and appropriately support their respective stances.

Student Factors: Potential Threats to Learning

Everyone at one time or another has had a learning experience, which consisted of them either mentally or physically doing things that led to changes in their knowledge, skills, or attitudes (Jones, Noyd, & Sagendorf, 2015). Regardless of the experience, many factors influenced the outcome of their learning efforts. The previous learning efforts may have been either positive or negative depending on the individual and how they perceived it. No matter how they may have been perceived, such outcomes that comprise the backgrounds and experiences related to learning, culture, family, self-esteem, and confidence, which provide the context within which learners exist. In addition, as a contextual framework within which learners live, background and experience also play a role in constructing or forming what they know, the attitudes they adopt, and any skills that they possess.

For any student learner, naïve conceptions, one's level of maturity, and his or her tendency to challenge authority are all products of their experience that may be categorized under knowledge, skills, and attitudes. Additionally, individuals of greater socioeconomic means may have more learning opportunities and exposures to learning than the less fortunate, which affords them chances to improve their attitude, correct knowledge deficiencies, or perfect a skill. Nonetheless, regardless student SES and despite the many potential factors that have the potential to detrimentally impact the learning outcomes, there is one key aspect of related to my course offering that I claim effectively neutralize most if not all the other potential student factors: *the elective nature of course enrollment*.

In an academic setting, professional enrichment program, or other formal environments in which registration for specific courses may be compulsory, among enrolled students there will exist factors that profoundly influence whether learning outcomes can be achieved. Nonetheless, the elective nature of enrollment in my course ensures that the students who ultimately enroll will be mature, motivated, interested, and confident. Moreover, the remaining factors such as socioeconomic status (SES) are also neutralized efficiently through the elimination of attendance costs thanks to both public and private funding obtained. Also, those attendees with little-to-no-science background coursework or who have previously performed poorly will accompany by inadequate basic science skills, which would understandably be expected to place them at a disadvantage in other courses. However, the need to acquire these skills will not impair their ability to succeed in my class because it was designed according to principles of a learner-centered curriculum (Jones, Noyd, & Sagendorf, 2015), which is self-contained so as to facilitate the process of learning to allow every student to accomplish the primary course goal by providing what they will need without relying on prior experiences.

Intentional and Unintentional Factors. Indeed, there can be no way to know with absolute certainty who shall attend my course. Nevertheless, I anticipate that, along with these students, there will exist various challenges that come with them as a result of both intentional factors and unintentional ones. Although many recognized challenges do exist, I feel it is necessary to distinguish between at least two varieties of a factor that will present as challenges due to their potential to affect students' ability to achieve an educational goal: Intentional and Unintentional Factors.

Unintentional factors I claim would be those circumstances, outcomes, or experiences over which students exert little to no control. An example of an unintentional factor would be having been raised in poverty or a low SES as a child, or suffering from a developmental disability. As opposed to unintentional ones as we have already mentioned, conversely, an intentional factor would be something over which one does have legitimate control yet he or she fails to exert it for whatever reason (e.g., obstinacy). It is crucial to understand that, in such cases, a factor at play need not result from the commission of an act in order to qualify as being intentional.

For instance, were a student to exhibit obstinacy related to a naïve conception held just discovered by him in class to be impossible, the student’s refusal to cooperate by responding with the obviously appropriate response (i.e., inaction) would be considered *intentional*. Now, unlike *unintentional* factors, such deliberate stubbornness by a student in class allows me to infer that a reason –or more accurately, an absence of reason– for such behavior exists. I would argue that the absence of reason would be related to a lack of *motivation, interest, or incentive.* In other words, if the student had the *motivation* to acknowledge the naïve conception was incorrect, *interest* in it being incorrect or determining what is correct, or i*ncentive* to come up with the correct response, then the intentional factor of stubbornness would cease to exist.

As a science educator, knowing that I would be unable to repair or replace any of the horrible experiences some students endured that may serve as unintentional factors (e.g., poverty, etc.) impeding both the efforts of students and myself would be disheartening. However, in the case of my course, since any student will either have intentional, unintentional, or both factors to contend with while learning in my course, fortunately, by virtue of there being no enrollment costs, registration being entirely voluntary, and made available on a first-come-first-served basis, not only will the majority of *unintentional* factors be directly and effectively neutralized (e.g., SES), but given the voluntary signup, each enrollee had to be already *motivated, interested*, and have the incentive to do so. In this fashion, my course offering also attempts to indirectly ensure that the potential for any remaining factors to be present –*intentional* or otherwise– is significantly reduced before the course even begins. While not guaranteed to eliminate all the potential challenges in the form of factors, efforts were put into all aspects of the course that are guaranteed to eliminate some factors. Upon their elimination, these student factors no longer threaten to detrimentally impact the material being taught or learned in the class.

Learning Goals

Learning goals may be understood as what students should be able to accomplish upon completing a course of study (Jones, Noyd, & Sagendorf, 2015). The visible result of completing my course would be that attendees will be capable of making their own independent assessment concerning scientific issues in society using logical reasoning and argumentation.

A Thorough understanding of science basics and an ability to employ logic, reasoning, and argumentation routinely to facilitate learning. Ultimately, successful students will find that education becomes a process of self-propagation. For instance, individuals claiming to know A, B, and C, for example, should be able to employ the skills that they have learned and, relying on them as premises, derive D; then, with A, B, C and D, conclude that E is the case. Possessing the ability to determine for themselves what justification –if any– there may be for believing something, whether that something is, in fact, true, and claiming to know that something is hugely empowering. Moreover, from this starting point, they may metacognitively engage themselves deducing from what is already known to add to their knowledge base as well as assess whether new claims are consistent with what is already known and why

General learning goals (GLGs) for the course include the following: 1) ability to make logical decisions relying on available evidence concerning scientific issues; 2) be capable of forming their own opinions regarding public policy and contribute to dialogue on critical issues in public discourse; 3) employ the acquired knowledge and skill to determine the best course of action with regard to their own behavior and of those for whom they are responsible including both relatives and the public.

Goal Descriptions

GLG 1 entails the use of logic, reasoning, and argumentation, for the purposes of increasing knowledge and aiding in decision-making according to a rational process that relies on available sources of evidence concerning particular scientific issues. GLGs 2 and 3 may be understood as giving students the tools needed to allow them to construct their own opinions regarding private (i.e., personal ethics) and public policy, thereby to equipping them with the ability to contribute to dialogue and discourse in the public forum. Of the GLGs, it is GLG 1 that serves as the primary learning goal for participants and is what guided curriculum design.

Summative Assessment

A summative assessment is used to evaluate the level of student comprehension and is given at the end of a course. Like the formative assessment, the summative assessment was aligned with the goal of the course. Aligning the summative assessment in such a fashion is akin to a method of validating that the course content, experiences, formative assessment, and proficiencies measure or reflect that students learned what they were supposed to learn. The summative assessment for my course is the following project:

> Given the available evidence regarding the phenomenon of global warming and climate change, conduct a review of the literature and choose 5 research papers claiming to support and 5 claiming to refute its occurrence. Then, analyze the evidence presented and using logic and reasoning, determine your stance on the issue and present an argument in support of it.

Learnings Proficiencies

In order to achieve the goals of this course, attendees must possess certain knowledge, skills, and attitudes (KSAs). Without these KSAs, students will be unable to move closer toward the ultimate learning goals of the course. Each step of the way students will acquire these KSAs to the point of proficiency so as to progress; Thus, since progression hinges on students' becoming proficient through "the acquisition of KSAs," the KSAs are referred to as Learning Proficiencies (Jones, Noyd, & Sagendorf, 2015).

Table 1 comprises the learning proficiencies (i.e., KSAs) for this course. The proficiencies in Table 1 have been categorized according to the Type by row and column, which allows for a coordinate designation to describe each one. For instance, the ability to recognize the basic structure of an argument comprising scientific evidence is located in row 2, column 2. The basis for the coordinate location system I decided upon is that an ability to recognize an argument requires knowledge of its general structure. Furthermore, though this proficiency may rely on knowledge that is derived from the cohesiveness of facts that yield concepts, it is neither factual nor itself a concept; I propose that *the proficiency may be conceived of as an ability that results from a thorough understanding of the concepts derived from the knowledge of isolated facts*.

Although it does a great job organizationally, Table 1 is descriptive. The descriptive elements in the table may be improved upon, in my opinion, by the adoption of an alternate framework. Instead of rightfully viewing learning proficiencies as merely being descriptive of the outcomes of a metaphoric "course goal equation," I wondered whether altering perspectives on either the goal, the equation itself, or both would lead to greater insights. Ultimately, it would be changing my perspective on the equation that made the most sense. By viewing each of the learning proficiencies as components of the overall goal equation that are individually necessary yet only sufficient together they have been transformed into what students ought to know, what they should be able to perform, and the attitude they should have to allow them to realize the outcomes of the course.

Table 1

Descriptive Learning Proficiencies for Fundamentals of Logic, Reasoning, & Argumentation

Type	Knowledge	Skills	Attitude
Principle	Participants will be able to recognize the basic structure of an argument that comprises scientific evidence.	Construct a basic scientific argument.	Students will be self-efficacious (i.e., believe in their own abilities).
Concept	Students will be able to distinguish between valid argument and invalid argument.	Critical thinking skills (e.g., critical reading, evaluation of evidence)	Students will be motivated to use logic, reasoning, and argumentation as a tool for self-education and decision-making
Concept	Identify characteristic parts of a given scientific argument.	Critique a scientific argument of others and evaluate for validity, soundness.	Students will be comfortable
Fact	Students will be able to define and describe the characteristics of an Argument, Its Premises, Its Assumptions, Its Conclusions, Validity, Soundness, Deduction Rules, Derivable Rules.	Metacognitive skills (e.g., monitoring their own progress) - critique their own scientific argument and evaluate for validity and soundness.	

Table 1. Proficiencies have been cross-tabulated by type only resulting from viewing them as descriptive.

Table 2

Descriptive Learning Proficiencies for Fundamentals of Logic, Reasoning, & Argumentation

Type	Beginner	Intermediate	Advanced
Attitude	Students will be motivated to use logic, reasoning, and argumentation	Students will be comfortable	Students will be self-efficacious (i.e., believe in their own abilities).
Knowledge	Participants will be able to recognize the basic structure of an argument that comprises scientific evidence.	Students will be able to distinguish between valid argument and invalid argument. Students will be able to identify parts of a scientific argument. Students will be able to define and describe An Argument, Its Premises, Its Assumptions, Its Conclusions, Validity, Soundness, Natural Deduction Rules of Logic, Derivable Rules of Basic System of Logic (System K)	
Skill	Students will be able to transcribe real-world scientific issues into the arguments that comprise them	Participants will be able to apply the basic rules of logic in the assessment of simple scientific arguments. Critical Thinking (e.g., critical reading, evaluation of evidence) - critique scientific arguments of others, evaluate them for validity and interpret the results.	Judge scientific arguments as evidence, determining any consequences and their impact, recommending courses of action to be taken based on the judgment, and suggest public policy concerning scientific issues. Metacognitive (e.g., monitoring their own progress) - critique their own scientific argument and evaluate for validity and soundness.

Table 3

Angelo & Cross' (1993) Classroom Assessment Techniques (CATs) That Will Be Among Those Implemented in the Assessment of Course-Related Knowledge, Skills, and Attitude.

Type	Beginner	Intermediate	Advanced
Attitude	Students will be motivated to use logic, reasoning, and argumentation	Students will be comfortable 39. Process Analysis: Students outline the process they take in completing a specified assignment.	31. Everyday Ethical Dilemma: Students respond to a case study that poses a discipline-related ethical dilemma
Knowledge	1. Background Knowledge Probe: short, simple questionnaires prepared by instructors for use at the beginning of a course or the start of new units or topics; can serve as a pretest; typically elicits more detailed information than CAT2.	2. Focused Listing: focuses students' attention on a single important term, name, or concept from a lesson or class session and directs students to list ideas related to the "focus."	3. Misconception or Preconception Check: focus is on uncovering prior knowledge or beliefs that hinder or block new learning; can be designed to uncover incorrect or incomplete knowledge, attitudes, or values
Skill (Analytic and Critical Thinking)	8. Categorizing Grid: student complete a grid containing 2 or 3 overarching concepts and a variety of related subordinate elements associated with the larger concepts	9. Defining Features Matrix: students categorize concepts according to the presence or absence of important defining features	10. Pro and Con Grid: students list pros/cons, costs/benefits, advantages/disadvantages of an issue, question or value of competing claims
Skill (Synthetic and Creative	13. One-Sentence Summary: students answer the questions "Who does what to whom, when, where, how, and why?" (WDWWWWHW) about a given topic and then creates a single informative, grammatical, and long summary sentence	15. Approximate Analogies: students complete the 2nd half of an analogy—a is to b as x is to y; described as approximate because rigor of formal logic is not required 16. Concept Maps: students draw or diagram the mental connections they make between a significant concept and other concepts they have learned	16. Concept Maps: students draw or diagram the mental connections they make between a significant concept and other concepts they have learned

Table 3. As found in the text by Angelo, T. A., & Cross, K. P. (1993). Classroom assessment techniques: A handbook for college teachers [Kindle 6].

The Curriculum Title and Its Target Audience

Fundamentals of Logic, Reasoning, and Argumentation for Public Engagement with Science (PES). The target audience includes adult students who are members of the public not considered scientists by profession.

Course Sequence and Description Of The Rationale For The Curriculum (Why It Is Needed, Your Approach To Educating Students Or The Public, Etc.)

The curriculum is necessary for multiple reasons that relate to understanding and engagement with science. For instance, interest in science is growing while scientific literacy is decreasing (Suleski & Ibaraki, 2010). Scientific literacy is required to understand as well as engage with science in any meaningful capacity. Moreover, with neither understanding nor engagement by the public (comprising yet other publics, which are themselves made up of still more publics), policy cannot be shaped by citizens it is meant to benefit. Furthermore, public policy concerning scientific issues can neither be said to truly benefit those who fail to understand nor participate in its establishment.

The Overall Goals And Specific Objectives You Expect Your Audience To Achieve After Completing The Curriculum

1. Participants will be able to recognize the basic structure of an argument that comprises scientific evidence (need to know parts, simple logic, etc.).

2. Students will be able to define and describe the characteristics of An Argument, Its Premises, Its Assumptions, Its Conclusions, Validity, Soundness, Natural Deduction Rules of Logic, Derivable Rules of Logic (System K).

3. Students will be comfortable in judging scientific arguments as evidence, determining any consequences and their impact, recommending courses of action to be taken based on the judgment, and suggest public policy concerning scientific issues.

Materials And Resources Needed To Implement The Curriculum;

James Garson; Modal Logic (2016)

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A Description Of Evaluation Activities To Be Conducted To Find Out If The Curriculum Goal And Objectives Are Met.

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