Teacher Refraction in a Hall Lined With Bottles of Añejo Tequila: Under the Influence of Wave-Like Vibrations
(or, The Importance of Being Earnest field instructors)
(or, De revolutionibus educatio)
(or, The Medium IS The Message)
(or, Refract, Refract, Refract: The Bohr-Snell Model for Teaching Teachers)
(or, On the Alleged Distinction Between Reflection and Refraction)
(or, Alchemic Refraction)
(or, Effective, Refractive Practice)
(or, In Search of Meaning)
(or, The Unbearable Lightness of Being a Teacher Teacher)
(or, Refraction Makes Practice)
(or, Divide and Conquer, Refract and Control)
(or, Our Final Paper for TE 921)

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“A complete elucidation of one and the same object may require diverse points of view which defy a unique description.”

- Neils Bohr (1934) quoted in Jammer (1974, p. 102)

Instrumental approaches to teacher preparation have been taking a beating recently in the U.S. Many ‘old school’ approaches to training teachers involving sink or swim immersion into classrooms have, through an apparent lack of consistency, fallen by the wayside. Furthermore, decreasing student scores on international comparison tests of math and science ability (e.g, TIMSS) have strengthened the arguments of opponents to teacher preparation. Recent media reports on the perceived ‘inefficiency’ of teacher preparation programs across the U.S have even engendered the rise of a vocal ‘anti-preparation’ movement, designed to block state and federal funding to Colleges of Education (COEs).

Our purpose in this paper is dual: (a) firstly, we would like to, as much as possible (in Neils Bohr’s words) ‘completely elucidate’ the current discourses surrounding teacher preparation, (b) secondly, we would like to go one step further and introduce new constructs that will illuminate the current research in this field. In order to do justice to our endeavor, we will be conducting a cross-disciplinary survey of concepts from diverse traditions of thought encapsulated in physics and post-modern studies. It must be kept in mind that our intention is not to indulge in an over-extensive debate on the conceptual foundations of the above-mentioned traditions of thought, but rather we aim to employ ideas from these traditions in order to better illustrate our thesis.

Who then is the ‘object’ of our study? Although this is a central question that will underpin our main thesis, in order to proceed, it is necessary to make certain assumptions. For our consideration, let the ‘object’ be denoted by ‘pre-service teacher.’ We are, thus, trying to observe (among other things) the behaviors, knowledge-requirements and dispositions of the pre-service teacher. In sum, what goes into the ‘making’ of a pre-service teacher?

It will be apparent to the perceptive reader that the process of ‘observing’ our thusly defined ‘object’ is almost immediately laden with a ‘performative’ contradiction: the impossibility of ‘observing’ a pre-service teacher without altering the characteristics of this ‘elusive’ being. In a sense, an objective observation may not be possible. In order to proceed, a familiarity with the central idea from Quantum physics will be helpful. Indeed, Heisenberg’s Uncertainty Principle, considered by many to be the fulcrum of Quantum physics, is central to our main argument in this paper.

“We can no longer speak of the behavior of the particle independently of the process of observation. As a final consequence, the natural laws formulated mathematically in quantum theory no longer deal with the elementary particles themselves but with our knowledge of them. Nor is it any longer possible to ask whether or not these particles exist in space and time objectively.” (Heisenberg, 1958, pp 15, 28-29)

Admittedly, Heisenberg’s Uncertainty Principle was originally restricted to elementary particles in the ‘micro’ world of sub-atomic space. Could this notion be applied in social sciences, specifically in teacher education? Recent generalizations and applications of Bell’s theorem (Greenberger, et al., 1989, 1990) to the ‘macro’ world (of tennis balls in that case and in our specific case, pre-service teachers), have given social scientists another useful way to look at
phenomena, which have until now been restricted to the ‘natural’ sciences. This recent generalization of Bell’s theorem has enormous implications for our purposes. The fact that observing a phenomenon in a particular time-space can \textit{simultaneously} affect another observation in a different time-space is phenomenal, yet under-explored, by social scientists.

What does all this mean for teacher preparation? Let us begin by applying the generalized version of Bell’s theorem. By the very act of ‘observing’ a pre-service teacher, we are changing phenomena surrounding other time-spaces related to teacher preparation, which apparently (due to the relatively large distances involved) do not seem to affect our observation. Where might these ‘other’ phenomena be affected, due to our observation? Although according to Bell’s theorem, the influence of one observation made in (say) a localized time-space can be felt as far as (say, again) the Andromeda galaxy, this is not useful for our consideration. Clearly, a sense of scale is required to contextualize our particular problem – considering a different time-space not as ‘extreme’ as the Andromeda galaxy, and yet \textit{relevant} to our consideration, is imperative. This ‘other,’ more localized space where the effects of our observation might be perceptibly felt is the space surrounding COEs. It is the simultaneity of dialogic observations that confounds the deterministic, Cartesian objectivity to which many COEs aspire. According to Britzman (1991):

“There is an attempt at insularity in the university and in the school of education, but such insularity is continually disturbed by the contradictory realities these institutions attempt to stabilize. As we have seen, problems arise when such complexity is ignored or deliberately suppressed. My argument is that significant change in the field of teacher education is dependent upon a simultaneity of changes in the larger culture. Yet at the same time, institutions of teacher education have the potential to arrange their programs in ways that can make a difference in the quality of the everyday lives of students and teachers.” (p.240)

Clearly, the standard \textit{ceteris paribus} model of examining teacher education and its effects upon the larger educational culture is inadequate. A model that allows for the recursive analysis of the dialogic in teacher education “allows us to move beyond the conversation itself to attend to the conditions of its production: the words we choose, the way we reinflect them with past and personal meanings, the style used to position meanings, and the mix of intentions that are inevitable when speakers interact” (Britzman, 1991, p.238).

This phenomenon has been analyzed by Tom Popkewitz in terms of an anachronistic (proto)type of chemistry, namely alchemy. In that analysis (see, especially \textit{Struggling for the Soul}), brilliant ivy-league educated young people are shown to be transformed into boring automatons through the influence of one summer of teacher education. This paper is offering a similar analysis using quantum physics rather than alchemy.

So how \textit{does} our observation of the pre-service teacher affect phenomena within COEs? In order to fully comprehend these effects, we need to digress and briefly explain the inner structure of COEs. To the uninitiated, these Colleges might appear to be chaotic, ‘formless’ globules of matter. A visitor from another College (or for that matter from another galaxy) might even be tempted to look upon these sites as ‘black holes.’ Future or formerly brilliant teachers (appositely, ‘stars’) seem to ‘collapse’ in the strong force-field of these institutions (ala Popkewitz) and seem to lose their ‘gravity’ (more appropriately, ‘gravitas’) in the process of churning out research articles. Nothing could be further from the truth, although some have argued that the Andromeda galaxy could, in fact, be further (See Lorentz et al., 1952). Clearly,
one would be dismissing these institutions and their constitutive ‘particles’ (i.e., teacher educators of all stripes) at great peril. Describing the essential ‘structure’ of these institutions is only one part of our analysis. The work of establishing the dialectic nature of our pair-wise observations (of the pre-service teacher and the subsequent, simultaneous effect felt in COEs) still remains, and constitutes a significant part of our analysis. Yet, we also must consider the confounding effects of our own observations—the resulting effects of which may not be known until after this descriptive analysis is complete. A mechanism for understanding the changes in pre-service teachers due to observation and instruction, therefore, must be suggested that will take into consideration both the internal nature of pre-service teachers, as well as the external forces acting upon them as members of the COE.

At a very fundamental level, the structure of COEs in the U.S. could be compared to the sub-atomic planetary system: At the center, analogous to the nucleus is the ‘core’ of the College, comprising the Chair, the Dean, various heads of departments, Team leaders and assorted ‘mainstays’ of the College. The nuclear-nature of this core should not be taken as an indication of the College’s interaction with the outside world, just as the nucleus of an atom does not determine its chemical properties alone—these properties are, in a large way, determined by the more accessible ‘outer layers.’ At the next ‘orbital’ level are the various professors and further removed from the core are the assistant and associate professors. At the periphery (the most loosely bound and highly reactive level) of this nuclear model are the students, those in the teacher preparation program and assorted graduate students. It is at this level, the outermost ‘orbit,’ that our present analysis will be centered. Although the work of establishing the overall shifts of consciousness due to observations made at any given ‘orbital’ level is extremely significant, it is an enormous enterprise and we will leave that to other researchers in this field, assuming of course that our present study is sufficiently illuminating and this direction of research is perceived as ‘useful.’

Having established our ‘domain’ to be this outermost ‘orbit,’ we would like to conduct a fine-grained analysis of the interactions that occur at this level. In a sense, we are ‘magnifying’ the events in this ‘domain’ through a high-powered ‘lens,’ one that will allow us to see these interactions more clearly. Upon ‘magnification,’ what do we observe at this level?

Among other events, we see one that stands out for our scrutiny more often than others. It is the interaction between the field instructors (in various COEs, this part of university supervision of the pre-service teacher is given different names, but we will call all such university supervision carried out on behalf of COEs as field instruction) and the intern teachers (also known as student teachers, pre-service teachers, etc.). This interaction ‘event’ occurs predominantly at the outer ‘orbital’ of our nuclear model—much like the chemical reactions in an atomic model—although, of course, the intern does interact with other ‘particles’ in other ‘orbits,’ such as assistant professors teaching 400/800 level courses in the College. As mentioned earlier, our analysis will exclusively concentrate on the interactions occurring at the outermost ‘orbital,’ without denying the existence or significance of inter-orbital interactions.

It is at this stage of our analysis that we will be taking recourse to certain constructs and concepts from physics (an area of interest and study for both the authors of this paper). Although the specific construct of physics (vectors) that we employ for our present study is elementary, a familiarity with it would be helpful before the reader continues. Many physical quantities, such as length, area, or volume, can be completely specified by a single real number. For example, one might say that the number of interns in a particular COE is 500. There is nothing else that we need to know or describe in order to fully understand this idea. Other quantities, such as directed
distances, velocities and forces, require for their complete specification both a magnitude and a
direction. The former are called scalar quantities and the latter are called vector quantities. It is
the latter construct (i.e., vectors) that will be useful for our analysis. It must also be kept in mind
that vectors can be geometrically represented by directed line segments (line segments with
arrowheads). This geometric sense of a vector is also pertinent to our study.

Let us now consider a ‘snapshot’ of the (apparently) chaotic events that occur at this
outer ‘orbital.’ Field instructors regularly visit interns who are teaching at various schools. Field
instructors are the ‘eyes and ears’ of the COEs, working on behalf of the Colleges, with a view to
‘instruct’ these interns and help them grow, pedagogically speaking. The field instructor, as
representative of the COE, is also aware of the non-natural state of the intern’s performance, but
must continue the ‘observation’ of the intern’s lesson, or be ‘emitted’ from the outer ‘orbital’ of
the COE. The intern, at the beginning of the internship period has a certain, non-trivial set of
assumptions and a particular disposition towards the practice of teaching, accumulated over
years of ‘observing’ other teachers (that have taught the intern when he or she was a student).
Lortie (1975) has described this as the ‘apprenticeship of observation.’ Although Lortie’s
construct has served researchers well, we believe that a further ‘elucidation’ of this idea is in
order. We propose to consider a dynamic dimension to Lortie’s static analysis. This non-trivial
set of assumptions and attitudes towards the practice of teaching is what gives the intern a
particular direction in his/her initial years as a pre-service teacher. Thus, the intern has a certain
pedagogical vector, at the beginning of the internship period. The magnitude of this vector is
moderated by all the subject matter knowledge that the intern has accumulated by taking (content
related) courses at the university, while also being influence by a host of other uncontrollable
factors. But, as is evident, it is not only the magnitude but also the direction of this quantity that
makes it a vector; hence these factors contribute to the overall ‘shape’ of the intern’s pedagogy.
This vector, in our analysis will be denoted by \( \vec{I} \).

In order to illuminate the wide variance in pedagogical vector directions, a comparison of
two different, yet entirely plausible examples is helpful. Imagine the cases of Becky and
Hakeem. Becky is a 20-year old elementary education major preparing to embark on her ‘student
teaching’ experience. She grew up and went to school in an area very similar to the environment
in which she will be interning – suburban, middle-class, and predominantly white – where her
mother was also an elementary teacher. Hakeem is a 35-year old secondary mathematics
education major completing a post-baccalaureate certification program at the same university,
and preparing to ‘student teach’ in the same district as Becky. He grew up and attended school
in a major metropolitan area that was culturally diverse, where he interacted with students and
teachers from a variety of backgrounds. After completing his undergraduate work at a different
institution, Hakeem spent several years working for a major software corporation as a computer
consultant, later deciding to pursue his interest in teaching after being ‘downsized.’ These two
individuals come into their teacher training with vastly different experiences, expectations and
beliefs about teaching – all of which contribute to and in large part direct their pedagogical
vectors, while also not being necessarily the result of any direct COE intervention.

Of course the COEs too have an associated pedagogical vector (denoted by \( \overline{TE} \)), one that
‘completely elucidates’ the direction and disposition of the COE under consideration. Every
COE has an underlying ethos, a non-trivial set of beliefs that guide the direction of research and
teacher preparation in that COE (though they may, in point of fact, be both widely varying and
hidden from the collective consciousness). At this stage it would be helpful to look at Figure 1,
in order to fully understand our mechanism for understanding the interactions between the intern, the field instructor and the COEs, and the associated pedagogical vectors.

In the geometrical representation of our model, several aspects require explanation. The shaded parallelogram represents the internal factors affecting the intern’s teaching; in the education literature, this space has been represented with constructs like identity, culture, autobiography, and self-conception. This will become important in the later discussion of the “refractive” nature of teaching. Below this lies the incident meaning – a cumulative reference to the larger meaning of the material to be taught prior to the alchemic transmogrification that takes place in the classroom (Popkewitz, 2002). Above the parallelogram is the ‘space’ (in practice) where teacher preparation tries to change the intern’s pedagogical vector; this space has been represented in the education literature with constructs like culture, society, discourse, and institution. In our model, this is a process of simple vector addition. It is important to recognize that this initial pedagogical vector of the intern may or may not be closely aligned to the TE vector (that is, the intern’s vector and the COE’s vector may or may not be parallel). In an extreme case, for any incident meaning vector, the ‘form’ of the intern’s initial pedagogical vector may be at ‘cross-purposes’ with that of the COE. In geometric terms, this would mean that the absolute value of $\theta$ is large (see Figure 1).

It is precisely in the avoidance of this outcome where the field instructor’s job lies. As per our model, the task of the field instructor is to create a suitable rectifying pedagogical vector (denoted by $\vec{FI}$) such that the addition of this vector with the original pedagogical vector of the intern ($\vec{I}$) results in a new vector, one that is more parallel to the TE vector. Thus, the job of the
field instructor is to reduce the intern’s $\theta$. It is to be clearly understood that the objective of this enterprise is to make $\theta$ approach 0, asymptotically. But, considering the limited period of time that field instructors spend with interns, it is not expected that a permanent change can be affected by the field instructor. In other words, although the field instructor can, upon suitable addition of his or her vector ($\vec{FI}$), temporarily rectify the intern vector ($\vec{I}$) in a direction that is more in accordance with the TE vector, this is, by definition, temporary. Yet, this is insufficient in that the whole point of teacher preparation is not to influence the pedagogical vector temporarily, but to create a more lasting, permanent effect. It is at this point where a more active and iterative model for learning to teach is required: again, a shift from static to dynamic modeling.

What do we mean by “the refractive nature of teaching,” and what sorts of iterations will be required for the transformation of student teacher into ‘teaching Teacher’? This requires some explanation, since these are new constructs, although they necessarily draw upon the work of researchers who have ‘moved on’ (either changed their research interest or are dead at this moment). Although the idea of ‘reflection’ and its historicity have been extremely useful, if not also problematic, in the field of Teacher Education (Fendler, 2003), an additional construct is required in order to further elucidate our thesis. This construct is needed since, according to us, ‘reflection’ does not address certain aspects of the process of becoming a Teacher. In optics, the idea of reflection assumes a “bouncing off” association between two things. A mirror (or any other reflecting surface) reflects a wave (perhaps of visible light), without changing $\alpha$, the ‘incident’ angle which is the same as the reflected angle (see Figure 2). This lack of change is worrisome when imported into the realm of teacher education.

The metaphor of ‘reflection’ as used in teacher education thus seems to suffer from this sense of ‘bouncing off without changing the incident angle’ quality of reflection. Thus, we believe that when speaking of the ‘reflection’ of an intern, in the discourse surrounding COEs, we are not doing justice to the necessarily changing, dynamic process of thinking about, and making meaning of, a “teaching incident.” We believe that an ‘educative experience’ (Dewey, 1938) has a strongly dynamic, protean nature, and this aspect of the experience is probably not completely captured by the word ‘reflection.’ ‘Refraction,’ on the other hand, has an active and vibrant—dynamic—quality associated with it – requiring an interaction and conveyance. Where reflection implies that the original wave is halted in its path and ejected from a boundary, or reflecting surface, refraction allows for the active alteration of the incident wave. When a wave passes from one medium to another, it ‘refracts,’ indicating a change in its original path (direction and/or speed). And in the ‘educative experience’ case too, we believe, the ‘experiencer’ makes active meaning of the experience. The ‘experiencer’ thus participates in the making of the meaning, by altering or changing his or her direction of thought (closely related to the direction of the pedagogical vector).
As Biesta (2002) points out, in employing the cybernetic model of ‘meaning making,’ it is the participation by the ‘experiencer’ (in that case the child on top of a traffic light, in our case the intern) that truly determines whether the meaning that the ‘sender’ sends is identical to the meaning made by the ‘receiver.’ Though one could easily argue for an active variant, the term ‘reflection’ has a passive, quiescent quality to it, while the metaphor of ‘refraction’ has an active, protean connotation. This is not the only reason we feel that ‘refraction’ is more appropriate than ‘reflection.’ The perceptive reader would have surmised that constant ‘reflection’ by the intern does not change his/her $\theta$ (see Figure 1), unless of course we employ the more sophisticated construct of ‘total internal reflection’ – which, itself, is easily explained within the model of refraction. Moreover, this latter construct might seem to have an active, protean connotation, yet it lacks any ‘output.’ In other words, this special type of ‘reflection’ remains ‘internal’ to the intern, and does not therefore influence the intern’s pedagogical vector in any significant way. And it must be clear by now (to the perceptive reader, of course) that we are interested in the overall change in the ‘output,’ or in our terms, the change in the intern’s pedagogical vector, and not interested in any reflection that does not have measurable influence upon his/her teaching.

Having established the usefulness of our new construct, we still need to look more closely at the ‘medium’ of refraction (see Figure 1) for the intern. What role does this ‘refractive medium’ play in the pedagogical growth of the intern? Is this ‘refractive medium’ a static and unalterable thing? We believe that after every ‘intervention’ by the field instructor, done in order to influence the pedagogical vector of the intern, the intern then may “fold back” (Pirie & Kieren, 1992) and make alterations within his or her refractive medium. Thus, in a sense, the job of the field instructor is not only to temporarily influence the pedagogical vector of the intern (through the suitable rectifications of the field instructor’s own vector, $\overline{FI}$), but to indirectly change the refractive index of the intern’s medium itself, since, quite typically, the refractive index of the intern’s medium is not close to the ‘ideal’ state (that which would yield $\theta \approx 0$). In order to go on, we need to define the refractive index of the intern’s medium.

$$\rho = \frac{\text{Subject}}{\text{Time – Space}}$$

Here, the refractive index, $\rho$, is defined as the ratio of ‘subject matter input’ over the ‘time-space output’ of the intern. All the content courses taken by the intern and all his or her subject matter knowledge is collapsed into ‘subject matter input,’ while the ability to transform this subject matter knowledge into appropriate pedagogical techniques is collapsed into ‘time-space output.’ In other words, this is the ratio of the intern’s content knowledge (CK) over his or her pedagogical knowledge (PK). For our purposes, $\rho_{\text{expert}} = 1$, and we assume that the ‘experts’ in the COE have a ratio that is close to that ideal value. The intern (or novice), typically has an index value that is either very small ($\rho_{\text{novice}} << 1$) or very large ($\rho_{\text{novice}} >> 1$). In the imaginary cases of Becky and Hakeem, their CKs are obviously different with respect to their relative content knowledge experience. Furthermore, their PKs have been shaped by the vicissitudes of time and the varying curvatures of space. Therefore the values of their respective refractive indices are vastly different – neither of which are necessarily closer to unity. On a first glance, it may appear that this model ignores the mutual relationship between learning and teaching. As one learns to transform subject matter into appropriate pedagogical techniques, one might argue that subject matter knowledge is actually enhanced. Yet, at this time, we are unsure whether it is enhanced in the same dimension as the original knowledge; this depends on how one defines subject matter and knowledge.
Going back to an earlier thread of thought, one can now see how the interaction between the field instructor and the intern has this ‘dual’ nature: (a) to change the pedagogical vector of the intern in the short term, and (b) to influence the refractive index of the intern’s medium in the long term. Although (a) takes place in the ‘moment,’ so to speak, (b) requires repeated iterations on the part of the intern and the field instructor. Also, considering the fact that once the intern has gone through the internship period, and then will be left alone, so to speak, in the ‘real’ world of teaching, without the continued support of a field instructor to change his or her pedagogical vector, it becomes imperative to institute a *permanent* change in the intern’s way of thinking. This, as we have seen, can be done through suitable modifications to the intern’s refractive index. What is the purpose of changing the intern’s refractive index with a view to permanently influencing his or her pedagogical vector? What is to be gained from this enterprise? Figure 3 will shed some light on the overall objective.

Here we see the two ‘streams’ of consciousness – the COE stream and the Schooling stream. Each ‘stream’ is essentially a ‘bundle’ of pedagogical vectors. The COE stream is moving in the direction of school ‘reform,’ while the Schooling stream moves in another direction, influenced by policy makers and society, in general. As can be gleaned from a quick perusal, these two streams seem to be moving at cross-purposes, as is the case in the ‘real’ world. The objective of school reform, in our terms, is to influence the direction of every pedagogical vector in the Schooling stream. This is certainly one way in which COEs can significantly ‘reform’ or at any rate change the direction of this stream. The hope is that when a critical mass
of vectors has been suitably aligned with the goals and general ‘direction’ of the COE stream, then the Schooling stream itself will develop sufficient impetus to completely change its course. Thus, in our view, school reform is akin to changing the course of a river. This is not to downplay the overwhelming difficulty of this endeavor, but to situate our model within a larger context. Further vector analysis within this ‘field’ is required and surely remains the goal of these authors.

Having elucidated, as far as possible, the inner working and structure of COEs, we now need to look at issues that threaten the proper implementation of the work of COEs. In other words, at our level of analysis, what can go wrong in the interaction between the field instructor and intern? In order to better explain this, we need to look at the pedagogical vectors of the field instructor and the intern.

As is clear from Figure 1, \( \overline{TE} \approx \overline{I} + \overline{FI} \). If we perform a simple rotational axis conversion to simplify matters, then \( \overline{I} = k\hat{i} \) – the intern’s pedagogical vector is taken to be parallel to the x-axis. Therefore, \( \overline{FI} = b_1\hat{i} + b_2\hat{j} \), which implies that some component of the field instructor’s task is in a parallel direction with that of the intern, while some rectifying component is needed (in the y-direction) in order to align the intern with \( \overline{TE} \). This process, though external to the intern, is undertaken with a mind toward providing substantive grist for the mill. The intern is able to, with the help of the field instructor’s y-component, recognize the required alterations and determine a suitable course for the adjustment of their density (either through the increase of his or her CK and/or PK). It is important to note that only increases in the CK and PK are implied by external factors (field instruction) – any other imposed alterations (decreases) can easily be perceived as ‘domination’ (Foucault, 1989/1996), or more appropriately, diminution of the intern. Furthermore, the field instructor’s pedagogical vector must be such that the component of \( \overline{FI} \) in the direction of the intern’s vector (the post-rotation x-direction) must be non-negative \( (b_1 \geq 0) \). This restriction of the field instructor’s practice (in vector terms, restrictions on \( \overline{FI} \)) is required to limit the opposition to the intern’s own vector. If this restriction is not kept in mind by the field instructor, then there is a significant chance of an alternative form of ‘domination’ occurring – one in which the intern’s pedagogical vector is decreased in magnitude, regardless of direction. In a manner of speaking, the field instructor must only add to the intern’s magnitude—never subtract.

Thus, although ‘relations of power’ necessarily exist between interns and field instructors, the above restriction on the value of \( b_1 \) is a measure to prevent ‘domination’ and abuse by the field instructor. In practical terms, if the field instructor discerns any ‘resistance’ from the intern, it would be wise to check the \( b_1 \) value of the field instructor’s pedagogical vector and increase it so that it attains a more positive value. In the absence of a clearly defined measure of ‘resistance,’ field instructors would be well advised to periodically check the emotional state of the intern – aberrations in which are often a clear signal indicating a maladjusted pedagogical vector. In this paper we have not looked at the other forms of ‘domination’ and ‘resistance,’ those that might occur between field instructors and COEs, or even between interns and COEs. This is left, at least partially, as an exercise for the discerning reader.

The act of teacher education is therefore nothing more (or less) than the alteration of an individual’s density so as to make it parallel to that of the sponsoring COE or educator. In this sense, it can be said: \( \lim_{{n \to \infty}} I = \overline{TE} \), where \( n \) stands for the number of refractive ‘cycles’ that the intern completes (including the alteration of their density). This is the ideal state in which teacher
education seeks to position itself – as the prime mover of the destiny (note: not density) of schooling.

For the COEs, the ‘game’ of TE is to encourage the alteration of density. This particular ‘game of truth’ involves the production of truth through the ‘rules’ set up by COEs – to the likely exclusion of other truths generated by the larger Schooling stream of consciousness (Foucault, 1989/1996). Power relations between COEs and this larger Schooling stream do not encompass the entirety of the truth game, but are representative of the connections between them. Interns, finding themselves positioned firmly between these two worlds, are required to negotiate such power relations in their attempts to satisfy the rules of multiple truth games. Our model allows for a geometric representation, and thus more complete elucidation, of the competing rule sets confronting the intern. Further study and research is required to determine the dialectic relation between these sets, and will hopefully yield a more global understanding of the relationship between the intern’s refractive medium and its shaping by (and of) the sometimes orthogonal truth games played within the COE and Schooling streams of consciousness, respectively.

One method by which the COEs could encourage this dialogic is in the alteration of the symbolic nomenclature associated with teacher education. While ‘teacher’ is one word, ‘teacher educator’ is two – thus imposing an unequal hegemoniacal relationship between the two. In order to reduce this linguistically-inspired tension, we suggest a more equitable nomenclature. Teachers teaching students in a K-12 environment or school may be referred to as ‘teaching teachers,’ while teachers teaching teachers to teach students in a K-12 environment or school may be referred to as ‘teacher teachers.’ In effect, we seek to teach teachers who teach teaching teachers teaching in K-12 schools or environments to be increasingly mindful of their use of appellations.

Perhaps one issue that the discerning reader might take with our overall thesis is the very definition of the refractive index of the intern’s (internal) medium. A slight digression into certain post-modern ideas will prove illuminating.

Is E = Mc² a sexed equation? Perhaps it is. Let us make the hypothesis that it is insofar as it privileges the speed of light over other speeds that are vitally necessary to us. What seems to me to indicate the possibly sexed nature of the equation is not directly its uses by nuclear weapons, rather it is having privileged what goes the fastest… (Irigaray, 1987, p. 110)

At other times, Irigaray has complained of the privileging of solid mechanics over fluid mechanics in physics research funding. Hayles (1992) has done a wonderful job of simplifying Irigaray’s main idea.

Although men, too, flow on occasion - when semen is emitted, for example - this aspect of their sexuality is not emphasized. It is the rigidity of the male organ that counts, not its complicity in fluid flow. (Hayles, 1992, p.17)

The post-modern psychoanalyst Jacques Lacan has also illuminated the above privileging.

...Thus the erectile organ comes to symbolize the place of jouissance, not in itself, or even in the form of an image, but as a part lacking in the desired image: that is why it is equivalent to the $\sqrt{-1}$ of the signification produced above, of the jouissance that it
restores by the coefficient of its statement to the function of lack of signifier (-1)... (Lacan, 1977b, pp. 318-320)

This seems to suggest that our definition is a sexed ratio – with the subject dominating the time-space.

The ‘top’ of our density definition is the content knowledge of the intern (CK), clearly identifiable with a ‘solid’ subject structure. At the ‘bottom,’ and being dominated by the ‘top’ is the pedagogical knowledge of the intern (PK). The CK is identifiable with a ‘solid’ structure since it is clearly above PK and thus has a ‘base’ on which to support itself while PK signifies an engagement in discourse, and thus has a ‘fluid’ connotation. Thus, our ratio as it stands, seems to privilege the traditional, status quo-ist ‘missionary’ sexual position with the erect ‘male’ on top. But that is a misunderstanding of the word ‘ratio.’ Every ratio has a numerator which is on the ‘top’ and it ‘dominates’ the denominator, at the ‘bottom’. One way out of this dilemma would be to convert the ratio into a decimal. So, for example a ratio of 4/5 could be written as 0.8. In this way, the ‘hegemony’ of the numerator would cede (but not seed) and thus we would have a representational ‘equality’ between the ‘solid’ and ‘fluid,’ or ‘male’ and ‘female’ components of our definition. Hence, any doubt of this being a sexed equation is thusly removed.

Having established the ‘asexual’ nature of our definition is not enough – we still need to determine exactly how this ratio can be influenced by the interaction between the field instructor and intern. Indeed, how can the interaction between the field instructor and the intern alter this ratio in a manner that is appropriate to the need of the hour? An illustrative example will explain our idea better. Suppose a particular intern has a ‘low’ refractive index (density). This would imply that the intern’s CK is much smaller than his or her PK. It is thus possible that the intern does not have a strong grasp of the fundamental subject matter and yet has the ‘gift of the gab’ that allows this intern to speak interminably when in a classroom. Once the field instructor realizes this fact, it is imperative that the intern is led toward taking more content-related courses or in some way to make up for this shortfall. Of course another way to increase the intern’s refractive index would be to decrease his or her PK while not altering the CK. But, as per the previous vector analysis, this is dangerous and in many essential ways would constitute an ‘abuse of power’ tantamount to domination. Thus, the overarching principle for the field instructor is: Never reduce or resist (negate the x-component of) the intern in any way. To be clear, any decrease in CK or PK that is externally imposed by the field instructor (in conjugation with the COEs), is abusive – congruent to the ‘forced reflection’ that is common within some COE courses. It is only when this diminution is internalized, through the process of refraction-in-action in teaching practice, that it is conducive to the pedagogical growth of the intern. This is not to say that indoctrination should be the aim of COE courses, but it does imply that resistance to the COE vector can be minimized by allowing space.

In the words of James Field and Margaret Latta, “the task for teacher education then becomes one of creating spaces… to be open to experience” (2001, p.894). To be receptive to new experiences is the hallmark of a cyclically ‘refracting’ individual. In Socratic terms, an un-refracted life is not worth living! Just as the very fact that the reader of this article has come so far is mute testimony to the reader’s willingness to engage their own ‘density,’ in a similar vein, COEs, including all its constitutive ‘particles’ need to be open to diverse, density-altering experiences. Creating new constructs such as we have endeavored to do in this piece is always fraught with the possibility of ridicule. Using the metaphor of ‘light’, we suggest a transformative ‘lightness’ in the discourses surrounding education, in general. Refraction instead
of reflection might seem facetious at best, but we believe otherwise. Like unbridled love for teaching, refraction might be a construct that dare not speak its name, while also being the gift that cannot be refused.
List of Works Cited


