



UNDERSTANDING AND IMPROVING THE DOCTORAL ADVISOR-ADVISEE RELATIONSHIP IN LABORATORY SCIENCES USING THE POWER-DEPENDENCE THEORY

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ABSTRACT

Aim/Purpose	The aim of this paper is to offer a theory-based model to investigate the power differential in the Ph.D. advisor-advisee relationship in laboratory-based sciences in the United States (U.S.) and to use it to shed light on the pertinent dependence and power dynamics in this relationship.
Background	Unsuccessful outcomes of Ph.D. students, such as attrition, low completion rates, prolonged time-to-degree, and challenges to well-being, remain significant concerns, including within the field of laboratory sciences. The advisor-advisee relationship, which is central to the 'apprenticeship' model of doctoral training, underlies the success of the advisee, the advisor, the graduate education system, and the associated research enterprise. However, challenges faced by doctoral students in this relationship, due to the high dependence on and the advisor's high power, impede these outcomes. These challenges are exacerbated by special circumstances in the doctoral process in laboratory sciences. Analyzing dependence circumstances and the associated power situation in a systematic, theory-based study is valuable for understanding and improving this relationship and its outcomes in the laboratory sciences.
Methodology	A systematic analytic model to study the power-dependence dynamics in the doctoral advisor-advisee relationship in laboratory sciences is developed based on the theoretical framework of Power-Dependence theory by Emerson (1962). Potential root causes and methods to mitigate the dependence-based power imbalance in this relationship are highlighted through informed discourse and maneuvering the power-balancing operations of the Power-Dependence framework.
Contribution	A model is provided to analyze and enhance the advisor-advisee relationship in laboratory sciences using the Power-Dependence theory. Valuable insights into

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the power dynamics and dependence in this relationship, as well as potential methods for improvement, are discussed. The Power-Dependence theory is applied here for the first time in an academic advisory setting or a laboratory supervisory relationship. The developed model provides a basis for dependence-based power analysis in empirical field studies.

Impact on Society	The analytic model derived and the insights gained are valuable for improving the doctoral advisor-advisee relationship in laboratory sciences, enhancing their productivity, supporting advisee well-being, and catalyzing scientific advancement.
Future Research	Applying the model developed in this study, analytical research drawing on Power-Dependence theory can be extended to empirical field studies to understand the power dynamics in this relationship. Analytical studies can also be conducted on different variables, including the stages of the doctoral degree, the circumstances of the advisor and advisee, and the demographic and socio-economic categories of the actors.
Keywords	dependence, power, doctoral advisor and advisee relationship, STEM, laboratory sciences, Emerson (1962), Power-Dependence Theory

INTRODUCTION

DOCTORAL EDUCATION IN STEM AND LABORATORY SCIENCES

Over 60% of the Doctor of Philosophy (Ph.D.) research doctoral degrees in the United States (U.S.) are awarded in the Science, Technology, Engineering, and Mathematics (STEM) fields (National Center for Science and Engineering Statistics, 2026). Among them, scientific laboratory-based research is a prominent mode of Ph.D. education in the natural sciences, including life sciences (e.g., molecular biology, biomedical sciences, microbiology) and physical sciences (e.g., chemistry, physics), as well as related scientific fields such as pharmaceutical sciences, food sciences, and engineering. Other scientific disciplines with abundant ‘field research’, such as environmental, agricultural, and earth sciences, also have subdisciplines or research areas that are predominantly laboratory-based. The Ph.D. student workforce and their future research contributions in laboratory-based STEM disciplines (henceforth referred to as ‘laboratory sciences’) are drivers of scientific discovery, advancement, and innovation (National Research Council, 2011). Supporting these needs in a growing knowledge economy, the production of Ph.D. (henceforth also referred to as ‘doctoral’ or ‘doctorate’) degrees has steadily increased in the U.S., including in STEM fields. For example, the average number of doctorates awarded annually in STEM fields over the past decade (2015 – 2024) was 23.64% higher than over the previous decade (2005 – 2014) (National Center for Science and Engineering Statistics, 2026). However, U.S. universities are not producing sufficient numbers of doctoral graduates in STEM fields, who are needed for diversified 21st-century careers, particularly in non-academic sectors, to sustain economic prosperity and international competitiveness through innovation (National Academies of Sciences, Engineering, and Medicine, 2018; National Research Council, 2011; Wendler et al., 2010).

The doctoral degree outcomes for students are concerning, such as attrition, degree completion rates, and time-to-degree (Lovitts & Nelson, 2000; Ruud et al., 2018; Sowell et al., 2008, 2010). This also includes STEM disciplines predominated by laboratory sciences (Ruud et al., 2018; Sowell et al., 2008, 2010). A study conducted on PhD completion showed that the 5-year, 7-year, and 10-year degree completion rates in STEM fields were 26.4%, 51.9%, and 59.1%, respectively, with 25.4% completing between 5-7 years, 7.2% completing between 7-10 years, and 9.2% persisting after 10 years (Sowell et al., 2008). A main cause limiting the production of doctoral degree-holders is this low completion efficiency of doctoral education, though most students entering doctoral education are

deemed academically competent (Lovitts, 2001; Wendler et al., 2010). The quality of the advisor-advisee relationship, including mentoring and support from the advisor during the challenging and lengthy trajectory of the doctoral degree, has been cited as one of the predominant reasons underlying doctoral student success or attrition (Golde & Dore, 2001; Lovitts, 2001; Qu & Harshman, 2022; Ruud et al., 2018; Young et al., 2019).

LITERATURE REVIEW

This literature review provides a general overview of the importance of the doctoral advisor-advisee relationship and an analysis of power as a tenet of social relationships, specifically in this relationship. Review of literature was accomplished via library resources available through Stockton University's Richard E. Bjork Library, as well as through the search engines Google Scholar and Google Search. For review of the doctoral advisor-advisee relationship, keywords including 'doctoral education', 'PhD'/Ph.D.', 'advisor advisee relationship', 'STEM', and 'science' were used. For the power analysis, the literature on power as a social construct in relationships, its advantages and disadvantages, and its intrinsic nature as a corrupting force was reviewed. Subsequently, focusing on the study, literature on the existence of power disparity as a tenet of the doctoral advisor-advisee relationship was reviewed. For these power-related literature searches, additional keywords such as 'power', 'relationship', 'corrupt', 'mentor mentee', 'asymmetry', 'disparity', 'differential', 'abuse', and 'misuse' were used. To understand the mechanisms of power manifestation, search of literature on power and doctoral education was further extended with keywords 'theory/theories' and 'framework/frameworks', and subsequently pursued with the insightful keywords that resulted, such as 'dependence', 'hierarchy/hierarchical', 'status', 'role', 'identity', the names of theories/frameworks and their authors.

DOCTORAL ADVISOR-ADVISEE RELATIONSHIP

The advisor-advisee relationship forms the main nucleus of doctoral education, where the doctoral trainee student (i.e., advisee) enters an advisory relationship with a supervising faculty member (i.e., advisor) (National Research Council, 2011; Schlosser, Lyons, et al., 2011a). It enables the advisee to receive tutelage to progress through the doctoral program and conduct research under the advisor's patronage over several years (i.e., typically 4-7 years in STEM) to produce a dissertation of publishable standard that contains original findings to enhance the field of study (National Academies of Sciences, Engineering, and Medicine, 2018; Taylor, 2023). The doctoral degree culminates with the student 'defending' the dissertation as well as demonstrating an in-depth understanding of the research and the field of specialization at an oral examination to earn graduation (National Academies of Sciences, Engineering, and Medicine, 2018; Taylor, 2023).

The doctoral advisor-advisee relationship determines the quality and outcomes of the graduate experience for the advisee, including emotional well-being, research productivity, degree completion, and time-to-degree, socialization into the professional field, professional development, and career transition (Qu & Harshman, 2022; Schlosser, Lyons, et al., 2011a; Schlosser, Talleyrand, et al., 2011; Taylor, 2023; Young et al., 2019; Zhao et al., 2007). The advisee's research, on the other hand, advances the advisor's research program, outcomes such as publications, grant funding, and recognition in the research field, as well as professional success as a faculty member (Golde & Dore, 2001; National Academies of Sciences, Engineering, and Medicine, 2018). Consequently, the advisor-advisee research achievements underlie the success of the doctoral degree-granting institutions (i.e., extramural grant funding, publications, patents, and rankings), where academic research at the highest level is conducted, which collectively uplift the broader research enterprise (Friedensen et al., 2024; National Academies of Sciences, Engineering, and Medicine, 2018; National Research Council, 2011). Thus, fostering a good advisor-advisee relationship is key to a much broader impact.

However, research studies and common knowledge inform that this relationship is vulnerable to challenges that may result in sub-optimal or undesirable advisor-adviser relationships, negatively affecting the outcomes for both actors (Golde & Dore, 2001; Lovitts, 2001; Perez-Kudzma, 2008; Qu

& Harshman, 2022; Ruud et al., 2018; Schlosser, Lyons, et al., 2011a, 2011b). It appears that the quality of individual advisor-advisee relationships range from extremely negative to extremely positive (Schlosser, Lyons, et al., 2011a, 2011b), with the relationship reaching the quality of a ‘mentoring relationship’ on one end where students feel “respected, supported and encouraged”, and on the other end viewed as ‘harmful’ and feeling “ignored, unimportant and neglected” (Schlosser, Lyons, et al., 2011a, p. 10). The advising relationship is reported to be particularly challenging for underrepresented or non-mainstream student groups, such as women, students of color, and international students (Council of Graduate Schools and The Jed Foundation, 2021; Primé et al., 2015; Ruud et al., 2018).

DOCTORAL ADVISOR-ADVISEE RELATIONSHIP AS A CONSTRUCT OF POWER

Power has been studied as a social construct in a wide array of research studies. A broad definition of power in social science and politics could be construed as the ability to influence others to think, feel, or act according to one’s preferences (Aguinis et al., 1996; Birnbaum, 1988; French & Raven, 1959). Power is necessary to create and maintain order (Tobore, 2023), coordinate and control functions (Birnbaum, 1988; Brown et al., 1983), and to achieve intended outcomes in relations with others (Basbug et al., 2023). However, it is widely acknowledged that power is a corrupting force (Keltner et al., 2003; Kipnis, 1976; Tobore, 2023) and power advantages encourage interpersonal negative behaviors including diminished empathy and egocentric focus (Tobore, 2023), unethical decision-making (Clark & Sechrest, 1976), exploitation and opportunistic behavior (Emerson, 1962; Wee et al., 2017), verbal aggression (Tepper, 2000), and use of coercion (Kipnis, 1976). The presence of a power asymmetry has been specifically acknowledged in the doctoral advisor-advisee relationship (Bargar & Mayo-Chamberlain, 1983; Friedensen et al., 2024; Qu & Harshman, 2022). The power relationship between the doctoral advisor and advisee is crucial to student success outcomes and satisfaction, as it can drive success through coordinated, goal-driven functions (Aguinis et al., 1996; Bargar & Mayo-Chamberlain, 1983; Tobore, 2023). Thus, power could be a valuable tool to train advisees to reach high achievement levels (Friedensen et al., 2024; Tobore, 2023). However, the existence of a power disparity also renders the advisor-advisee relationship vulnerable to the corrupting forces of power, leading to misuse or abuse of power (Bargar & Mayo-Chamberlain, 1983; Friedensen et al., 2024; Qu & Harshman, 2022).

Several interrelated theories and frameworks, with overlapping elements, have been instrumental in defining power in relationships. For example, a group of theories attributed power based on the control of goals or valued resources, including the Power-Dependence theory (Emerson, 1962, 1964), Social Exchange theory (Blau, 1964; Emerson, 1972a, 1972b; Homans, 1961), Rational Choice theory (Sato, 2013), and Resource Dependence theory (Pfeffer & Salancik, 1978). In other frameworks of power, the hierarchical position or rank held by an individual, the roles fulfilled within a group, society, or an organization, the status or the identity of an individual, determine the power held (Basbug et al., 2023; Emerson, 1962; Friedensen et al., 2024; Johnson-Bailey & Cervero, 2004; Keltner et al., 2003; Magee & Galinsky, 2008; Palumbo, 1969; Wee et al., 2017). Further, French and Raven’s (1959) theory posits the main bases of power as ‘referent’ (i.e., perceived as desirable to associate or identify with), ‘legitimate’ (i.e., perceived as having a legitimate right to influence), ‘expert’ (i.e., perceived as having special knowledge or expertise), ‘reward’ (i.e., perceived ability to provide benefits) and ‘coercive’ (i.e., perceived ability to punish). On the other hand, Guerrero et al. (2020) delineated principles of power as ‘a perception’, ‘relational’, ‘resource-based’, ‘having less to lose’, ‘enabling or disabling’, and ‘prerogative’.

Social, cultural, and economic factors may underlie the definition of power in the graduate education environment (Qu & Harshman, 2022). The nature of doctoral education provides a profound opportunity for a power imbalance between the advisor and advisee (Bettencourt et al., 2024; Friedensen et al., 2024; Qu & Harshman, 2022). However, the mechanisms of power manifestation in this relationship are poorly understood. The excessive dependence of the advisee on the advisor can create a power imbalance between them. For example, the advisor provides not only constant guidance to the

advisee on research and degree progress but also serves as the main evaluator of the advisee's performance over several years. The expectations of each partner are vague and poorly understood, and the advisee relies predominantly on the advisor for sense-making of the doctoral trajectory and experiences (Bettencourt et al., 2024; Golde & Dore, 2001). The degree progress evaluation criteria are also generally poorly defined and subjectively determined (Golde & Dore, 2001), depending on factors such as the academic field, research type, and the advisee or advisor's circumstances. Further, the advisor usually acts as the gateway to career transition and success (Qu & Harshman, 2022; Schlosser, Lyons, et al., 2011a; Schlosser, Talleyrand, et al., 2011; Taylor, 2023; Young et al., 2019; Zhao et al., 2007). Thus, arguably, a high degree of dependence of the advisee on the advisor and thereby a high power differential exist in this relationship, with a potential for misuse (Friedensen et al., 2024).

Understanding and addressing power imbalances in the doctoral advisor-advisee relationship would be key to improving both the relationship and its outcomes. However, published literature applying the aforementioned theories or frameworks of power to analyze the power situation in doctoral advisor-advisee relationships is limited, though invaluable. Aguinis et al. (1996) applied French and Raven's (1959) power bases to analyze the power interactions between graduate students and faculty supervisors. In Qu and Harshman (2022), based on a study conducted in a laboratory science field (i.e., chemistry), hierarchical status-derived power differences between the doctoral advisor and advisee were posited to affect their communication. Bettencourt et al. (2024) and Friedensen et al. (2024) conducted power analyses of the STEM doctoral advisor-advisee relationship using Linder's (2018) power-conscious framework. Friedensen et al. (2024) utilized Guerrero et al.'s (2020) five categories of power to understand and interpret the power relations they encountered in their study. Studies applying feminist and race-related theoretical frameworks to analyze this relationship have also found power implications based on identity (Friedensen et al., 2024).

Special features in doctoral education in laboratory sciences increase the advisee's dependence on the advisor and create a power imbalance that can lead to misuse of power (Bettencourt et al., 2024; Primé et al., 2015). For example, laboratory-based research that incurs high expenses generally requires competitive extramural research grants obtained by the advisors to support their advisees' research (Golde, 1998). Further, to support full-time study required for time-consuming laboratory research, a stipend as a research assistantship is often provided to advisees through the advisor's grants, thereby making recipients of such research assistantships dependent upon the advisor for financial subsistence as well (Friedensen et al., 2024; Golde, 1998). Also in terms of operations, the laboratory-based doctoral education system is posited to subject advisees to a tightly bound, isolating, and hierarchical operating system with high dependence on, and high power to the advisor (Bettencourt et al., 2024; Friedensen et al., 2024; Golde, 1998; Primé et al., 2015). A systematic, theory-based analysis of the power dynamics in the doctoral advisor-advisee relationship in laboratory sciences would be valuable for improving this relationship and scientific productivity.

METHODOLOGY

The objective of this study is to develop a systematic analytic model using Emerson's (1962) Power-Dependence theory for empirical field studies and to use it to derive insights into the potential causes and mitigation strategies of this power differential. A theory-based analysis leverages the advantage of investigating a phenomenon through the lens of an established theoretical framework and provides guidance on research design, data collection, analysis, and interpretation of results (Fried, 2020; Luft et al., 2022; van der Walddt, 2021). By capturing these benefits of a theory-based analysis, the analytic model developed herein, based on the Power-Dependence theory, offers a simplified, quantitative methodology to aid future field applications (Fried, 2020; Souza Filho et al., 2023).

THEORETICAL FRAMEWORK

The Power-Dependence theory of dyadic relationships by Emerson (1962) is a sociological theory that views relationships in terms of 'mutual dependence' within social systems. It excludes power as a

static attribute of the actors and instead treats it as a dynamic property of the relationship. This theory develops an understanding of how the power of each actor over the other is determined by the degree of dependence on the other to reach their own goals through the facilitation of the other. It appears highly applicable to dissect and understand the power dynamics in the doctoral advisor-advisee relationship, in which the advisee and advisor depend on each other to achieve their personal goals in their professional pursuits. Positioning the doctoral advisor-advisee relationship as a social interdependent relationship for the application of the Power-Dependence theory aligns with the close, mutually beneficial mentor-mentee relationship it is expected to be (Schlosser, Lyons, et al., 2011a), and thereby the analysis could uncover methods to improve this relationship toward that ideal. With the simplicity and broad applicability of the Power-Dependence theory as well as its further developments in Social Exchange and Resource Dependence theories, it has been used to analyze diverse relationships in varied fields, including empirical studies where the dependence-based power concepts of this theory have been validated [e.g., nonprofit industry (Provan et al., 1980), suppliers and retailers (Brown et al., 1983), manufacturers and dealers (Skinner et al., 1987), employer-employee relations (Thau et al., 2004), leaders/supervisees and followers/supervisees (Wee et al., 2017), multinational enterprise and state bargaining (Müllner & Puck, 2018), customer-salesperson price negotiations (Cardy et al., 2023), healthcare (Laguecir et al., 2025)]. However, so far, the Power-Dependence theory has not been applied to research-related academic or professional goals, academic advisory relationships, or laboratory supervisory relationships in the available literature, making this study the first of such application.

Power-dependence theory

As laid out by the Power-Dependence theory (Emerson, 1962), the power of actor A over actor B (P_{ab}) is 'equal to and based upon' the dependence of actor B over actor A (D_{ba}). Similarly, the power of actor B over actor A (P_{ba}) is 'equal to and based upon' the dependence of actor A over actor B (D_{ab}). Emerson (1962) thus depicted the power-dependence relationship as $P_{ab} = D_{ba}$ and $P_{ba} = D_{ab}$. Brown et al. (1983) refined this relationship to denote power more broadly as a function of dependence; thereby, the relationship was expressed as $P_{ab} = f(D_{ba})$ and $P_{ba} = f(D_{ab})$. For simplicity, Emerson (1962)'s definitions will be used in the model below, with the understanding that the components analyzed may have more complex relationships in reality.

According to Emerson (1962), the dependence of one actor on the other is determined by two variables, where the dependence of A over B (D_{ab}) is (I) directly proportional to the degree of A's desire to achieve A's goals mediated by the A-B relationship [i.e., 'motivational investment' (MI)]: $D_{ab} \propto MI$, and (II) inversely proportional to the availability of those goals to A outside of the A-B relationship [i.e., 'alternatives' (AL)]: $D_{ab} \propto 1/AL$. MI is henceforth denoted as 'factor 1 of dependence' and AL as 'factor 2 of dependence'. Therefore, based on factor 1 of dependence, the higher the ambition or desire that A has to reach goal X (e.g., obtain 1000 liters of ice cream) that is facilitated by the A-B relationship (e.g., B supplies ice cream to A), the higher the 'factor 1 of dependence' of D_{ab} would be, thereby increasing D_{ab} . On the other hand, when other alternatives to reach goal X are available to A (e.g., alternative ice cream suppliers), the 'factor 2 of dependence' of D_{ab} (i.e., AL) is higher, thereby reducing D_{ab} due to the inverse relationship.

The same arguments can be applied for the opposite direction of the relationship, where D_{ba} will be determined by the 'motivational investment' (MI) B holds on B's goals facilitated by the A-B relationship (e.g., ice cream sales) ('factor 1 of dependence') and the 'alternatives' (AL) that B holds to reach the specific goals through other actors (i.e., other buyers of ice cream) ('factor 2 of dependence'). D_{ab} will, in turn, determine P_{ba} , and D_{ba} will, in turn, determine P_{ab} . The net power advantage or disadvantage of this dyadic, mutual relationship is defined as $P_{ab} - P_{ba}$, which can be either positive or negative, depending on which actor holds greater power. Thus, four factors determine the overall power difference between the two actors as depicted by $P_{ab} - P_{ba}$, namely the 'dependence factors 1 and 2' that determine D_{ab} and P_{ba} , and the 'dependence factors 1 and 2' that determine D_{ba} and P_{ab} .

METHODOLOGICAL APPROACH

The analytic model using the Power-Dependence theory is developed herein in a stepwise manner, considering multiple goals of the advisee and advisor, using the D and P dimensions for each specific goal, and simplified equations from the Power-Dependence theory. Goals for each actor are subsequently combined to derive the overall dependence and power of each actor on the other, as well as the net power disparity between them. The discussion extends to utilize the model to suggest root causes and potential solutions to reduce the power disparity or its negative outcomes in this relationship.

Thus, within the doctoral education literature, this paper provides insights at the intersection of the advisor-advisor relationship, the dimension of power, and STEM, where the literature is sparse. Particularly focusing on the field of laboratory sciences, it presents an analytic model to evaluate the dependence-based power in this relationship using the Power-Dependence theory. Exploration of the theoretical components of the model and maneuvering its power-balancing operations suggest potential causes underlying the dependence-based power differential as well as practical tips to enhance this power relationship and productivity.

POWER-DEPENDENCE MODEL DEVELOPMENT

STEP 1: DEFINING GOALS FOR EACH ACTOR

Past applications of this theory have been limited to a single goal for each actor. This model proposes using multiple clearly defined goals for the advisor and advisee, facilitated by the relationship with the other actor. Because the specific goals will be central to an authentic analysis in field applications, conducting focus groups or pre-surveys with advisees and advisors could be helpful to identify the main goals of each actor population.

STEP 2: MOTIVATIONAL INVESTMENT AND ALTERNATIVES AVAILABLE TO ADVISEE FOR ADVISOR-FACILITATED ADVISEE GOALS (FACTORS 1 AND 2 OF DEPENDENCE)

Doctoral advisees participating in future field studies would evaluate MI and AL for each of the identified goals facilitated by the advisor, based on the advisee's perceptions. Ratings on a 1-10 numeric scale may be appropriate for quantitative analysis with sufficient and nuanced resolution.

STEP 3: ADVISEE DEPENDENCE ON ADVISOR, BASED ON FACTORS 1 AND 2 OF DEPENDENCE

The two-part determination of 'dependence' based on factors 1 and 2 could be represented by the following equations [adapted from Emerson (1962) and Brown et al. (1983)]:

$$\text{Dependence (D)} \propto \text{Motivational Investment (MI)} \dots\dots\dots (1)$$

(i.e., D is dependent on MI, with a positive correlation)

$$\text{Dependence (D)} \propto 1/\text{Alternatives (AL)} \dots\dots\dots (2)$$

(i.e., D is dependent on AL, with an inverse correlation)

Thereby, combining (1) and (2) expressions:

$$D \propto (\text{MI})/(\text{AL}) \dots\dots\dots (3)$$

Expressing D as a function of (MI)/(AL):

$$D = f (\text{MI})/(\text{AL}) \dots\dots\dots (4)$$

For simplicity, assuming a linear relationship with a gradient of 1:

$$D = (\text{MI})/(\text{AL}) \dots\dots\dots (5)$$

With advisee designated as ‘A’ and advisor designated as ‘B’, MI_{ab} represents the rating for motivational investment of advisee for an advisee goal facilitated by advisor, and AL_{ab} represents the rating for alternatives available to advisee to reach the goal via other means outside the advisor-advisee relationship.

Thereby, D_{ab} is the computed 1-10 numeric scale rating for the dependence of the advisee on the advisor for this goal, based on the equation:

$$\text{Computed } D_{ab} = MI_{ab}/AL_{ab} \dots\dots\dots (6)$$

Thus, each goal of the advisee would have a Computed D_{ab} value designated as $D_{1(ab)}$, $D_{2(ab)}$, and $D_{3(ab)}$ through $D_{n(ab)}$ for an n number of goals.

$$\text{Computed } D_{1(ab)} = MI_{1(ab)}/AL_{1(ab)} \dots\dots\dots (6-a)$$

$$\text{Computed } D_{2(ab)} = MI_{2(ab)}/AL_{2(ab)} \dots\dots\dots (6-b)$$

$$\text{Computed } D_{3(ab)} = MI_{3(ab)}/AL_{3(ab)} \dots\dots\dots (6-c)$$

$$\text{Computed } D_{n(ab)} = MI_{n(ab)}/AL_{n(ab)} \dots\dots\dots (6-d)$$

STEP 4: COMBINING DEPENDENCE RATINGS FROM MULTIPLE GOALS TO COMPUTE THE OVERALL DEPENDENCE RATING

When multiple goals are considered, it is logical that the overall dependence rating be computed as the average of the dependence ratings for all the goals considered, with the assumption that the rating for motivational investment (MI) entrenches the due weightage for each goal.

For n number of goals:

$$D_{ab} = \frac{D_{1(ab)} + D_{2(ab)} + D_{3(ab)} \dots\dots\dots D_{n(ab)}}{n} \dots\dots\dots (7)$$

$$D_{ab} = \frac{MI_{1(ab)}/AL_{1(ab)} + MI_{2(ab)}/AL_{2(ab)} + MI_{3(ab)}/AL_{3(ab)} \dots\dots\dots MI_{n(ab)}/AL_{n(ab)}}{n} \dots\dots\dots (8)$$

Because the power of advisor over advisee (P_{ba}) according to the Power-Dependence theory would positively correlate with, and is a function of the dependence of advisee on advisor (D_{ab}) [adapted from Emerson (1962) and Brown et al. (1983)]:

$$P_{ba} \propto D_{ab} \dots\dots\dots (9)$$

$$P_{ba} = f(D_{ab}) \dots\dots\dots (10)$$

For simplicity, and as delineated in Emerson (1962) as well, assuming a linear relationship with a gradient of 1:

$$P_{ba} = D_{ab} \dots\dots\dots (11)$$

STEP 5: COMPUTING ADVISOR-DEPENDENCE ON ADVISEE

Similarly, values for dependence of advisor on advisee (D_{ba}) will be computed for each goal of advisor in the numeric 1-10 scale, adapting equation (6) in Step 3:

$$\text{Computed } D_{ba} = M_{ba}/AL_{ba} \dots\dots\dots (12)$$

Thus, the Computed D_{ba} value for each goal could be designated as $D_{1(ba)}$, $D_{2(ba)}$, and $D_{3(ba)}$ through $D_{n(ba)}$ for an n number of goals.

$$\text{Computed } D_{1(ba)} = MI_{1(ba)}/AL_{1(ba)} \dots\dots\dots (12-a)$$

$$\text{Computed } D_{2(ba)} = MI_{2(ba)}/AL_{2(ba)} \dots\dots\dots (12-b)$$

$$\text{Computed } D_{3(ba)} = MI_{3(ba)}/AL_{3(ba)} \dots\dots\dots (12-c)$$

$$\text{Computed } D_{n(ba)} = MI_{n(ba)}/AL_{n(ba)} \dots\dots\dots (12-d)$$

Applying the concepts in equations (7) and (8) in Step 4 to determine the overall dependence of advisor on advisee (D_{ba}) for n number of goals:

$$D_{ba} = \frac{D_{1(ba)} + D_{2(ba)} + D_{3(ba)} \dots \dots \dots D_{n(ba)} \dots \dots \dots}{n} \quad (13)$$

$$D_{ba} = \frac{MI_{1(ba)}/AL_{1(ba)} + MI_{2(ba)}/AL_{2(ba)} + MI_{3(ba)}/AL_{3(ba)} \dots \dots \dots MI_{n(ba)}/AL_{n(ba)} \dots \dots \dots}{n} \quad (14)$$

Applying concepts in equations (9) to (11) in Step 4 to compute the power of the advisee over the advisor:

$$P_{ab} = D_{ba}$$

STEP 6: COMPUTING THE OVERALL DEPENDENCE-BASED POWER ADVANTAGE OR DISADVANTAGE

Overall power advantage to advisor over advisee = $P_{ba} - P_{ab}$

Overall power disadvantage to advisee over advisor = $P_{ab} - P_{ba}$

This analytic model is illustrated in Figure 1.

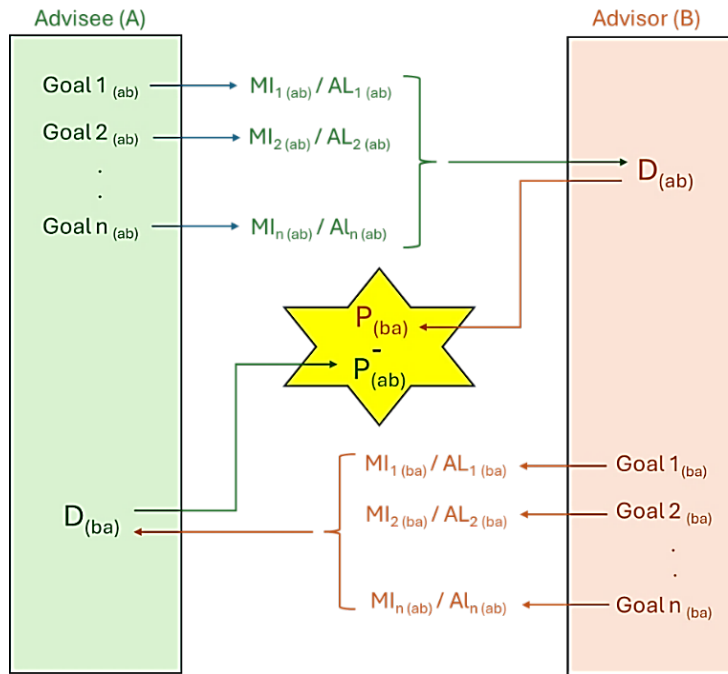


Figure 1. Analytic model

Note: The proposed analytic model for dependence-based power analysis in the doctoral advisor-advisee relationship in laboratory sciences is based on the Power-Dependence theory by Emerson (1962). The advisee and advisor are represented by letters A and B, respectively. The goals of the advisee (any number of goals from 1 through n) that are facilitated by the advisor via the advisor-advisee relationship are denoted as Goal 1_(ab) ... Goal n_(ab). The goals of the advisor (any number of goals from 1 through n) that are facilitated by the advisee via the advisor-advisee relationship are denoted as Goal 1_(ba) ... Goal n_(ba). For each goal, motivational investment (MI) divided by alternatives (AL) provides the dependence (D) contribution per the Power-Dependence theory, assuming a linear relationship with a gradient of 1 for simplicity. Quantitative ratings on a numeric scale (e.g., 1-10) for MI and AL independent variables would provide the quantitative data required to compute the dependent variables [i.e., power (P) and dependence (D)] for each goal, as well as for all goals of each actor collectively. Assuming MI to account for the weightage of D for each goal of each actor, D contributions are averaged to find the respective overall D values [i.e., D_(ab): dependence of advisee over advisor, D_(ba): dependence of advisor over advisee]. As per the Power-Dependence theory, and when assuming a linear relationship with a gradient of 1 for simplicity, P of advisor over the advisee P_(ba) will be equal to D of the advisee on advisor D_(ab), and P of advisor over the advisee P_(ba) will be equal to D of the advisee on advisor D_(ab). The power difference

between the advisor and advisee is denoted by $P_{(ba)} - P_{(ab)}$. Although the simplest form of relationships between the independent and dependent variables with a gradient of 1 is assumed in the depicted model, more complex relationships may be possible (Brown et al., 1983; Emerson, 1962) and potentially elucidated during empirical field applications.

DISCUSSION

STRENGTHS, LIMITATIONS, AND FUTURE DIRECTIONS

Application of the Power-Dependence theory to the doctoral advisor-advisee power differential in laboratory sciences provided a simplified, quantitative, preliminary analytic model for empirical studies, which can be refined through field applications (Fried, 2020; Souza Filho et al., 2023). Because the theoretical developments and practical applications of the Power-Dependence theory so far have been limited to calculating dependence and power for each actor's overarching goal, a methodology for a multiple-goal analysis was not available. In contrast, the developed model enables several specific goals to be carefully identified and defined for each actor, and a fragmented analysis to be conducted for each of the advisee's and advisor's goals. Subsequently, the results for each goal will be combined to compute an average to represent the overall dependence and power of each actor on the other, and thereby calculate the overall power differential between the two actors. Thus, this model extends the single-component methodology utilized in hitherto studies to a multicomponent analysis for a more insightful analysis of the Power-Dependence situation in a relationship.

This multi-component model, in which the primary analysis is conducted for each independent goal of each actor, would enable deep insights into each goal. Here, the two-factor analysis of actor dependence on the other actor for each goal (i.e., MI and AL) could provide insights into the reasons underlying the dependence and, hence, the power outcomes in a goal-specific manner, as well as potential solutions to improve the power situation for each goal. Such insights may not be elicited if the analysis is conducted for one broader overarching goal for each actor. For example, defining an overarching broad goal such as 'graduate school and postgraduation success' for the advisee, and 'professional success as a graduate faculty' for the advisor may not reach the depth of analysis and resolution achievable in a fragmented approach with more specific goals such as 'research success', 'graduation' and 'post-graduation employment' for the advisee (Schlosser, Lyons, et al., 2011b), or 'research productivity', 'research funding' and 'advisee success' for the advisor (National Research Council, 2011).

In the model developed herein, the simplest forms of the equations of the Power-Dependence theory were used, assuming linear relationships with a gradient of 1 for simplicity of analysis and depiction (i.e., $D = MI/AL$ and $P = D$). However, it may be possible that more complex relationships exist in reality between the independent and dependent variables (Brown et al., 1983; Emerson, 1962). For example, gradients other than 1 [e.g., depicted as a constant C in $D = C_1 (MI/AL)$, $P = C_2 (D)$] or functions [e.g., depicted as f in $D = f_1 (MI/AL)$, $P = f_2 (D)$] (Brown et al., 1983) may determine the relationship between factors in the Power-Dependence equations. Therefore, it remains to be tested empirically whether more complex relationships exist. Further, in the multi-goal analysis, the dependence and, hence, power outputs of the different goals were averaged to compute the final dependence and power values, assuming 'motivational investment' to entrench the respective weights for each goal. However, in reality, the contributions of different goals to actual or effective dependence or power may not be equal, which is another aspect to investigate in field studies.

The goals, ratings, as well as relationships between the different power-dependence factors, may depend on other factors, such as the stage of the doctoral degree, specific institution or institution type, advisor and advisee characteristics, the stage in the advisor's faculty career, field of study, or mechanism of student funding. The analytic model can be applied to specific circumstances for detailed analysis, with actor goals clearly defined in the context. Also, cultural contexts that could potentially,

or are known to, enhance power disparity situations or concerns may be of special interest to investigate, such as male advisor-female advisee, Caucasian advisor and advisee of color, or citizen advisor and foreign student advisee combinations (Friedensen et al., 2024; Schlosser, Lyons, et al., 2011b). As for the methodology, a mixed-methods approach could provide clarity into the enigmatic processes of dependence and power manifestation in this relationship. For example, in addition to quantitative ratings of the factors of the Power-Dependence theory (i.e., MI, AL, D and P) based on advisee and advisor perceptions, qualitative elaborations such as reasoning for their ratings, effects of these factors on the nature of the advisor-advisee relationship, the actors' physical and psychological experiences, as well as research and professional outcomes could provide such valuable insights.

It is important to note that there may be unknown factors that affect dependence-based power that are not accounted for in the theory used or that may not be considered to their full extent. For example, in addition to goal dependence, resource dependence has been postulated as an intertwined factor in determining dependence-based power (Wee et al., 2017), which may be particularly significant in analyses of laboratory sciences given the advisee's high reliance on the advisor's laboratory and expertise. Also, the critical factors of MI and AL are broad concepts that may need refinement to enable effective evaluation and elicit insightful information. For example, the original Power-Dependence theory postulates 'availability' and 'cost' as determinants of the AL factor (Emerson, 1962). Brown et al. (1983), in their application of the Power-Dependence theory in the supplier-retailer relationship context, used perceived difficulty of switching to alternatives based on the number of alternatives and 'costs' (i.e., losses) of switching, as important determinants of AL. Further, there may be additional mechanisms that bestow greater power on the advisor than on the advisee beyond the Power-Dependence theory, such as role, rank, status, or identity; French and Raven's (1959) power bases; or Guerrero et al.'s (2020) principles of power. Finally, it is important to be cognizant that, as dependence and power are complex social concepts, they may have complicated or enigmatic facets that require extensive research studies to uncover.

IMPROVING THE ADVISOR-ADVISEE RELATIONSHIP BASED ON THE POWER-DEPENDENCE MODEL

A power differential between the two actors in the doctoral advisor-advisee relationship may contribute to a strained relationship and widely known challenges faced by doctoral advisees to reach their goals, such as graduation success and timely graduation, as well as their mental well-being and motivation to persist (Aguinis et al., 1996; Bargar & Mayo-Chamberlain, 1983; Bettencourt et al., 2024; Harding-DeKam et al., 2012; Lovitts, 2001; Qu & Harshman, 2022). A perceived power disparity is shown to elicit 'leader-subordinate' or 'boss-employee' type of one-way relationship with restrictive behaviors to the advisee (Qu & Harshman, 2022). Under a power imbalance in the advisor-advisee relationship, advisors may resort to negative power-related behaviors (e.g., diminished empathy, exploitation, opportunistic behavior, and coercion), thereby contributing to these outcomes. Situations described in literature on sub-optimal doctoral advisor-advisee relationships provide evidence suggestive of such potential power misuse, including in STEM (Bettencourt et al., 2024; Friedensen et al., 2024; Perez-Kudzma, 2008; Ruud et al., 2018). Reducing the power differential between these actors may mitigate these negative effects and yield better outcomes.

To reduce the power disparity between the advisor and advisee in laboratory sciences, the variables of the Power-Dependence theory can be maneuvered to reduce the dependence of the weaker actor (advisee) on the stronger actor (advisor), and increase the dependence of the stronger actor (advisor) on the weaker actor (advisee), via four power-balancing operations (Emerson, 1962, 1964). According to equations (6) and (12), these power-balancing operations are:

- (i) Decrease the motivational investment of the advisee for the advisee's goals that are facilitated by the relationship (MI_{ab} - Factor 1 of dependence of advisee on advisor)
- (ii) Increase the alternatives available to the advisee to reach the advisee's goals outside of the relationship (AL_{ab} - Factor 2 of dependence of advisee on advisor)

- (iii) Increase the motivational investment of the advisor in the advisor's goals that are facilitated by the relationship (MI_{ba} - Factor 1 of dependence of advisor on advisee)
- (iv) Reduce the alternatives available to the advisor to reach the advisor's goals outside of the relationship (AL_{ba} - Factor 2 of dependence of advisor on advisee)

Operations (I) and (II) would reduce the advisee's dependence on the advisor, and operations (III) and (IV) would increase the advisor's dependence on the advisee, thereby reducing the power imbalance. These operations are discussed within the focal context of the doctoral advisor-advisee relationship in laboratory sciences in this section, based on the literature, the author's contextual knowledge, and informed discourse to infer potential root causes underlying the power differential and to propose mitigation methods. For clarity, it will be assumed that the advisor is a female and the advisee is a male, using the respective pronouns 'he/him/his' and 'she/her/her' to distinguish the two actors. However, gender is not a tenet in this analytic model.

Consistent with the analysis of Schlosser, Lyons, et al. (2011b), the personal goals of a doctoral student from the advisor-advisee relationship in laboratory sciences can be defined as completing the milestones of the doctoral degree to achieve graduation and post-graduation employment via: (1) 'research success' (i.e., positive research results sufficient to compile a dissertation of expected standards, meet the peer-reviewed publications requirement for graduation, and be competitive in terms of research experiences and achievements for the desired career); (2) 'graduation' (i.e., meeting the graduation requirements in a timely manner that primarily involves fulfilling the research-related productivity expectations, publications, dissertation completion, and defense, as well as timely graduation; and (3) 'post-graduation employment' (i.e., secure a desired employment opportunity or offer, with remuneration and other rewards matching the educational achievements [i.e., gainful employment] prior to graduation or during the desired time frame). On the other hand, reflective of the faculty values identified in the National Research Council (2011)'s research study, the main goals of the advisor from the doctoral advisor-advisee relationship in laboratory sciences can be defined as: (1) 'research productivity', based on the advisee's research success (i.e., research outcomes advancing the advisor's research portfolio including breakthrough findings, co-authored peer-reviewed publications and citations of published work, conference presentations, prestige or recognition in the research field, and honorific awards); (2) 'research funding' (i.e., research grants, particularly extramural grants based on the advisee's research contributions); and (3) 'advisee success', which stands as a testament to the advisor's mentoring success. While the primary goals for the advisee and advisor populations remain to be determined through field studies, the discussion herein will be conducted based on the aforementioned goals.

Power-balancing operation I

Advisee's goals 'research success', 'graduation', and 'post-graduation employment' encompass the success of his doctoral degree pursuit and securing gainful employment. Achieving a doctoral degree leads to potential higher earnings and lower unemployment (U.S. Bureau of Labor Statistics, 2024), and pursuing a doctoral degree is considered an "enormous personal commitment" of a lengthy duration and a "life choice of great importance" (National Research Council, 2011, P. 19). The failure to achieve the degree may lead to life-long negative effects such as diminished self-worth, loss of identity and self-confidence, or depression (Lovitts, 2001; Lovitts & Nelson, 2000). As such, the motivational investment of the advisee in these goals (i.e., MI_{ab} - Factor 1 of dependence of the advisee on the advisor) would arguably be very high, thereby increasing dependence on and power to the advisor. Though high motivational investment of advisee toward his goals would thus contribute to the power differential, attempts to reduce this motivational investment according to the power-balancing operation I [i.e., 'motivational withdrawal' as per Wee et al. (2017)] may not be a promising direction. This is because such high motivational investment may be imperative for the advisee to overcome challenges and persist towards the difficult goals of the doctoral trajectory. Therefore, the power-balancing operation I may not be an effective tool for reducing the power differential in this relationship.

Power-balancing operation II

Within the apprenticeship training model of a Ph.D. degree, profound alternative means (AL_{ab} - Factor 2 of dependence of advisee on advisor) for the advisee to achieve 'research success' and 'graduation' goals outside of the advisor-advisee relationship are inconceivable, because the advisor serves as the main facilitator of the doctoral training and evaluation of doctoral work (Bettencourt et al., 2024; Friedensen et al., 2024; Golde & Dore, 2001). In addition to funding generally tied to the advisor's laboratory, several other factors exacerbate this situation in the doctoral context of the laboratory sciences. For example, in the highly specialized subfield of science that an advisor's laboratory pursues research, the starting research material, equipment, research projects, field-specific knowledge, and experimental guidance required by an advisee are usually provided by the advisor or her designees from the laboratory, and the availability of such resources, expertise, and experimental procedures may be limited to the advisor's laboratory. Further, in laboratory sciences, research findings are closely associated with the research laboratory and are often produced through shared efforts with other members of the laboratory. The advisor, who is the Principal Investigator of the research laboratory and of research grant funding, is a co-contributor and co-author of the advisee's research outcomes, and the advisee would require the advisor's approval to use the research outcomes toward his dissertation and research publications. Therefore, overall, alternatives for the advisee's 'research success' goal outside the advisor would be very limited, thereby increasing dependence on the advisor and the advisor's power, as well as enhancing the advisor-advisee power differential according to the Power-Dependence model.

In the enigmatic, poorly structured, and subjective doctoral trajectory, the advisees depend on the advisor's guidance to progress through degree requirements and milestones toward their graduation goal (Bettencourt et al., 2024; Friedensen et al., 2024; Golde & Dore, 2001). Since the Ph.D. is a research-based degree, the students' ability to graduate ultimately depends on their research productivity. The advisor, who is the expert on the research content, would generally determine the sufficiency of the advisee's research productivity and readiness in terms of research and associated academic competence to warrant graduation. Similarly, due to her expertise, the advisor would be the most impactful evaluator of the advisee's performance at the defense. Thus, the advisor's expertise and, by extension, evaluation proficiency would be difficult to replace for the advisee's graduation goal. Therefore, for the 'graduation' goal of the advisee as well, viable alternatives available to reach this goal via an alternative means outside of the advisor-advisee relationship could be considered very low. This would increase the dependence on and power of the advisor, as well as enhance the power differential as a result, as per the Power-Dependence model.

For post-graduation employment, the advisor's recommendation is often solicited, particularly for research-intensive careers, including postdoctoral positions, tenure-track faculty positions in universities with high research activity, industry research positions, as well as federal, state, and university research positions (Inman et al., 2011; Pinheiro et al., 2017; Qu & Harshman, 2022). Further, for these employment placements, the advisor's professional network, facilitation, and advice are instrumental (National Research Council, 2011; Schlosser, Lyons, et al., 2011a). Therefore, in this advisor-centric context, alternatives for the advisee to meet the post-graduate employment goal outside the advisor could be very limited, thereby increasing dependence on and the power of the advisor, as well as enhancing the power differential in line with the Power-Dependence model. However, for doctoral students seeking non-research-intensive careers, including faculty positions in more teaching-oriented institutions (e.g., comprehensive universities, liberal arts colleges, community colleges) as well as policy, legal, sales, administrative, scientific writing, or other alternative careers, the advisor's ability to advise and facilitate job placement could be limited. Also, her recommendation would be desirable, but the advisee may be able to justify an alternative by presenting more relevant information for the position through other sources, such as teaching supervisors, employers, or internship supervisors. As such, for non-research-intensive alternative careers, alternatives available to the advisee outside the advisor could be comparatively higher, thereby decreasing the 'advisee's dependence on the advisor and the advisor's power over the advisee, as well as decreasing the power differential according to

the Power-Dependence model. Therefore, the availability of alternatives outside the advisor-advisee relationship for advisees' post-graduate employment goals may depend on the career goals of the advisees, which need to be considered during field studies.

Thus, for the advisee's goals of research success, graduation, and postgraduate employment in research positions, a very low AL_{ab} (i.e., Factor 2: the degree of the advisee's dependence on the advisor) would contribute to the power differential between them. Perceivable actions to increase alternatives to the advisee (i.e., increase AL_{ab}) via strategic maneuvering of the power-balancing operation II include those by the advisee, the advisor, or other stakeholders in graduate education.

Advisee actions. Emerson (1962) and Wee et al. (2017) posited that power-balancing operations are a tactic that the weaker actor in a power-unbalanced relationship is motivated to use to reduce dependence on the stronger actor to overcome the tensions or stressful situations that arise as a result of dependence-based power. Actions a doctoral advisee could take in this respect include enhancing self-reliance, increasing reliance on others with expertise other than the advisor, and utilizing resources available at the university.

Utilizing self: Toward the 'research success' goal, the advisee could make intentional efforts to enhance his own competencies related to research, such as by improving background knowledge, developing critical thinking skills to determine directions of his research, and enhancing troubleshooting and problem-solving skills. These efforts may include extensive reading, greater dedication and engagement, seeking assistance from other personnel, and attending seminars and workshops. Similarly, for 'graduation'-related processes, an advisee could intentionally enhance his self-dependence via actions such as improving knowledge of the requirements and procedures related to graduation, augmenting scientific presentation skills, and enhancing competencies for masterful dissertation compilation. Enhancing the availability and quality of guidance information on websites, progress-tracking documents, and student handbooks is a practice institutions use to aid doctoral student self-guidance (Sowell et al., 2010). Toward the 'post-graduation employment' goal as well, intentionally developing self-competencies such as masterful preparation of application material and interviewing skills, improving teamwork and other advantageous workplace skills during the graduate experiences, and developing vital networks may strengthen candidacy for gainful job opportunities. These may serve as effective alternatives to excessive reliance on the advisor for securing employment, such as introductions to her professional networks and exemplary recommendations.

Utilizing other personnel: Assistance to reach these goals could be actively sought by the advisee from others outside of the advisor. For example, help toward the 'research success' goal could be sought from others conducting similar research or using similar experimental methods, such as senior members in the laboratory, colleagues in other laboratories, research collaborators, as well as dissertation committee members (Bettencourt et al., 2024; Friedensen et al., 2024). In addition to organizing events and opportunities to enhance connections among doctoral students and with faculty that may facilitate this power-balancing operation, some institutions are also taking steps to train and assign peer mentors to new doctoral students as well as provide external mentors (Sowell et al., 2010).

Utilizing resourceful offices: To the extent available, advisees could seek help toward their goals from on-campus resourceful offices. These may include scientific facility centers for experimental support, departmental and graduate school student services personnel for advice on graduation-related processes, professional development opportunities provided by academic departments, graduate programs, and the university's teaching center, as well as assistance from the university's career center. Institutions have been particularly active in establishing dissertation-writing support, spaces, and activities, as well as professional development and employment-search activities for doctoral students (Sowell et al., 2010).

Advisor actions. Based on the Power-Dependence theory, enhanced advisee competency, his self-reliance, and reliance on alternatives for success would arguably result in a power trade-off for the advisor. However, it could also be a highly productive and time-saving mechanism for advisors, given

the extensive effort, commitment, and time investment required to facilitate the success of each doctoral advisee. As such, the advisor could actively facilitate and encourage the advisee's self-advancement and the use of other personnel and resourceful offices. These may include introducing the advisee to her peer networks, sponsoring or otherwise supporting the advisee to attend conferences, workshops, or other professional development activities, and facilitating applications for external fellowships or grants, thereby nurturing holistic student development.

Stakeholder actions. These may vary depending on the expertise, resources, and mission of the stakeholder entity, their level of access to and potential influence on the doctoral education system, or on the advisor-advisee relationship itself. Some entities may hold special advantages to encourage positive change, particularly given the types of powers they may hold, including reward power (French & Raven, 1959) such as in tenure and promotion structures, monetary awards, grant funding and recognitions to incentivize beneficial directions (Friedensen et al., 2024; National Academies of Sciences, Engineering, and Medicine, 2018) and legitimate or referent power (French & Raven, 1959) to influence policy, practices and culture (Friedensen et al., 2024). Further, research operations and graduate education in laboratory sciences, which depend on extramural funding, would give granting agencies a unique position to facilitate positive change (National Academies of Sciences, Engineering, and Medicine, 2018). Such potential specific actions by stakeholders to enhance alternatives to the advisee (i.e., increase AL_{ab}) are as follows.

Financial support: Uncoupling the financial dependence of the advisee from the advisor would arguably reduce the power imbalance in the advisor-advisee relationship (Bettencourt et al., 2024; Friedensen et al., 2024). For example, stakeholders providing funding sources earmarked for doctoral students would grant them an 'alternative' to an advisor's funding, thereby increasing AL_{ab} for advisee's 'research success' and 'graduation' goals with respect to expenses. While research funding would reduce the advisee's dependence on the advisor for dissertation-related expenses, a stipend would provide separation of the advisee's livelihood from the advisor's influence.

Power-balancing in Dissertation Committees: A dissertation committee guiding a student's progress through research and the degree is envisioned to ameliorate the power differential between advisor and advisee, compared to the advisor serving as the sole guide (Friedensen et al., 2024; National Academies of Sciences, Engineering, and Medicine, 2018). Policies and procedures established early in the student's journey, such as forming the dissertation committee and holding frequent committee meetings, are examples of applying the power-balancing operation II in this regard, thereby increasing AL_{ab} . Further, given the critical nature of the decisions made by the dissertation committee, AL_{ab} could be increased by establishing dissertation committees with a more equitable distribution of power among their members. For example, analysis of websites shows that occasionally a graduate program has a policy in which the chair of the dissertation committee is a faculty member outside the student's advisor. As a result, part of executive decision-making would rely on the alternative dissertation committee chair, thereby reducing the advisee's dependence on the advisor and the advisor's power. Similarly, AL_{ab} could be increased by including a representative in the dissertation committee specifically tasked with a student support role to help the advisee with degree navigation, performance improvement, and emotional support, thereby serving as an alternative to excessive dependence on the advisor for such support. This 'success coach' approach, trending in master's and professional doctoral programs, could become a valuable addition to enhance the student-centered developmental aspects of the Ph.D. education process and support student well-being.

Structure and monitoring: Establishing policies, procedures, and incentives that enhance the structure, monitoring, and support mechanisms of the doctoral education process by vested stakeholders could increase alternatives available to the advisee (i.e., increase AL_{ab}) by detecting issues in a timely manner and broadening their sources of advice and support. While faculty priorities for degree completion and time-to-degree for advisees have been shown to be low (National Research Council, 2011), structured programs with greater supervision and more frequent mentoring have been shown to be beneficial for advisee success (Schlosser, Lyons, et al., 2011a; Schlosser, Talleyrand, et al., 2011).

As evident by graduate school and graduate program websites, some doctoral institutions are making efforts toward more structured doctoral programs with annual goal-setting and documented progress evaluations for each advisee, coupled with dissertation committee meetings, thereby enabling structured monitoring and intervention when necessary (Schlosser, Lyons, et al., 2011b).

Mediation and customized solutions: When a need for intervention is identified through dissertation committee activities, structured monitoring, a personal communication to a stakeholder, or an official complaint or grievance filing, providing individualized solutions via mediation is a valuable approach to enhance AL_{ab} . Given the apprehensions of advisees about addressing challenges directly with their advisor (Qu & Harshman, 2022) and the power differential between them, a stakeholder mediator (e.g., a dissertation committee member, the ‘success coach’) facilitating the solutions may in itself constitute a beneficial alternative for the advisee, instead of strong decision-making by the advisor. These mediations may include solutions to research and degree progress-related challenges or concerns related to a sub-optimal advisor-advisee relationship. Such may be particularly helpful to advisees where a change of advisor is advisable, given the sensitivity of such situations and the potential negative effects on advisees’ degree progression (Bettencourt et al., 2024; Friedensen et al., 2024).

Joint mentorship and research: The narrow field in which a student conducts his research in laboratory sciences, for which the expertise and resources at the institution are generally available only via the advisor, remains a major factor for limited alternatives to the advisee for ‘research success’ and hence ‘graduation’ (Primé et al., 2015; Taylor, 2023). Faculty ‘cluster hires’ in overlapping research areas, as well as incentivizing research collaborations and providing joint mentorships to doctoral students, would be helpful to this end (Taylor, 2023; Walker et al., 2008; Young et al., 2019). Further, joint dissertation projects between students and lock-step progression through the dissertation as a cohort have been experimented with, to facilitate progression through the doctoral degree (Young et al., 2019). These approaches have the advantage of enhancing peer support, which may provide an alternative to dependence on the advisor for experimental, intellectual, and emotional support to some degree (i.e., increase AL_{ab}).

Opening up the relationship: Relationship isolation, along with graduate education culture, limits the alternatives available to the advisee (i.e., low AL_{ab}). Due to the way the doctoral education structure is traditionally set up within the apprenticeship model, the advisor-advisee relationships may largely exist in isolation, day to day, from other on-campus relationships and processes (Taylor, 2023). For example, an advanced-stage doctoral student may work in the laboratory conducting experiments or writing the dissertation, engaging almost exclusively with the advisor in the process, sometimes for weeks or months without closely involving other faculty, students, or offices for help (Primé et al., 2015). On the other hand, the graduate education culture also promotes, expects, and assigns the doctoral student almost to the total care to the advisor (Taylor, 2023). This culture and tradition, in turn, promote excessive dependence on the advisor by discouraging alternative sources of support for the advisee outside the advisor-advisee relationship (Qu & Harshman, 2022). To address this situation, particularly the institutional stakeholders could strive to change this culture and traditions to ‘open up’ the advisor-advisee relationship and broaden the support structure for the doctoral students.

Career development support: Some of the stakeholder actions discussed may also aid in enhancing AL_{ab} toward the post-graduation employment goal. For example, the dissertation committee structure, joint mentorship, and ‘opening up’ the traditionally ‘closed’ advisor-advisee relationship, in which mentors outside the primary advisor are involved in student guidance and support, may expose the student to additional networking opportunities and resources that are helpful for professional development and career placement. These mentors will also gain legitimacy to provide insights into doctoral students’ competencies and an objective view of their doctoral experience to support employment applications, particularly helpful to advisees in sub-optimal advisor-advisee relationships. Also, stakeholders such as graduate programs and graduate schools, or external funding agencies, augmenting their efforts in doctoral student professional development and career transition,

would thereby enhance AI_{ab} by reducing the advisee's dependence on the advisor for these processes.

As challenges in social integration and isolation are known as a major cause of attrition for doctoral students (Breitenbach, 2024; Rigler et al., 2017; Young et al., 2019), concerted efforts to broaden support and mentorship (i.e., increased AI_{ab}) may provide a supportive network, role-models, and an enhanced sense of belonging for each student. Further, it may broaden the experiences, learning opportunities, and perspectives of the doctoral students for multidimensional development. However, it is logical to assume that, in most cases, dependence on the advisor could be reduced only partially by these alternatives, not eliminated, due to the central and critical role the advisor plays in an advisee's doctoral trajectory. On the other hand, broader changes at the national or doctoral education level would be impactful to facilitate reduced dependence of the advisee on the advisor (Friedensen et al., 2024). Funding policies that enhance allocation of portable funding sources to advisees (Friedensen et al., 2024), broader funding sources for international students (Bettencourt et al., 2024), and funding mechanisms that incentivize research projects with two- or multi-faculty mentorship (Friedensen et al., 2024; Taylor, 2023) are such potential actions with respect to funding. Enhancing accountability in doctoral education, including through data reporting requirements (Friedensen et al., 2024; Lively, 2022) and incentives for experimentation with mentoring models that reduce advisee dependence on the advisor (Friedensen et al., 2024; Taylor, 2023), are among other potential broad directions.

Power-balancing operation III

Research-related accomplishments (e.g., publications, citations, grants, awards) are considered the primary indicator of professional success of individual faculty members, where such achievements are affiliated with prestige and rewards, including tenure and promotion at the institution, recognition, resources, and influence (National Academies of Sciences, Engineering, and Medicine, 2018; National Research Council, 2011). As such, these priorities are internalized by the faculty members and the doctoral education system as its value system and culture (National Academies of Sciences, Engineering, and Medicine, 2018). Therefore, the motivational investment (i.e., MI_{ba} - Factor 1 of dependence of advisor on advisee) for 'research productivity' and 'research funding' goals by the advisor population could be very high in general, thereby increasing dependence on, and power to advisee, and as a result, reducing the power differential according to the Power-Dependence model. However, for advisors who are not as motivated by these research-related achievements, particularly post-tenure (Kozlov, 2025), providing incentives and maintaining high productivity expectations by institutions are strategies that can be intentionally used to maneuver the power-balancing operation III to reduce the power differential in their doctoral advisor-advisee relationships.

For the advisor's third goal of 'advisee success,' that may signify the advisor's mentoring success, the motivational investment by most doctoral advisors would logically be much lower compared to their motivational investment toward the two research-related goals analyzed. Unfortunately, this is primarily due to the lower emphasis, recognition, and rewards to the advisors based on mentoring and advisee success, particularly compared to the benefits for research productivity and research funding (National Academies of Sciences, Engineering, and Medicine, 2018). A study by the National Research Council (2011) showed that the weight placed by science and engineering faculty on faculty research-related productivity, relative to student support and outcomes, was approximately 5:3. Considering this evaluation as well, motivational investment by the advisor population for the 'advisee success' goal could be regarded as moderate. According to the power-balancing operation III, increasing the motivational investment of the advisor for her 'advisee success' goal (i.e., MI_{ba} - Factor 1 of dependence of advisor on advisee) would provide an opportunity to reduce the power disparity between the advisor and advisee.

Advisee's support for advisor's 'research productivity' and 'research funding' goals. A special opportunity exists to enhance advisors' interest in the 'advisee success' goal through research, be-

cause the advisor's goal for 'research productivity' overlaps with the advisee's goal for 'research success', where both actors have a very high motivational investment, thereby unifying the goals into a common purpose. Therefore, the advisor's motivational investment toward the 'advisee success' goal can be expected to increase if the advisee's 'research success' is especially appealing to the advisor's research interests. From the advisee's end, investing efforts to identify, align with, and fulfill the advisor's research interests through his dissertation project(s), undertaking research in the advisor's preferred areas of research, and striving for research excellence would be helpful actions in this regard. Achieving research-related distinctions, particularly from early stages of the doctoral study, would be valuable for gaining the advisor's motivational investment and support to benefit advisee's degree progression. Further, the advisees could align their 'research success' goal with the advisor's 'research funding' goal to increase the advisor's motivational investment in the 'advisee success' goal, leveraging the advisor's high motivational investment in the 'research funding' goal. This may include pursuing successful research in directions competitive with the advisor's grant proposals, assisting with her grant proposal preparation, and, as a doctoral student, securing research grants, research-based fellowships, or traineeships to support the advisor's research program financially.

Stakeholders' support for the advisor's 'research productivity' and 'research funding' goals through provisions to advisees. Stakeholders in graduate education could also enhance advisors' interest in the 'advisee success' goal, utilizing advisors' high motivational investment toward 'research productivity' and 'research funding' goals. For example, providing research grants to support advisees' research that would in turn advance the advisor's research goals, supporting research-related professional development opportunities to advisees (e.g., funding to attend technical workshops and research conferences), as well as providing a stipend to advisees via fellowships or traineeships that enables them to devote undivided time and attention to research, would be helpful to this end. These strategies that facilitate research-related achievements of the advisee by enhancing research productivity, competency, portfolio, visibility, and network development would be valuable to the advisor's research program, which may in turn enhance her motivational investment (MI_{ba}) for the 'advisee success' goal.

A cultural shift and accountability. Generally, in the graduate education culture where research productivity and grant funding remain the top priority and highest prestige (National Academies of Sciences, Engineering, and Medicine, 2018; National Research Council, 2011), enhancing an advisor's motivational investment toward the 'advisee success' goal by itself is challenging. A cultural shift would be valuable to this end and could be aided by thoughtful institutional policies and practices, as well as reward mechanisms. As institutions are attempting to create a more appreciative culture of mentorship and advisee success, where advisors are incentivized, recognized, and rewarded for such successes (National Academies of Sciences, Engineering, and Medicine, 2018; Sowell et al., 2010), this would provide opportunities to increase advisors' motivational investment in their 'advisee success' goal. Institutional leadership, as well as granting agencies and donors, could be instrumental in developing a rewards-based system to support this shift. As discussed in the literature, enhanced accountability for advisors placed by institutional and external stakeholders toward advisee success in a student outcomes-oriented, more structured, and data-informed effort (Friedensen et al., 2024; Taylor, 2023) is another mechanism that could enhance advisor motivation toward the 'advisee success' goal.

Power-balancing operation IV

Although the advisor may have a very high motivational investment for her 'research productivity' and 'research funding' goals, the advisee in question (i.e., focal advisee) may only be one of several means by which the advisor could achieve these goals. For example, a doctoral advisor may guide several research personnel at a given time, including other doctoral and master's students, postdoctoral scholars, staff scientists, and undergraduate researchers, whose research collectively would contribute to the advisor's 'research productivity' and 'research funding' success. In situations where the relationship with the focal advisee and/or their research project becomes less favorable, the advisor

could instead shift efforts and resources to alternative personnel and their research projects, or invest in recruits. Such switches are easy to execute due to the low-binding and highly flexible nature of doctoral advisor-advisee agreements. Postdoctoral researchers are particularly advantageous as alternatives to Ph.D. students, as their stipends are close in cost to those of Ph.D. students, they are more qualified, and they can devote themselves full-time to research. Therefore, the alternatives available to the advisor (i.e., AL_{ba} - Factor 2 of dependence of advisor on advisee) to reach outcomes of ‘research productivity’ and ‘research funding’ are perceivably high, thereby decreasing dependence on, and power to advisee, and as a result, increasing the power differential between advisor and advisee according to the Power-Dependence model.

On the other hand, for the advisor’s goal of ‘advisee success’ that may signify the advisor’s mentoring success, the focal advisee would likely be one of several doctoral advisees that the advisor guides or has guided hitherto. Also, other research advisees, including postdoctoral scholars and master’s and undergraduate students who are being guided, or have been guided, by the advisor, would collectively represent the advisor’s mentoring success. However, unlike for the ‘research productivity’ and ‘research funding’ goals, where the productivity of postdoctoral scholars, staff researchers, and other advisees could serve as good substitutes for the focal advisee, for the ‘advisee success’ goal, on the other hand, each doctoral advisee would arguably receive more prominence. This is contributed to by factors such as the tradition of the master-apprentice model in doctoral education, doctoral students’ participation in an academic program aligned with the institution’s educational mission, and their pursuit of a challenging yet highly regarded terminal degree. Thus, the graduate education community and culture tend to assign expectations and responsibilities to the advisor regarding each doctoral student’s success, though the advisor-advisee relationship itself is low-binding. Therefore, the advisor may not be able to perfectly substitute an advisee’s deficient success with the successes of alternative current or former advisees, particularly if the focal advisee is an above-average student with research talent. Therefore, the alternatives available to the advisor (i.e., AL_{ba} - Factor 2 of dependence of advisor on advisee) to reach the ‘advisee success’ goal circumventing the focal advisee are perceivably less than that for ‘research productivity’ and ‘research funding’ goals, thereby increasing dependence on, and power to the advisee, and as a result, decreasing the power differential according to the Power-Dependence model. Strategic approaches to maneuver the power-balancing operation IV by reducing alternatives to the advisor (i.e., lowering AL_{ba}) could enhance the advisor’s dependence on the advisee, thereby ameliorating the power disparity.

Advisee value enhancement. The rating for ‘alternatives’ entrenches not only the availability of alternatives, but also the preference of the advisor to use the alternatives. This provides an opportunity for the advisee to augment his attractiveness to the advisor as the preferred and effective ‘go to’ option for the advisor’s ‘research productivity’ and ‘research funding’ goals. Efforts by the advisee and stakeholders to enhance the advisee’s competence and productivity in research, to align the advisee’s research with the advisor’s interests, and to foster collegiality with the advisor are beneficial actions to this end. Also, research funds and stipend directly awarded to the advisee (instead of through the advisor), developing the advisee’s skills and services that are beneficial to the research laboratory operation (e.g., laboratory management and technical skills), as well as competitive grant funding, networks, and recognitions secured by the advisee, are other examples of ways in which an advisee could outcompete alternatives available to the advisor.

Student-centered doctoral education culture. Improving the advisor-advisee relationship by enriching institutional culture, rewards, accountability, and associated policies should help with this power-balancing effort as well, by reducing the effectiveness of the alternatives available to the advisor to achieve her ‘advisee success’ goal. In this approach, each advisee’s success would be centered in the graduate education system, and the advisee’s performance would be recognized for the advisor’s mentoring success, with associated rewards as well. This may encourage the advisor to invest more effort in the focal advisee, including seeking help from additional mentors or university resource offices during challenging situations, rather than replacing the advisee with an ‘alternative’.

Given the abundant availability of postdoctoral scholars in many laboratory science fields (National Center for Science and Engineering Statistics, 2026; National Research Council, 2011), who may cost comparably, devote full-time to research, and are more qualified, the attractiveness of a doctoral student may rely to a large degree on such cultural and accountability underpinnings.

Enrich the advisor-advisee relationship. Toward enhancing both the advisor's motivational investment in the 'advisee success' goal in the power-balancing operation III, and for reducing the advisor's motivation to use alternatives outside of the advisee in the power-balancing operation IV, enrichment of the advisor-advisee relationship would be valuable. This could be achieved professionally and interpersonally, so that the advisor would be inclined to devote more to the advisee's success. Firstly, a compatible advisor-advisee match would be critical to developing a positive relationship between them (Primé et al., 2015; Schlosser, Lyons, et al., 2011b; Young et al., 2019), to which end, laboratory rotations are conducted by new students in some laboratory sciences fields to identify a matching advisor (National Academies of Sciences, Engineering, and Medicine, 2018). Enhancing advisor and advisee awareness of the graduate education landscape and trends, the critical nature and vulnerability of the advisor-advisee relationship, the mutual benefits of a good mentoring relationship, each other's inherent challenges, and methods to nurture the relationship would be another promising approach. While only about a quarter of advisors receive formal training in mentoring doctoral students (Young et al., 2019), it would be valuable to expand professional development opportunities for advisors, including training on mentoring, issue resolution, and evidence-based methods to improve advisee success. While a higher expectation on effective relationship development is placed on the stronger actor (i.e., advisor) (Qu & Harshman, 2022; Wee et al., 2017), efforts from advisor toward mutual trust development as well as open, clear, direct and cordial communication from the beginning of the relationship, including setting goals, expectations and timelines, have been highlighted as vital to the flourishing of this relationship (Qu & Harshman, 2022; Young et al., 2019). On the other hand, Young et al. (2019) recommended that the advisee as well takes an active role in developing a good relationship with the advisor, which includes being courteous and showing appreciation, advice-seeking for goal attainment, safeguarding the advisor's reputation, as well as enjoyable interactions (Young et al., 2019). Informal interactions are also beneficial for developing a strong mentoring relationship (Schlosser, Lyons, et al., 2011a). Stakeholders, such as the doctoral program, department, graduate school, and graduate student government, that facilitate social encounters and bonding opportunities for advisors and advisees, may thus contribute to nurturing their relationship.

Power balancing, improving the social relationship, and power navigation

Analysis of each power-balancing operation provided specific insights into potential approaches to reduce the dependence-based power differential in three of the four operations. Some of these approaches are currently used in graduate education to varying degrees. However, insights gained from the analysis herein using the Power-Dependence model provide an incentive to explore and enhance actions to intentionally utilize the model to mitigate the power differential between these two actors. Similarly, strategic power-disparity mitigation methods based on other theories and frameworks of power would be valuable for a combined effect. For example, elevating the status of doctoral students in the university or in the graduate education system could be one such effort.

Based on a sociological theory, reducing the power imbalance in the doctoral advisor-advisee relationship should lead to enhanced cohesion between the two actors and improve their relationship as an interpersonal, social relationship (Emerson, 1962, 1964). The analysis also elucidated actions that could particularly enrich the doctoral advisor-advisee relationship while reducing power disparities. For example, actions to converge goals of each actor in a manner that aligns with the goals of the other actor (e.g., advisee aligning his 'research success' goal with advisor's 'research productivity' and 'research funding' goals), or enhancing the focus on goals that benefit the other actor (e.g., 'advisee success' goal of advisor), should potentially enrich their interpersonal relationship. Also, intentional efforts to enhance the advisor-advisee relationship were discussed as a strategy to mitigate the power

differential through the power-balancing operations III and IV, where a close relationship would encourage the advisor to devote more effort to the focal advisee and dissuade the advisor from using alternatives. Thus, the use of a sociological theory for this analysis was valuable for deriving insights to improve the social relationship between the two actors.

Despite the efforts discussed, it was apparent that the power disparity based on dependence in this relationship has limited room for improvement, given the nature of doctoral education, the centrality of the advisor in the advisee's success, and the exacerbating circumstances in laboratory sciences. Therefore, effective power navigation methods to mitigate the negative effects of this power differential would be vital. Being the powerful actor with direct access and tools to improve this relationship, the advisor's efforts in healthy power navigation would be particularly effective (Qu & Harshman, 2022; Wee et al., 2017). To this end, raising awareness among advisors of the extent of this power disparity, its nature, and potential outcomes would be helpful. Also, advisors cultivating healthy power navigation practices toward advisees, including social awareness, communication skills, collaboration, and empathy (Bettencourt et al., 2024; Friedensen et al., 2024), as well as prudent and productive use of power, including mitigation of misuse, could be thus valuable for the success of the advisor-advisee team.

On the other hand, enhancing advisees' awareness and understanding of the inherent power imbalance in this relationship, and facilitating advisees' development of a healthy, objective view of this power disparity, is expected to enhance the advisor-advisee relationship (Friedensen et al., 2024; Qu & Harshman, 2022) and, arguably, the outcomes. Also, educating advisees of ways to successfully navigate the power disadvantage and the enigmatic doctoral degree with a hidden curriculum (Friedensen et al., 2024), as well as on available resources, would be valuable. Further, skill development workshops for advisees on topics such as negotiation and conflict resolution, resilience, managing stress and anxiety, advanced communication skills, thriving under challenging circumstances, time and priority management, and productivity strategies could be particularly valuable. However, as advisees are the 'weaker actor' in terms of power, it would add an extra layer of challenge for them to impact the advisor-advisee relationship, therefore support personnel and mechanisms to facilitate their efforts would be key. On the other hand, as power is a corrupting force as discussed, and given the significant power disparity in the doctoral advisor-advisee relationship, vigilance, early identification, and intervention in situations of power misuse would be a valuable direction. Particularly, stakeholders closest to the advisor-advisee relationship and have student success-related functions (e.g., dissertation committee, 'success coach', graduate program, or department) would likely have opportunities for such insights and actions.

CONCLUSIONS

Emerson's (1962) Power-Dependence theory was used herein to develop a simplified, quantitative analytic model to investigate the power differential between the doctoral advisor and advisee in laboratory sciences in future empirical field studies, while testing, adapting, and improving the model as needed.

Using the model, the independent variables of the Power-Dependence theory (i.e., MI and AL) were discussed in the context of the power differential in the doctoral advisor-advisee relationship in laboratory sciences. A potential primary root cause of the dependence-based power differential was the deficiency of alternatives available to the advisee to achieve his goals outside the relationship with the advisor, in contrast to the abundance of alternatives available to the advisor to achieve her goals outside the relationship with the specific advisee. The low advisee-centeredness of the doctoral education system and the isolated (i.e., 'closed') nature of the doctoral advisor-advisee relationship also emerged as other potential root causes of the power differential. Further, the high value placed on research prestige and grant funding as measures of faculty success, compared to their mentoring effectiveness and advisee-success outcomes, was surmised as another potential root cause. The theory's

simplicity and robustness, along with its conceptual compatibility with the focal phenomenon, enhanced its explanatory power and generated valuable insights.

The power-balancing operations of the Power-Dependence model were maneuvered in the focal context to suggest potential solutions to reduce the power disparity. These approaches were potential actions by advisee, advisor and other vested stakeholders of graduate education, which included developing advisee competence and self-efficacy, enhancing alternative support and resources to advisee, augmenting the value of each advisee with respect to advisor goals, converging advisor and advisee goals, early identification and mediation of challenging situations to assist with productive solutions, as well as nurturing a more 'open' and advisee-centric doctoral education culture with successful advisor-advisee socio-academic relationships. The effectiveness of these potential power mitigation methods could be investigated in empirical field studies. While some of these methods are practiced to varying degrees in doctoral education, the intentional use of these approaches, guided by the Power-Dependence framework, would provide a strategic means of reducing the power differential. Consistent with the theory's sociological roots, reducing the power imbalance and the specific approaches identified to do so can be expected to improve the social relationship between these two actors.

Power-Dependence theory was applied here for the first time in an academic advisory relationship or a research laboratory supervisory context. Compared to hitherto less insightful single-goal analyses, the developed analytic model advances the Power-Dependence analysis methodology to a more insightful multi-goal model. As such, this study provides a foundation for assessing and addressing dependence-based power mechanisms in the focal relationship in real-life settings, while also advancing the field of power research. Upon optimizing the methodology through field applications, it holds promise for application across diverse doctoral advisor-advisee relationships with varying characteristics and circumstances, as well as for analyzing dependence and power dimensions in other academic or laboratory-based relationships. However, it is important to be cognizant that this study and methodology pertain to a single mechanism of power, which is dependence-based, while other mechanisms of power (e.g., rank, status, identity, referent, reward, coercive) are arguably important in determining the overall power situation in this relationship.

Given the importance of the doctoral advisor-advisee relationship to the success of both actors, institutions, and the laboratory-based research enterprise, as well as the concerning rates of unsuccessful advisee outcomes and negative effects on their wellness, the mitigation of the power differential in this critical relationship must receive due focus. However, reducing the power differential in this relationship has limitations due to the apprenticeship model of doctoral education and the operational methods in laboratory sciences, including advisor-dependent mechanisms of funding and shared intellectual ownership. Accepting these limitations to reduce the power imbalance in this relationship, other ways to improve the relationship and outcomes via effective power management were discussed. These included raising awareness of the power dynamics and productive power-navigation methods for the advisor and advisee, as well as early identification of power misuse and intervention.

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REFERENCES

- Aguinis, H., Nesler, M. S., Quigley, B. M., Lee, S.-J., & Tedeschi, J. T. (1996). Power bases of faculty supervisors and educational outcomes for graduate students. *The Journal of Higher Education*, 67(3), 267–297.
<https://doi.org/10.2307/2943845>

- Bargar, R. R., & Mayo-Chamberlain, J. (1983). Advisor and advisee issues in doctoral education. *The Journal of Higher Education*, 54(4), 407–432. <https://doi.org/10.1080/00221546.1983.11778213>
- Basbug, G., Cavicchi, A., & Silbey, S. S. (2023). Rank has its privileges: Explaining why laboratory safety is a persistent challenge. *Journal of Business Ethics*, 184, 571–587. <https://doi.org/10.1007/s10551-022-05169-z>
- Bettencourt, G. M., Friedensen, R. E., & Bartlett, M. L. (2024). The role of power in STEM doctoral students' meaning-making of advising relationships. *Journal of College Student Development*, 65(3), 272–287. <https://doi.org/10.1353/csd.2024.a929242>
- Birnbaum, R. (1988). *How colleges work: The cybernetics of academic organization and leadership*. Jossey-Bass.
- Blau, P. M. (1964). *Exchange and power in social life*. Wiley.
- Breitenbach, E. (2024). Factors influencing doctoral program completion. In D. Dias & T. Candeias (Eds.), *Academic performance – Students, teachers, and institutions on the stage* (pp. 143–158). IntechOpen. <https://doi.org/10.5772/intechopen.113824>
- Brown, J. R., Lusch, R. F., & Muehling, D. D. (1983). Conflict and power-dependence relations in retailer-supplier channels. *Journal of Retailing*, 59(4), 53–80.
- Cardy, C., Chaker, N. N., Habel, J., Klarmann, M., & Plötner, O. (2023). Customer–salesperson price negotiations during exceptional demand contractions. *Journal of Service Research*, 26(3), 351–370. <https://doi.org/10.1177/10946705221136270>
- Clark, R. D., & Sechrest, L. B. (1976). The mandate phenomenon. *Journal of Personality and Social Psychology*, 34(6), 1057–1061. <https://doi.org/10.1037/0022-3514.34.6.1057>
- Council of Graduate Schools and The Jed Foundation. (2021). *Supporting graduate student mental health and well-being: Evidence-informed recommendations for the graduate community*. <https://jedfoundation.org/wp-content/uploads/2021/07/CGS-JED-Grad-Student-Mental-Health-Report.pdf>
- Emerson, R. M. (1962). Power-dependence relations. *American Sociological Review*, 27(1), 31–41. <https://doi.org/10.2307/2089716>
- Emerson, R. M. (1964). Power-dependence relations: Two experiments. *Sociometry*, 27(3), 282–298. <https://doi.org/10.2307/2785619>
- Emerson, R. M. (1972a). Exchange theory, part I: A psychological basis for social exchange. In J. Berger, M. Zelditch, & B. Anderson (Eds.), *Sociological theories in progress* (Vol. 2, pp. 38–57). Houghton Mifflin.
- Emerson, R. M. (1972b). Exchange theory, part II: Exchange relations and network structures. In J. Berger, M. Zelditch, & B. Anderson (Eds.), *Sociological theories in progress* (Vol. 2, pp. 58–87). Houghton Mifflin.
- French, J. R. P., Jr., & Raven, B. (1959). The bases of social power. In D. Cartwright (Ed.), *Studies in social power* (pp. 150–167). University of Michigan.
- Fried, E. I. (2020). Theories and models: What they are, what they are for, and what they are about. *Psychological Inquiry*, 31(4), 336–344. <https://doi.org/10.1080/1047840X.2020.1854011>
- Friedensen, R. E., Bettencourt, G. M., & Bartlett, M. L. (2024). Power-conscious ecosystems: Understanding how power dynamics in US doctoral advising shape students' experiences. *Higher Education*, 87, 149–164. <https://doi.org/10.1007/s10734-023-00998-x>
- Golde, C. M. (1998). Beginning graduate school: Explaining first year doctoral attrition. In M. Anderson (Ed.), *The experience of being in graduate school: An exploration* (pp. 55–64). Jossey-Bass. <https://doi.org/10.1002/he.10105>
- Golde, C. M., & Dore, T. M. (2001). *At cross purposes: What the experiences of today's doctoral students reveal about doctoral education*. Pew Charitable Trusts. https://archive.org/details/ERIC_ED450628/page/n33/mode/2up
- Guerrero, L. K., Andersen, P. A., & Afifi, W. A. (2020). *Close encounters: Communication in relationships* (6th ed.). Sage.
- Harding-DeKam, J. L., Hamilton, B., & Loyd, S. (2012). The hidden curriculum of doctoral advising. *NACADA Journal*, 32(2), 5–16. <https://doi.org/10.12930/0271-9517-32.2.5>

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- Homans, G. C. (1961). *Social behavior: Its elementary forms*. Harcourt Brace & World.
- Inman, A. G., Schlosser, L. Z., Ladany, N., Howard, E. E., Boyd, D. L., Altman, A. N., & Stein, E. P. (2011). Advisee nondisclosures in doctoral-level advising relationships. *Training and Education in Professional Psychology, 5*(3), 149–159. <https://doi.org/10.1037/a0024022>
- Johnson-Bailey, J., & Cervero, R. M. (2004). Mentoring in black and white: The intricacies of cross-cultural mentoring. *Mentoring & Tutoring: Partnership in Learning, 12*(1), 7–21. <https://doi.org/10.1080/1361126042000183075>
- Keltner, D., Gruenfeld, D. H., & Anderson, C. (2003). Power, approach, and inhibition. *Psychological Review, 110*(2), 265–284. <https://doi.org/10.1037/0033-295X.110.2.265>
- Kipnis, D. (1976). *The powerholders*. University of Chicago Press.
- Kozlov, M. (2025). How getting tenure changes researchers' publication habits – and citations. *Nature, 643*, 1165–1166. <https://doi.org/10.1038/d41586-025-02320-4>
- Laguecir, A., Chapman, C. S., Gebreiter, F., & Lemaire, C. (2025). Patient empowerment in public healthcare funding system reform: A power network perspective. *Accounting Forum, 49*(3), 634–667. <https://doi.org/10.1080/01559982.2024.2364955>
- Linder, C. (2018). *Sexual violence on campus: Power-conscious approaches to awareness, prevention, and response*. Emerald Publishing Limited. <https://doi.org/10.1108/9781787432284>
- Lively, C. (2022). Reporting of doctoral student attrition: A policy brief. *Journal of Multicultural Affairs, 7*(3), Article 3. <https://scholarworks.sfasu.edu/jma/vol7/iss3/3>
- Lovitts, B. E. (2001). *Leaving the ivory tower: The causes and consequences of departure from doctoral study*. Rowman & Littlefield. <https://doi.org/10.5040/9798216409847>
- Lovitts, B. E., & Nelson, C. (2000). The hidden crisis in graduate education: Attrition from Ph.D. programs. *Academe, 86*(6), 44–50. <https://doi.org/10.2307/40251951>
- Luft, J. A., Jeong, S., Idsardi, R., & Gardner, G. (2022). Literature reviews, theoretical frameworks, and conceptual frameworks: An introduction for new biology education researchers. *CBE Life Sciences Education, 21*(3). <https://doi.org/10.1187/cbe.21-05-0134>
- Magee, J. C., & Galinsky, A. D. (2008). Social hierarchy: The self-reinforcing nature of power and status. *The Academy of Management Annals, 2*(1), 351–398. <https://doi.org/10.1080/19416520802211628>
- Müllner, J., & Puck, J. (2018). Towards a holistic framework of MNE–state bargaining: A formal model and case-based analysis. *Journal of World Business, 53*(1), 15–26. <https://doi.org/10.1016/j.jwb.2017.07.003>
- National Academies of Sciences, Engineering, and Medicine. (2018). *Graduate STEM Education for the 21st Century*. The National Academies Press. <https://doi.org/10.17226/25038>
- National Center for Science and Engineering Statistics. (2026). *Doctorate recipients from U.S. universities*. <https://nces.nsf.gov/surveys/earned-doctorates>
- National Research Council. (2011). *A Data-Based Assessment of Research-Doctorate Programs in the United States*. The National Academies Press. <https://doi.org/10.17226/12994>
- Palumbo, D. J. (1969). Power and role specificity in organization theory. *Public Administration Review, 29*(3), 237–248. <https://doi.org/10.2307/973538>
- Perez-Kudzman, C. (2008). Fiduciary duties in academia: An uphill battle. *IDEA: The Intellectual Property Law Review, 48*(4), 491–522. <https://law.unh.edu/academics/journals/idea>
- Pfeffer, J., & Salancik, G. R. (1978). *The external control of organizations: A resource dependence perspective*. Harper & Row.
- Pinheiro, D. L., Melkers, J., & Newton, S. (2017). Take me where I want to go: Institutional prestige, advisor sponsorship, and academic career placement preferences. *PLoS ONE, 12*(5), e0176977. <https://doi.org/10.1371/journal.pone.0176977>

- Primé, D. R., Bernstein, B. L., Wilkins, K. G., & Bekki, J. M. (2015). Measuring the advising alliance for female graduate students in science and engineering: An emerging structure. *Journal of Career Assessment*, 23(1), 64-78. <https://doi.org/10.1177/1069072714523086>
- Provan, K., Beyer, J., & Kruytbosch, C. (1980). Environmental linkages and power in resource-dependence relations between organizations. *Administrative Science Quarterly*, 25(2), 200–225. <https://doi.org/10.2307/2392452>
- Qu, T., & Harshman, J. (2022). Situational interview based investigation of advisor–advisee conflict communication in U.S. chemistry graduate education. *Journal of Chemical Education*, 99(3), 1400-1409. <https://doi.org/10.1021/acs.jchemed.1c01117>
- Rigler, K. L., Bowlin, L. K., Sweat, K., Watts, S., & Throne, R. (2017). Agency, socialization, and support: A critical review of doctoral student attrition. *Paper presented at the 3rd International Conference on Doctoral Education, University of Central Florida*. <https://eric.ed.gov/?id=ED580853>
- Ruud, C. M., Saclarides, E. S., George-Jackson, C. E., & Lubienski, S. T. (2018). Tipping points: Doctoral students and consideration of departure. *Journal of College Student Retention: Research, Theory & Practice*, 20(3), 286-307. <https://doi.org/10.1177/1521025116666082>
- Sato, Y. (2013). Rational choice theory. *Sociopedia*.
- Schlosser, L. Z., Lyons, H. Z., Talleyrand, R. M., Kim, B. S. K., & Johnson, W. B. (2011a). Advisor-advisee relationships in graduate training programs. *Journal of Career Development*, 38(1), 3-18. <https://doi.org/10.1177/0894845309358887>
- Schlosser, L. Z., Lyons, H. Z., Talleyrand, R. M., Kim, B. S. K., & Johnson, W. B. (2011b). A multiculturally infused model of graduate advising relationships. *Journal of Career Development*, 38(1), 44-61. <https://doi.org/10.1177/0894845309359286>
- Schlosser, L. Z., Talleyrand, R. M., Lyons, H. Z., Kim, B. S. K., & Johnson, W. B. (2011). Multicultural issues in graduate advising relationships. *Journal of Career Development*, 38(1), 19-43. <https://doi.org/10.1177/0894845309359285>
- Skinner, S., Donnelly, J., & Ivancevich, J. (1987). Effects of transactional form on environmental linkages and power-dependence relations. *Academy of Management Journal*, 30(3), 577–588. <https://doi.org/10.2307/256016>
- Souza Filho, B. A., Tritany, E. F., Arana, G. A. C., & Struchiner, C. J. (2023). Theoretical models: Necessary reflections. *Revista Brasileira de Epidemiologia*, 26, e230038. <https://doi.org/10.1590/1980-549720230038>
- Sowell, R., Bell, N., & Kirby, S. N. (2010). *Ph.D. Completion and attrition: Policies and practices to promote student success*. Council of Graduate Schools. <https://cgsnet.org/publications/ph-d-completion-and-attrition-policies-and-practices-to-promote-student-success#/productdetail/4d4897b0-715f-ec11-8f8f-000d3a9a26c4>
- Sowell, R., Zhang, T., Bell, N., & Redd, K. (2008). *Ph.D. completion and attrition: Analysis of baseline program data from the Ph.D. completion project*. Council of Graduate Schools. https://cgsnet.org/wp-content/uploads/2022/01/phd_completion_and_attrition_analysis_of_baseline_demographic_data-2.pdf
- Taylor, S. (2023). The changing landscape of doctoral education: A framework for analysis and introduction to the special issue. *Innovations in Education and Teaching International*, 60(5), 606-622. <https://doi.org/10.1080/14703297.2023.2237962>
- Tepper, B. J. (2000). Consequences of abusive supervision. *Academy of Management Journal*, 43(2), 178–190. <https://doi.org/10.2307/1556375>
- Thau, S., Bennett, R. J., Stahlberg, D., & Werner, J. M. (2004). Why should I be generous when I have valued and accessible alternatives? Alternative exchange partners and OCB. *Journal of Organizational Behavior*, 25(6), 607–626. <https://doi.org/10.1002/job.260>
- Tobore, T. O. (2023). On power and its corrupting effects: The effects of power on human behavior and the limits of accountability systems. *Communicative & Integrative Biology*, 16(1), Article 2246793. <https://doi.org/10.1080/19420889.2023.2246793>

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- U.S. Bureau of Labor Statistics. (2024, April). *Education pays, 2023*. Career Outlook. <https://www.bls.gov/careeroutlook/2024/data-on-display/education-pays.htm>
- van der Waldt, G. (2021). The judicious use of theory in social science research. *The Journal for Transdisciplinary Research in Southern Africa*, 17(1), Article a1039. <https://doi.org/10.4102/td.v17i1.1039>
- Walker, G. E., Golde, C. M., Jones, L., Bueschel, A. C., & Hutchings, P. (2008). *The formation of scholars: Rethinking doctoral education for the twenty-first century*. Jossey-Bass.
- Wee, E. X., Liao, H., Liu, D., & Liu, J. (2017). Moving from abuse to reconciliation: A power-dependence perspective on when and how a follower can break the spiral of abuse. *Academy of Management Journal*, 60(6), 2352–2380. <https://doi.org/10.5465/amj.2015.0866>
- Wendler, C., Bridgeman, B., Cline, F., Millett, C. M., Rock, J. L., Bell, N. E., & McAllister, P. H. (2010). *The Path Forward: The Future of Graduate Education in the United States*. Educational Testing Service. https://www.ets.org/research/policy_research_reports/publications/report/2010/ibhf.html
- Young, S. N., VanWye, W. R., Schafer, M. A., Robertson, T. A., & Poore, A. V. (2019). Factors affecting PhD student success. *International Journal of Exercise Science*, 12(1), 34-45. <https://doi.org/10.70252/CEJT2520>
- Zhao, C., Golde, C. M., & McCormick, A. C. (2007). More than a signature: how advisor choice and advisor behaviour affect doctoral student satisfaction. *Journal of Further and Higher Education*, 31(3), 263–281. <https://doi.org/10.1080/03098770701424983>

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