The "*Ideal Type*" Advisor: How Advisors Help STEM Graduate Students Find Their 'Scientific Feet'

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Abstract: This paper delves into STEM (science, technology, engineering, and mathematics) Ph.D. students' relationships with their advisors. Through in-depth, semi-structured interviews, late-stage graduate students in STEM fields describe characteristics of their primary advisors as well as the dynamics of their relationships with them. From these narratives we construct an "*ideal type*" advisor. Weber's notion of an *ideal type* is a conceptual heuristic that reflects or encompasses essential characteristics of a phenomenon in order to generate a "pure" type that is then examined against reality. In this analysis we propose that an *ideal type* advisor offers students departmental and disciplinary moorings, career and program advice, and mentoring. As we develop this construct, we examine the consequences for students of having or not having advisors that approximate the *ideal type*. An emphasis on gender highlights how women's experiences differ from men's. Recommendations for advisors, departments, and graduate programs are also offered.

Keywords: Graduate education, advising, STEM, science, ideal type.

INTRODUCTION

"Only the American bedroom has more privacy associated with it than the relationship between the faculty member and the Ph.D. student," says George Walker, director of the Carnegie Initiative on the Doctorate [1]. Walker's remark highlights how graduate advising is commonly understood as a private affair. In the course of our research, we have come to think of graduate advising as analogous to another relationship, parenting in the privacy of the home. A parent disciplines and guides as s/he sees fit, while the child is subject to parental power and discretion. Parental dominance abates as the child matures and becomes independent and self-sufficient. This metaphor is useful in understanding both the private nature of the advisor and advisee relationship and the changing dynamic between them. In this article, we examine the ill-explored world of U.S. STEM (science, technology, engineering, and mathematics) Ph.D. students' relationships with their advisors.

Graduate students' relationships with their advisors are pivotal in completing the degree [2] and in maintaining graduates' long-term interest in STEM careers. The success of advising relationships has broad impact as well: highly trained STEM professionals are critical in the development of scientific and technological innovations that sustain a nation's ability to participate in an increasingly competitive global economy. Yet attrition among Ph.D. students in STEM fields is high, and persistence to the Ph.D., particularly for women, continues to be of critical importance [3]. In the U.S., attrition of women and both women and men of color is of particular concern. Thus it is useful to understand how advising may affect Ph.D. students' persistence or attrition from their programs. In this report, we contribute to an ongoing conversation about graduate education by focusing on advising relationships of U.S. students. We conducted semi-structured interviews with late-stage graduate students in STEM. All of these students were at the ABD ("all but dissertation") stage of their graduate work, having completed successfully their coursework, comprehensive exams, dissertation proposals, and in some cases Ph.D. defenses.

The role of advisor-advisee relationships in graduate education is critical for several reasons. In her study of students who left Ph.D. programs across the humanities and science disciplines, Golde [4] observed that students "must" connect with a faculty member since their tuition, stipend, research topic, and mentoring is often dependent on the successful incorporation into a faculty-led research team. Though the chance to work closely with a faculty member is critical for most students, this arrangement can also create deleterious dependencies. As we explore here, these dependencies can be serious, with impacts on students beyond the basic function of degree attainment. In a similar vein, Stacy [5] has warned that too much advisor control over the process of obtaining a degree can be negative if students do not learn to formulate their own questions or grapple with the open-endedness of science until the end of their graduate work. Thus, advisors as well as their students must be able to strike a balance between dependency and independence.

While the need for both support and independence is generally true across disciplines, the challenges of balancing the advising relationship may be most evident in the STEM fields. Graduate students in STEM typically have more interdependent relationships with their advisors than those in the social sciences and humanities. After an initial teaching appointment, they are almost always entirely dependent on the advisor's research grants for funding, as opposed to

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departmental funds that most often support students in the social sciences and humanities. In turn, STEM advisors rely on their students to advance their funded projects. This mutual interdependence is evident in the common publication of scholarly work coauthored by STEM graduate students, their advisors, and other members of the research group.

While the graduate advising relationship has not been well-studied, other aspects of graduate education have received more scrutiny. Attrition from Ph.D. programs in general is high, by some estimates near 50% [6]. Attrition rates are generally lower in the sciences, at about 30-40% [7-9] - strongly biased by gender and ethnicity. Indeed, numerous studies on graduate education focus on graduate students who left their programs before receiving their intended degrees [2,4,6,7,9,10], though none of these focus solely on STEM fields.

A few studies specifically focus on the process and experiences of graduate school [2,7,11-16]. These portray a journey to the Ph.D. that is fraught with obstacles which need not be inevitable. In addition to attrition, concerns about other aspects of graduate education, including diversity, preparation for interdisciplinary work, and leadership roles, have also been raised [5, 17]. Many authors have noted that graduate education does not prepare students for the changing landscape of careers both within and outside the academy [13,18-21]. Initiatives to improve graduate education address curriculum, advising, interdisciplinary training, internships, outreach, recruitment and retention of a more diverse student body, and career preparation [14, 22-24]. Whether critiquing graduate education or seeking to improve it, it is vital to maintain a dual focus on not just how many students get through, but who and why.

This paper draws from a set of semi-structured, in-depth interviews conducted with ABD graduate students in STEM disciplines. These Ph.D. candidates were asked to describe their relationships with their advisors, how the relationship had come about, and whether there was anything lacking in what they received from their advisors. Together their narratives offer a rich collection of differing advisor characteristics and behaviors. But a mere list of these traits would contribute little to understanding how these traits explain the pivotal role advisors play in their students' careers. Instead, a distilled set of advising characteristics can be analytically derived by isolating what is essential in advising based on student accounts. We draw on the theoretical concept of an "*ideal type*" advisor [25]. For sociologists, the *ideal type* is a heuristic device that "arranges certain traits actually found in society in an unclear and even confused state, and develops these into a consistent ideal construct by an elucidation of their essential elements" [26, p. 271]. An *ideal type* is an analytical construct used to highlight similarities and differences in a particular realm of social life. It is not a typology to distinguish a "good advisor" from a "poor advisor", but rather a coherent organization of concepts common to a range of experiences. Coser [27] explains how the *ideal type* never actually corresponds to a concrete reality, nor is it ideal in an evaluative sense. Rather, it is a theory created from features of a reality, reflecting a synthesis of "a great many diffuse, discrete, more or less present and occasionally absent *concrete individual* phenomena" (223). Weber [25] suggested that "in its conceptual purity, this mental construct… cannot be found empirically anywhere in reality" (90). Thus, the elements of advising highlighted here are not characteristics or actions of any one advisor - or that any hypothetical advisor could embody. Instead, from graduate student interviews, we gather those features of advising that were most salient to graduate student success and distill them into essential traits of departmental and disciplinary mooring, career advisor, and mentor.

METHODS AND METHODOLOGY

These data were gathered as part of a larger study at the University of Colorado at Boulder, funded by an ADVANCE grant from the National Science Foundation to the LEAP project, Leadership Education for Advancement and Promotion.[1] The study examined academic career paths of STEM Ph.D.-holders, including tenure-track and non-tenure-track faculty and graduate students in these fields, with an emphasis on the career paths of women and men.

This article is based on 28 interviews with Ph.D. candidates, conducted in 2003 at a research university in the western U.S. The sample was developed from an institutional list of 1,148 Ph.D. students in STEM fields, clustered into six disciplinary groups: geosciences, chemistry, physics, mathematics, engineering, and life sciences. The numbers of graduate students in these clusters ranged from 378 in the seven engineering departments to 56 in mathematics, while the other four clusters included about 150 students each. To select interviewees who were 1-2 years from receiving the Ph.D. and thus approaching career decisions, we used a list of students who had advanced to candidacy, in combination with information from each department about its norms for candidacy and degree completion. Because of the project's focus on women, and because there were fewer, we chose a sample of 19 women first, then a matched, smaller sample of 9 men. Target numbers of 3 women per cluster were established and adjusted for different cluster sizes in mathematics (2) and engineering (5). In some cases, after these criteria were applied, only 3-4 women met the selection criteria in a cluster. Because overall minority enrollment was low, minority women were oversampled to include their perspective; otherwise, selection of interviewees from this pool was random.

The first author was the primary interviewer. She had recently completed her Ph.D. in sociology, for which she conducted a three-year independent ethnographic study of gender and self-defense [28, 29]. Her training was in sociology, specializing in gender studies, and conducting both course work and field work in qualitative methods. Her work was overseen by three senior researchers at Ethnography & Evaluation Research, one of whom is the second author.

Semi-structured, in-depth interviews lasted 30 minutes to two hours. Consistent with feminist interviewing methods [30], the interviews allowed students' accounts of their graduate school experiences to surface with few structured questions. Even so, we acknowledge that the study implicitly and explicitly presumed problems in the specific university setting and more broadly within STEM fields. Several respondents shared that this was the first time they had spoken

[1] We acknowledge support from LEAP under the U.S. National Science Foundation ADVANCE program, grant #HRD-0123636.

of their experiences with such candor. Though respondents were assured of confidentiality when they signed informed consent forms (at the time of the interviews), some were concerned about being identified by their accounts of faculty advisors. Many identifying details have thus been omitted. The university's Institutional Review Board approved all data gathering and analysis strategies.

In keeping with our approved protocol, interviews were recorded and transcribed using an external transcriber unaffiliated with the university, then analyzed using qualitative data software. We first conducted open coding [31] to analyze each line of each transcript, followed by focused coding [31] to focus conceptual attention on themes emerging from the open coding. Broader categories, or "clusters", emerged as an interaction of theory and data [32, 33]. This process of "subsuming particulars into more general classes is a conceptual and theoretical activity" [34] requiring that the analyst "shuttle back and forth between first-level data and more general categories that evolve and develop through successive iterations until the category is 'saturated'" [34, p.256; 36]. We then examined these categories for their relationships, connections, and patterns [35].

Once all interviews had been analyzed according to general categories, we began the process of interpretation. This entailed frequent meetings between the authors and their co-researchers, who were assigned to other aspects of the project. We discussed the relationships, connections, and patterns between the categories, confirming or denying our collective impressions against the data. We drew on existing literature on graduate education in the U.S., as well as other ongoing or completed projects of the research unit [21, 36, 37]. We then would explore how well the conceptual themes captured the experiences of those interviewed. Often, plausible explanations were not supported by the data, and we would reject those hypotheses. Our findings reflect relationships among the major constructs of disciplinary/departmental mooring, career advisor, and mentor.

FINDINGS

Faculty advisors ideally fulfill simultaneous needs for their students, enabling these emerging scholars to develop their talents and skills while they also consider their career options. How successfully advisors meet these needs influences graduate student satisfaction, success during graduate school, and early career decision-making. Faculty advisors' roles can be categorized within three predominant realms: disciplinary and departmental mooring, career advisor, and mentor. From students' accounts of their relationships with their primary advisors, we are able to construct an "*ideal type*" advisor that emphasizes these three essential roles. As we develop this construct, we examine the consequences for students of having advisors that approximate the *ideal type* to varying degrees. This paper also addresses the ways in which graduate students cope with advisors that meet these expectations to a lesser extent.

DEPARTMENTAL AND DISCIPLINARY MOORING

Before they can succeed in a Ph.D program, graduate students must first identify with their disciplines beyond a casual interest. Like any new member of a community, graduate students benefit from formal and informal mechanisms that integrate them into their departmental and disciplinary cultures. In fact, integration into one's department is akin to a gateway for disciplinary identification [14]. Although fellow graduate students are often a primary and reliable source of such integration, advisors too serve a key function in securing students' footing in their fields. As Lovitts [6] suggests, "Integrative experiences with one's adviser are critical for helping students develop cognitive maps of the program, the discipline, and the profession, as well as for having a positive and fulfilling graduate school experience" (131). In this section, we examine the role of the advisor in fostering connections to professional communities at several levels.

Many students described their choice to attend graduate school as driven by a mixture of motives: wanting to continue in school, wanting to know more about their chosen field, gaining experience in research, and interacting with like-minded academics. Close to half of our sample reported doing research as undergraduates. This high interaction with a faculty member, research group, department, and the broader discipline was influential on their decisions to pursue a graduate degree. Often, undergraduate research experiences helped shape what students envisioned for themselves in graduate school [38, 39]. They imagined in-depth coursework on intriguing topics, communities of collegial scholars, and independent research. As one student explained, this idealized vision of graduate school is often revealed later to be a myth [4]. Her description of a fellow graduate student's experience must have resonated with her own:

> *He came to drink from the fountain of knowledge - and it ended up to be the fire hose of knowledge, and that's kind of how it is. You expect it's going to be this wonderful thing and you're just going to learn and enjoy it. But basically you just cram all the information into you, and they give you problems and tests and stuff, until basically you don't enjoy it anymore.*

Our interviewees described navigating coursework and comprehensive exams, choosing labs or research groups, and meeting other requirements - most of which occur at the departmental rather than university level [40]. But at the organizational level, departments are not necessarily explicit about their interest in seeing graduate students through, and in some cases resist innovations that benefit students [40]. Organizations often offer low status to newcomers, in this case students, but are offered the promise of high status and rewards if they successfully navigate the process. In such a system, faculty advisors can be crucial fixtures of support and information, or they can contribute to students' anxieties about their new surroundings. Across disciplines, students described the first years of their programs as "sink or swim" and fraught with the need to prove their worth; a very different reality from the collegial environment that they had envisioned:

> *[The first year] it's almost like an initiation—you have to go through this really difficult, arduous right of passage that proves your worth.*

> *[Professors] tell you that you're stupid or whatever, and then you have to fight back. At the beginning it's kind of hard. Like the first two*

> *years are really terrible—I'd never do that again—that was like hell.*

While some students see their induction into graduate school as traumatic, faculty may see the resulting attrition as natural. Lovitts' [6] faculty interview data suggests that faculty believe attrition is minimal, that the admissions process works, and that talent is scarce. Thus, faculty views their job as to find the talent, not develop it. Seymour [41] describes how newer faculty experiences a similar phenomenon, the "proving imperative." This is when "faculty have a deeply internalized imperative to constantly demonstrate to colleagues (and especially senior colleagues) that the work they do is high quality" (personal communication, February 04, 2008). For women, this obligation to prove themselves leads to awareness of themselves *as women* in male-dominated fields and influences how they interpret their experiences. This rang true for our women respondents. For example, one physicist explained how the proving imperative affected women more than men, because women's confidence was already lower. This affected her deeply: "There were definitely times where my confidence was really low, and I thought about not continuing." In direct contrast, a man in the same discipline saw proving himself as a necessary step toward his professional goals: "Becoming a professional physicist is learning to roll with the punches." Many of the difficulties in STEM programs and careers were similarly dichotomized by men and women. Women tended to see these as obstacles, while men tended to see them as "hoops" to jump through, required rites of passage.

The Role of Research Groups

In addition to these broad early experiences, the particular setting in which graduate students work is also important. For example, though students varied in their preference for a "hands-off" or more "hands-on" advisor, other research group members - postdocs, advanced graduate students, and skilled technicians - helped to create an environment where questions could be answered and where students felt at ease. Advisors have an influential role in the way their research groups interact and communicate, and thus how the group attracts and retains students, as this woman biologist explained:

> *He sets up the atmosphere for the lab, [where] everybody in the lab [is] very fun to work with and they can always help you. So if your advisor is not there, there are other people in the lab that know more about specific protocols, specific procedures that they've done that they can help you within - so a lot of resources in the lab. He just keeps everybody happy, and it's just kind of nice that way, so everybody is helping everybody.*

In contrast, a male student credited attrition in his group to the "hands-off" nature of his advisor:

> *In our group, there's been a lot of people that have come and left because [Joe] is on a different planet. …This group I'm in with sucks, I mean they just stink - and I've seen a whole bunch of people just come and leave because of this.*[2]

The gender ratio in the group mattered for some. A woman in physics observed that many women sought groups that had women members already:

> *If you see this group and the advisors and there are 10 men, you're probably going to think... 'I'm going to be out of place here,' you know? 'I'm going to be a minority.' You probably feel better if you see a group that's half women or [has] a few female advisors or something. People are like, yeah, well, 'You would probably be more comfortable,' you know?*

Her concerns were echoed by a woman in chemistry: "I work in a lab with 15 people and there's one other woman. So if those numbers were reversed, 13 women and two men, I think it would feel very different going into work every day." In this same department, one group was identified as hostile towards women. As a male student explained, "The lab I was in, up until two years ago, a woman had never finished with a Ph.D. They've always left - joined other labs or left with masters," adding, "I've heard that said… if you are a woman in his lab, you're not going to make it." While he attributed this gendered attrition pattern to "luck of the draw,"[3] it is clear that advisors have a tremendous influence on how their group interacts, including how welcome - and successful - women and minority students will be.

Departments

A primary influential mooring that graduate students need is within their departments, which students reported to be their most important communities after their immediate research groups, especially in the early stages of coursework and comprehensive exams. Fox [43] finds that science and engineering departments with high interactions between students and faculty advisors tend to produce more women Ph.D.s, suggesting that integration into departmental culture can have greater consequence for women. However, close to a quarter of our sample described their departments as non-supportive, and two students (one man and one woman, both in physics) made even stronger statements about a "weeding-out" process that they saw as intense, deliberate, and unnecessary. They felt that they had to prove themselves to faculty and other graduate students before they were taken seriously in any way. Other students talked of being invisible in their departments, receiving little advice about the program or careers. An engineering student observed that no one took responsibility to provide such information: "I think [my advisor] thought that other people in the department were going to inform us, but all the students kind of thought that our advisors would inform us." Without formalized means to obtain information, graduate students' successful navigation of their programs may be impeded - though our sample obviously drew upon students who had managed to devise

[2] This student goes on to say that his advisor's style works for him, and he does enjoy working with his group.

[3] In fact a great deal of attrition was explained as resulting from individual choice-making or circumstance, as opposed to structured systems of disadvantages and advantages accumulating unequally for men, women, and minorities. This echoes Lovitt's [6] findings on individual attributions of responsibility among those who leave graduate programs.

strategies to get through. Given strong evidence that integration into a department contributes to degree completion [6,14,42], information about departmental processes and career options are areas where departments and faculty advisors can work to institutionalize supports.

Disciplines

Another influential anchoring for graduate students is within their disciplines. While 21% of our sample engaged in what they termed "interdisciplinary" projects, the majority, like most scholars, identified a single discipline as their "home," locating their scholarly identities within the culture of that discipline. Late-stage students who identified strongly as members of a wider intellectual community had experiences publishing papers, attending conferences, and networking with others in their fields. Often, it was the stronger and more invested advisors who facilitated these interactions and opportunities for students.

Professional socialization, the cultural process of "joining the profession," has multiple sources - graduate school, research experience, presentations and authorship, and membership in professional organizations [43]. Through professional socialization, individuals learn the formal policies and rules of their profession, as well as the informal norms shared by members of their professional community [44]. For STEM graduate students, enculturation into their disciplines bears upon retention, success, and career outcomes, shaping their ideas about expectations for them and their beliefs about where within - or outside - the profession they can thrive and succeed [37].

The advisor should be a key figure in encouraging students to attend conferences, prepare articles for publication, write grants, and professionally affiliate themselves with others. In this sample, 17 respondents (61% of the sample) described such activities as part of their graduate careers. Five students had written or were writing manuscripts, nine students reporting attending professional conferences, and three students had experience writing grants. One woman in engineering described her advisor's efforts to incorporate students into the broader community:

> *Besides doing our own research, he has really pulled us into the professional community that we're part of. We go to one conference every year, we publish as first authors on papers…I've written four conference papers and one journal article with him, which is great.*

A man in chemistry acknowledged the role of his advisor in helping him to build professional skills and join professional networks:

> *One thing that is really very helpful is being able to communicate your ideas effectively to other people. And I think my advisor encouraging me to do lots of talks at conferences and do posters and all that stuff definitely has helped me be a better scientist. I guess making connections is pretty big. When you go to these conferences, you know, you meet lots of other people that are in your field, and you exchange ideas and they get an idea of what your name is and what you're doing. And obviously that can help you get jobs later, and further your career.*

Other students described interacting with their advisors around sharing ideas, building theoretical models, tailoring CVs, and discussing other professional issues.

Advisors also model for students the values of the field and academic work in general. For example, one student described meeting frequently with his advisor to discuss ideas, address questions, and dispel confusion.

> *You start to feel like, 'Oh, it's not so intimidating any more,' when this guy sitting next to you who's just totally amazing [and you] would have a discussion about mathematics and you are both contributing, like both putting pieces together.*

For another student, his advisor's approach to physics became a source for his own scholarly identity: "It gives you a stronger sense of group identity - it's not just that you're some individual researcher who's been tossed out there…. It becomes a source of affirmation; it becomes a way of saying, 'The type of physics I'm doing is an important type of physics'." A woman biologist described her advisor's expectations about the behavior of an emerging scholar:

> *[He said] "Now you're a doctoral student, now this is your own research, now you need to come to me when you can't go any further. Do your own troubleshooting and then come to me." You're expected to know and find out, flesh out the area completely and when you come to a sticking point, [go] to him. Kind of like…in a way, a trial run of what you would do as an independent investigator - you'd have to figure these things out and then go to your colleagues.*

Graduate students learn, mostly by example, what it takes to be successful in the field. Students reported varied expectations for "face time" in the lab or office. Some advisors were strict, requiring students to work 9 to 5, or "no less than 60 hours a week," while others expected the work to get done but saw no need for students to "punch a time card." Students whose advisors wanted them in the lab during business hours, and who also experienced pressure to publish, seemed to have an unfavorable picture of the requirements of a professional scientist (or mathematician, engineer, etc.). For example, one physicist explained her impression of what it took to achieve status within and beyond graduate school:

> *If I was the sort of person who did really well working in a box by myself, then I would have done a lot better in this program. Right? And so then I would have had my stellar publication record and then I could go and apply for academic jobs, right? So then I would be moving forward in the structure instead of stepping out of it.*

Her advisor barely spoke with her, she reported, and was only remotely connected to her research. She was isolated from others and had a negative perception of her department. Though she had published prior to joining her research group, under a previous advisor whose funding had ended,

she had stopped publishing and attending conferences because, she said, her advisor showed no interest in her work. According to her, more than her lack of publishing or presenting at conferences, this lack of integration led her to feel isolated and rejected from the physics community. As a result, she planned to complete her degree but then leave science entirely. A story like this shows that it is not just a publication record, but assimilation into the discipline's culture that confers both external status and respect among peers and internal confidence.

What emerges here is one set of characteristics of an *ideal type* advisor who brings students into the discipline. S/he encourages students to write up their work and present at conferences, to exchange ideas, and to take risks with experiments, theoretical models, or grant-writing. Students on the receiving end of such encouragement reported feeling connected to their disciplines, confident in discussing ideas, and, most importantly, contributors to the knowledge in their fields. In light of Lovitt's [6] findings about the importance of community for graduate student retention, it seems plausible that individuals who feel like contributing members of their broader intellectual communities will be more likely to persist in STEM careers. Advisors play a key role in facilitating this connection.

CAREER ADVISOR

While anchoring in the department and discipline is a crucial early function of advisors, career advice is a role that becomes increasingly important in later stages of a Ph.D program. Emerging Ph.D.s develop their ideas about careers in a variety of ways, including direct career advice, graduate experiences, and ideas developed even before entering graduate school. Students' post-Ph.D careers thus reflect the faculty advisor's guidance as well as the student's talents and efforts. Our interviewees reported mixed levels of career advice from faculty advisors: 44% of the sample reported receiving career advice (including advice about postdocs)[4] directly from their advisors, while 36% received no advice, and 20% received some advice, but less than they would have liked. Advisors passed along job notices, looked over CVs and job applications with students, encouraged students to pursue specific positions, or described possible career paths. One biology student described how her advisor kept her in mind when relevant opportunities came across his desk:

> *My mentor comes to me and says, "Have you tried this lab or this area or…?", that sort of thing. And if he gets specific calls for Postdoc candidates, then he forwards them to me. He has also helped me significantly with my CV and letters of interest and, just looking over the first few things that I was sending out, [advising] "Well, maybe you shouldn't say this way, because it's not quite as specific as you want to be in this case." It's fantastic. I don't feel like I have to worry about making a decision. I can always go to him at this point and just say, 'Should I be asking about money yet, in this conversation?' You know, what are some of the questions I should be asking?*

Other students' advisors helped to develop their professional networks. For example, one engineer described the role his advisor played in helping him secure a postdoctoral position:

> *I've gotten pretty good career advice from my advisor, actually. He was really the one that put me on the track for [a prestigious government] position. And kind of made the connections for me, introduced me to the right people to try and make some connections for funding my research.*

Advisors' support of students in late stages of the degree is crucial. Advice about careers and postdoctoral positions was clearly important, as were letters of recommendation and help with networking. One student explained why: "It's really a big part that your advisor is helping you. Because you're not at the stage where you are impressing anyone yet, you know?" In addition to a student's immediate advisor, other faculty within a department can also play a significant role in providing career advice. For example, one student described his department's career information sessions: "We've gotten some guidance from several different professors who go to those seminars." He emphasized that professors' participation in these sessions was especially useful. Such sessions might compensate in part for advisors who do not provide career advice.

Sometimes advisors gave advice that was too limited or not applicable to students' career choices. However, most students reported receiving very specific advice, most often about academia, and more specifically on tenure-track careers. This is not uncommon; most advisors assume their students are aspiring faculty [12, 13]. For example, a woman chemist received good advice about postdocs, but was left wondering about how to pursue her actual career interests outside academe. She paraphrased her advisor: "If you want to do a postdoc you should do all of these things… and if you want to get a job, like in industry, then I don't really know." A woman biologist, likewise pursuing a nonacademic career, offered her understanding: "If that's not the career path that you're headed for, they have a difficult time giving you advice on anything other than that, because that's not what they did." Students who did not receive advice reported a variety of alternate sources of information: figuring things out on their own, contacting former advisors from masters or undergraduate institutions, or talking with recent graduates and current postdocs from their research groups. When mentioned, career centers and expos were felt to be unhelpful. In sum, though most late-stage students found their way to at least some career advice, those who received direct, personalized, and multi-faceted career advice seemed most confident about their next steps and ready to make informed choices.

In contrast, students who were less definitive in their career objectives reported receiving no career advice. In these situations students may have felt unworthy or experi-

[4] Postdoctoral positions, which often serve as transitional between the Ph.D. and careers in research, are common in STEM fields. These often-critical positions allow recent graduates the opportunity to focus on research in their area of specialty without coursework, teaching, or other duties and to diversify their research skills. They also serve as a holding period for many Ph.D.s seeking more permanent employment [45].

enced a lack of confidence. They expressed confusion about what they were qualified to do, and several were leaving STEM entirely. Other students received little or no career advice, but reported they were not adversely affected by it. For example, one was leaving mechanical engineering for medical school, others were considering industry careers, and another student was going to pursue a postdoc and then pursue a tenure-track job at a four-year institution.

Although we over-sampled women in our study, a curious pattern emerged in graduate women's career resources and outcomes. A disproportionate number of women reported not receiving career advice (close to 40% of the sample); *only* women expressed dissatisfaction with their advisors; and of the four students leaving STEM, only one was a man. Furthermore, all of the women who were considering leaving STEM reported receiving inadequate career advice. While lack of career advice does not spell career failure, the connection between inadequate advice and dissatisfaction with career advising points to a potential loss of confidence and diminished awareness of options, which may impact women more acutely.

The second set of characteristics of an *ideal type* advisor is hereby evident. An *ideal type* advisor is aware of when students are ready to receive career advice and tailors that advice to a student's career goals. S/he integrates students into her/his professional networks, thereby introducing students to other career options, influential scholars, or funding opportunities. S/he does not allow students to flounder regarding future options, by assuming that they will get their information from someone or somewhere else. Ultimately, an *ideal type* in regards to career advice reflects a set of characteristics that helps students confidently make the transition out of graduate school into the professional world.

MENTORING

Finally, our interviews addressed whether faculty advisors were also mentors for students, a role that drew on the role of provider of professional socialization and career advice. To ensure common understanding of the term, the interviewer described "advisors" as meeting purely instrumental, task-oriented needs for students, while "mentors" additionally met expressive needs, or those that were socio-emotional in nature. Respondents helped construct the mentoring features of the *ideal type* advisor by describing their mentors and highlighting relevant characteristics. For example, mentors were advisors who responded to and saw the student as a whole person, knowing them on a personal level, not simply as another graduate student in a sea of semi-anonymous others. By seeing students in full view, mentors could personalize the mix of direct teaching and independent learning as they responded to student needs.

Students described how their mentors created assignments and tasks that allowed them to learn experientially and increasingly independently. Mentors met instrumental needs, serving as departmental and disciplinary anchor and career advisor, but also went one step further to meet students' expressive needs, offering personal support, and consistent and reliable communication. As an engineering student said, "A mentor is not something you can just fill like a job applicant. Mentors are kind of a gift. They're not, you know, a fill-in-the-blank sort of thing." Lovitts [6] found that "interest in me as a person" was an important factor in students' satisfaction with their graduate advising. Lack of interest can thus be devastating, as this woman chemist states: "I almost feel like I can just say 'Okay, I can graduate tomorrow then.' I mean, it's like there's absolutely no interest - so why don't I just leave now?" A distinction made by Golde and coauthors [23] serves us well here: "Mentorship is aligned with the idea of stewardship. It connotes the development of a person's complete professional identity, not limited to particular skills or tasks. The term implies affection and care, but, like stewardship, we associate it with high standards. It is not about being nice or friendly, but rather about setting the conditions that elicit high-quality work." (25). In our data, the primary emergent themes related to "stewardship" fell into two categories: support and guidance, and effective communication. In representing the various ways in which advisors go beyond formal expectations to serve as mentors (or not), together these categories construct the mentoring characteristics of the *ideal type* advisor.

Support & Guidance

The type of support or guidance offered by advisors varied, as did respondents' interpretations of that support. In addition to career advice and help with networking (as described above), some students noted specific support that had been useful throughout the graduate career. For example, a woman in mathematics explained how her advisor monitored as well as encouraged students' progress:

> *He's really good [at] giving us very clear direction too, like we always know what our short- and long-term goals were as far as we wanted to try and accomplish [them]. And he's just keeping us on track as far as, 'Well why don't you go ahead and write this up, why don't you write that up?'*

Other students described their advisors as not allowing them to flounder too long before stepping in. Independent work was expected by both students and advisors, in a process that happens over time as the student matures, according to Nyquist and coauthors [16]. They write, "To develop a sense of self and confidence in their own ability, graduate students must break away from supervisors to establish separateness and, eventually, independence" (23). As they carried out their research, students appreciated the opportunity to figure things out on their own, while also knowing their advisor was not far away if needed. Students who received the right balance of independence and support felt that they had been challenged, but not neglected. As one student explained: "For me [his style] was very, very effective. I was very pleased with it because it forced me to stand on my feet, my scientific feet." Another student was more hesitant, but still appreciated her early independence: "I wish I was given a more exact thing to do, but at the same time I think it is very useful. And I think once you've done it, you feel really great." Students less enthusiastic about their advisors' hands-off approach mostly spoke about lack of direction in the initial stages of their research, or a lack of direction in overcoming hurdles such as comprehensive exams. One student joked, a little bitterly, "It was like, 'Okay, here you go, have fun for five years'." A woman chemist offered this advice to

advisors stressing the importance of balancing guidance and independence:

> *I feel like you need to keep giving a lot of attention to the grad students and make sure they really are doing fine and make sure that they're doing well – and that it might take a little bit more effort to find that out than to just say, "Oh, how are you doing?" You might really need to look into it more and to keep on them, even when they're doing fine.*

Facilitating this balance also meant having a strong research group. According to Golde *et al.* [23], the traditions of faculty autonomy often manifest in an advising structure where "solo sponsorship" prevails. However, in most STEM fields, the advisor is not the only person to whom a student can go for guidance, and the student learns not to be wholly dependent on the advisor. Some advisors created such situations for their students, as this man in chemistry described:

> *But [he's] never actually in the lab looking over my shoulder and saying, 'Oh how are you doing this? Maybe you want to try this?' Because there's a lot of other workers, just regular scientists who aren't my advisor, that can give the more direct input.*

While some advisors offered support and balanced independence with good advice, other students did not receive these from their advisors. One woman described how her advisor had stopped writing grant proposals and had essentially disappeared. Even though she was confident in her own abilities and work, she stated:

> *I just really need some help here. At this point I should be a pretty independent researcher…. Starting your fifth year, you should know what you're doing, and you should be able to work on your own. But it's nice to be supported in some way… encouragement is key, still very important.*

A handful of students saw their advisors as taking the notion of independent work to an extreme. They felt as though their advisors had abandoned them and left them to flail on their own. However, even students who would have preferred more hands-on advising, at least initially, still benefited by learning to work on their own. The extreme cases, although few, suggest that sometimes advisors neglect their students in the spirit of fostering independent research.

In sum, student needs for independence are much more subtle than a simple "hands-on/hands-off" dichotomy might suggest. Retrospective data from these late-stage students highlighted the importance of advisors' active intervention over time, fostering independence but providing guidance when needed, much like an effective parent. Effective advisors kept tabs on student progress and did not just assume that their students were doing fine.

Effective Communicator

An additional mentoring practice of the *ideal type* advisor was regular, useful, and timely communication with students. Access to advisors was influential in shaping students' views of helpful and communicative mentors. Those who were pleased with their communication patterns felt that their advisors offered readiness to help as well as interest in their project and general well-being. Both in scheduled meetings and when dropping in for problem-solving, brainstorming, or advice, these students knew they would be met with a positive reception. Regular contact was crucial in feeling supported, even when working long-distance, like this engineering student explained: "We meet several times a year; we have a teleconference once a week, go back and forth on e-mail." Students felt supported by advisors who were approachable, who had "good working relationships" with their students, and who talked with them often. Advisors who responded to students quickly were praised, as were those who despite busy schedules made time to see their students. Some students were aware of the demands this placed on their advisors:

> *I can always go in if there's something I want to tell him, like something exciting or something that didn't work, like I want some help. I can always talk to him; he always will make time for you. You can always schedule appointments or you can just walk in. He has an open office, pretty much… I don't know how he gets anything done (Laughs).*

Such reports contrast with those from students who did not have good communication or felt their advisors were inaccessible. Poor or absent communication slowed progress and wasted investment in a project. For example, two women, one in physics and one in chemistry, had invested time and effort in projects that their advisors had initially encouraged them to pursue. After receiving bad research advice and little communication, each found herself at odds with her advisor, yet not quite knowing how she got there:

> *So in the end I did something like six or seven drafts of this paper, which is not that unusual, except it then usually gets published. Instead, in the end he says, "Well, you're not qualified to write this, and I'm not going to help you, and it's not worth my time to help you or to talk to you about this." And that was it. So it's kind of like a lot of time invested and zero gain, I felt. I mean he* ***encouraged me to work on this model****, and I spent a lot of time thinking about it. And then in the end, it was like, just cut off. So I don't have a lot of trust, or any trust [in him] (Original emphasis).*

Another woman described how the relationship with her advisor degenerated over differences in communication styles, and resulted in significant gaps in their contact:

> *We started having these communications problems, where I wanted to do things more in the lab and she wanted to talk more about ideas, and so I kind of started avoiding her and then she avoided me, and then… for years we just didn't talk to each other.*

These women, and several other students, started out with good advising relationships. Some described the shift from good to bad communication as resulting from their professors traveling too much, preparing for tenure, or becoming disinterested in the students or preoccupied with other

matters. Students were pained by this change and often took it personally, ultimately becoming discouraged with their own projects and their progress. As one woman stated:

> *It's become a very independent learning experience, but at the same time it's made me bitter and angry, because I don't feel like I'm getting the support that other students are getting in other groups. And it's very hard to come up with a lot of enthusiasm and motivation for your project when you're the only person who is supporting it.*

There was no gender pattern among respondents who reported having good communication with their advisors. However, there was a gender pattern among those who reported bad communication with their advisors, as women were more likely to say that they suffered bad communication patterns with their advisors than were men. The implications of poor advisor-advisee communication may be a contributing factor to women's differential attrition rates from doctoral programs in STEM.

In comparing students who were doing well and had reliable, constructive conversations with their advisors with those who were flailing and felt abandoned, we encounter traits of an *ideal type* advisor, who is accessible, interested in student projects, and maintains contact with students so as to adapt to student needs.

While these accounts come from a student perspective, advisors are likewise aware of their need for additional skills. In a related study, we spoke with pre-tenure faculty about their career development needs [46]. Mentoring graduate students was one set of skills that new faculty reported as lacking in their preparation for their new professional roles, more often than any other specific skill. Early-career faculty felt that they had received no training in advising, which had emerged as a complex and difficult role. Just as graduate students benefit from explicit socialization into their new professional roles, faculty benefit from preparation for the role of advisor [46]. They found that a one-size-fits-all approach does not work in mentoring all students, just as students expressed desires for different advising styles:

> *My advisor is much more on keeping tabs on you. Like making sure you're doing the lab work you're doing, your research, [that] you're moving along, and so he doesn't let people flounder that much. He doesn't let you waste too much time. Kind of, he'll see if you're on path and guide you back.*

This student preferred independence from her advisor:

> *My advisor, he really gives you a lot of freedom. He will suggest a lot of things - whether you **do it or not** is another thing, but at least he gives you some idea. And then you can also think of your own experiments to do and you can talk to him about it or, then, just try it…. So you shouldn't be babysat by your advisor that much when you're a grad student. (original emphasis)*

Returning to the metaphor of parenting, advisors need to know when to scale back supervision and allow students the freedom to make mistakes and discoveries. However, junior faculty need to learn how to do this—much like new parents, they are unsure, though it is assumed that they will know instinctively how to "parent." Senior faculty in the same study did not identify a need for advising help. Perhaps they have found alternative sources of information and training, or have become so entrenched in their advising style that they are not aware or concerned about their impact on students.

Friends Versus Mentors

Students who saw their advisors as mentors did not necessarily see them as friends. Only a handful of students described friendly relationships with advisors, while more reported knowing little about their advisors' non-academic lives, interests, or family. Some did not mind detachment or preferred not to have a personal relationship with their advisor, but others remained resentfully curious about who their advisors were. As a male physics student stated, "I sometimes wonder where he goes and what he does. But it's not important to me as a scientist; it's just natural human curiosity. Who is this person I've been working for the past six years?"

Some of our respondents described an assumption that women, more than men, need advisors who are interested in them as people and who make personal connections with them. One woman geologist iterated this assumption though she belied it with her own preference:

> *I like to keep work and personal separate. But I know some people have struggled with advisors when they don't take into account some personal things…. I don't know if it's because as a female you're **more sensitive** to certain issues, or if you have to go home for some family event and maybe your advisor doesn't understand, or you're going through some emotional problem. Some people maybe want to tell their advisor about it. I would never want to. I would want to keep my personal problems separate and not tell them…. It's maybe also a male/female thing, where female students sort of **need** to bond to have a more personal relationship with their advisor. (Original emphasis)*

Another woman in engineering suggested that advisors may adapt to this assumption about women's need for a personal relationship, despite students' objections:

> *With her female students there's always been much more of a social aspect, and I wasn't prepared for that. She's not the first woman I've ever worked with, but she's the first woman who didn't treat me professionally. She came in and wanted to talk social, and I just didn't know how to handle that. With the guys she's much more professional. And I've overheard, as I'm waiting outside her office, the kinds of things they talk about; it's pure science… what I wanted.*

For others, however, friendship with their advisors was valuable. As one man stated:

> *I don't do well with somebody where you walk in the office and you just do your job and go*

> *home and that's it. It's worked really well for me to have somebody that was almost more of a friend than really a professional advisor, and he's somebody who's is very concerned that his graduate students are doing well overall.*

Here we see that at least one man would have preferred a more personal relationship with his advisor, while two women expressed partiality towards more formal ones. Idiosyncratic preferences for advising styles cannot be anticipated by either students or faculty, but variety in approaches can be. Our findings suggest that advisors should not make assumptions about their students' needs based on gender or other stereotyped categories. But advisors can be reflective and explicit about their advising style, thereby offering valuable information to prospective graduate students. In fact, when asked their advice for students starting out in graduate school, many students said that choosing an advisor carefully to match one's own personality or work style was the most important thing for new students to consider.

Moreover, advisors did not need to be considered "mentors" by students in order to be perceived as good advisors. A full 50% of our sample identified their advisors as mentors when asked specifically if they viewed their advisors in this way. An additional 21% did not identify their advisors as "mentors" but considered them good advisors nonetheless; four of these had other advisors, some of whom were defined as mentors. This suggests that advisors who are not mentors can still benefit their students in multi-dimensional ways, but that students do not need their advisors to serve in both roles. What is more vital is that students have access to individuals that me*et al*l their advising and mentoring needs. Golde and Dore [19] suggest that having more than one advisor is a successful strategy - for example, instead of "solo sponsorship," students might have separate research and teaching mentors [23]. Our data suggests that students will seek out others who meet their needs for support, advice, research and career guidance. Students need to be emboldened to do so, however, since they may believe that their primary advisor *should* me*et al*l of their needs.

A SET OF COMPARATIVE EXCEPTIONS

In a few distressing cases, some students received so little support from their advisors that they felt abandoned, disrespected, and not valued. Two cases stand out. Two women, one in chemistry and one in physics, had poor experiences with their advisors - they have been quoted extensively above - and both were leaving science entirely. One described her advisor as insulting to her on a number of occasions:

> *[He has said things like] 'Your brain isn't capable of understanding science.' To me I'm not going to go to that person for advice about my career, in anything (laughs), because he's written me off. And so I don't want his opinion about what I can do and what I can't do and what I'm good at or bad at, because I don't think he's seeing me at all.*

She went on to clarify why her advisor's opinion of her mattered:

> *And to me that am obvious, how can I advance in this field? I mean, he's supposed to be the person who, when you graduate… it would be his recommendation that would get me that job. And so knowing you don't have that is, well, for one you don't want to stay in the field. But I guess at some point it's really hard to deal with knowing that you're not going to get it. You are not going to get this person's approval.*

This woman's self-confidence was shaken to the point that she had given up plans for a career in science, despite her impending credentials. Nor was she alone.

Another woman resented feeling forced to leave science because of her advisor's negative assessment. She characterized their relationship as extremely distant and felt her advisor had held her back significantly, causing her to lose both research momentum and faith in her abilities. In fact, of the few students who reported outright dissatisfaction with their advisors (21% of the sample), increased time to degree was the most significant effect reported. Lack of good mentoring or advising did not necessarily deter students from a STEM career path; indeed, many students who did not have strong positive relationships with their advisors still continued to express interest in academic and non-academic STEM jobs. For example, a woman who had difficult experiences in two departments felt that she had been "abused" by an advisor, stating:

> *This one professor… was abusive, and had some serious psychological problems. But there's really no way to say, "Look, you've got someone who's being abusive to their graduate students." And then there's an underlying expectation that, "Well, you're a graduate student, you're supposed to be abused."*

She was one of those few students who had no advisor or mentor to speak of. Yet she had already secured a postdoc position, with the eventual hope of securing a tenure-track job.[5] Thus having poor or even cruel advisors does not spell the end of a scientific career. What is significant is that, of the entire sample, the only two individuals who had decided to leave STEM were both women with what they described as harmful and unsupportive advisors.

How do students without good advisors compensate? As noted, some students rely on others in their research groups, while others seek out previous advisors or other researchers connected to the project. Other students find the information they need on their own. They turn to support groups on and off campus, rely on other graduate students, or plod along slowly, picking up bits of information and advice here and there, though not in any coherent pattern. Some drop out - a group whom we did not study. In this study, the majority of students with inadequate advising sought out others to fill in the gaps. However, as the data demonstrates, there is little substitute for a primary advisor who is uncommunicative,

[5] This woman was an older student who had extensive experience in industry prior to returning to graduate school. Her familiarity with industry, and having worked as a consultant, gave her the credentials and the confidence to persist in her career goals despite the marked lack of support from her Professors.

unresponsive, uninterested, and shows little faith in her/his students.

CONCLUSIONS

According to Golde *et al*. [23], "Outstanding advisers challenge their students, set high expectations and standards, generously share their expertise, and individually tailor their students' educational experiences" (5). Across STEM disciplines, many students described their advisors in ways that reflect such "outstanding" advising. They felt supported, respected and listened to. They reported a strong sense of professional identity and strong career goals. They felt challenged appropriately while also being guided. By distilling these characteristics into the "essential" elements of advising - departmental and disciplinary mooring, career advisor, and mentor, we construct the *ideal type* advisor. Once again, the ideal type is not a set of features that can be found together in any empirical reality, but rather, a theoretical construct to highlight the vital elements of an advisor. And since the notion of an *ideal type* lends itself well to comparisons [27], comparative exceptions among students who succeed despite the ways in which their advisor differs from the *ideal type* should offer us pause. Children are parented in different ways, and despite poor parenting, may turn out to be exceptional individuals, yet this would never excuse abusive or neglectful parenting. Likewise, despite coping mechanisms that some students develop to compensate for inadequate advisors, the impacts of a strong advisor versus a weak one are apparent in their adverse effects on students, and particularly women.

What is highlighted by examining graduate students' accounts of their advisors? In the theoretical sense we have portrayed an *ideal type*. In the empirical sense, we find that an advisor who tailors his or her own role to changing student needs, who communicates well and supports student learning and student choices, and who offers guidance and sets high standards, contributes to development of confident, knowledgeable, and well-connected STEM professionals. Such advisors are also identified as mentors, who advance their students into careers with confidence, know-how, and support. By supporting all students, they also foster diversity in the STEM workforce. The picture of graduate advising that emerges in this analysis resembles what Robinson and Golde [39] term a "pipeline effect." In their study on undergraduates pursuing Ph.D.s, they found that individuals who had the strongest goals, the most accurate expectations of their futures as Ph.D. candidates, and the most knowledge about the process of graduate school were the students who had already had experiences doing research, working closely alongside a faculty member. Similarly in our study, advisors who contributed to students' professional socialization, offered direct and relevant career advice, and served as mentors by going "above and beyond," left students well prepared for their pursuits beyond the Ph.D [6] on "high producers".

Advisors support their students in a variety of ways, narrowly and also more comprehensively. Students need financial, emotional, and professional support as they develop their professional identities, yet haphazard access to such support causes them to perceive good advising as "luck" [23]. One student explained:

> *The only thing that was really chance was that I had no idea that I would be working with people who would be so understanding (laughs) and how lucky I am that that happened. I mean, I would say that was definitely chance. Because when you are interviewing at grad schools you have no idea how the advisor is going to be, you know, at all. I've heard so many stories from my friends who are stuck with people they can't stand, and I think that happens more often than not.*

Good advising should not be a game of chance. Incoming graduate students should choose their advisors carefully, and not just based on their field of interest. Choosing an advisor was seen by our respondents as the most important choice after choosing a field and a program.

> *[My advice is] to pick an advisor that you can get along with…. **It seems obvious**, but some people pick advisors because they do cutting-edge research. Finding that match with an advisor is easier, research-wise. (original emphasis)*
>
> *I would really give the advice [to find] out as much as you can about your research group, about your advisor…. Try to have a feeling for what sort of working style they have, what sort of working atmosphere, not just with the advisor but with the group. What [are] other people who have left that group doing?*
>
> *Just be really careful who you talk to and who you work for.*

Thus, at the programmatic level, departments and Ph.D. programs should offer graduate students the information they need about choosing an advisor. Departments should create opportunities for prospective students to converse with potential advisors about their advising styles, not just their research. For example, Stacy [5] argues that rotating through labs before choosing an advisor is a valuable way to ensure a "good fit" between advisors and their students.

For advising relationships to work, advisors must be aware of their advising styles, their approaches to research, publishing, career advice, and communication styles. However, reflective advising is not an inherent skill. Having recently turned a professional corner themselves, new faculty are perhaps most acutely aware of the importance of good advising and many will seek training as advisors. Departments and programs thus should also provide training for their faculty on how to be a good advisor. Improved advising can reduce attrition rates among Ph.D. candidates [40]. Such training may be especially relevant for STEM fields where advisors and advisees are more interdependent.

To summarize, from these narratives we develop a construct for an *ideal type* advisor. The features of the *ideal type* advisor can be summarized as an advisor who:

- Creates structure for labs, meetings, communication;
- Offers support regardless of students' career plans;
- Carries out hands-on/hands-off advising when appropriate;

- Maintains flexibility, but is firm when necessary;
- Makes time for students;
- Sets high standards;
- Increases challenge as students develop;
- Encourages independent thinking;
- Fosters independent work;
- Does not let students flounder;
- Demonstrates concern over students' well-being;
- Encourages attending conferences, writing papers and grants;
- May work alongside students;
- Reflective of one's own advising style;
- Able to ask for help with advising.

This construct of the *ideal type* advisor allows us to uncover why it matters to be a good advisor. In short, advisors influence the future STEM workforce. By meeting student needs more deliberately or encouraging students to connect with others who can, advisors can contribute to student satisfaction throughout graduate school, and hence help to retain promising scholars and professionals. Students' satisfaction in graduate school contributes to a stronger sense of agency. This manifests as greater self-confidence, more deliberate and informed pursuit of career paths, and a stronger sense of professional identity. The elements of an *ideal type* advisor contribute to understanding how STEM advisors, departments, and graduate programs can help emerging Ph.D.s find and then stand on their "scientific feet."

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