Implementing an IDP Process in Graduate Chemical Engineering: Reflections from the First Three Years

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Abstract

As part of a broader effort to personalize graduate education, the Chemical Engineering department at the University of Pittsburgh launched a new Individual Development Plan (IDP) process designed to foster intentional, student-centered academic and professional growth. The IDP is a core component of a Personalized Learning Model (PLM) that integrates flexible coursework and professional development streams - academia, industry, and entrepreneurship - to align training with students' career goals. This paper describes both the implementation of IDPs within this model and the graduate students' and faculty's experiences with IDPs across the first three years of implementation.

In our model, the IDP functions as both a planning tool and a living, supportive document. To scaffold meaningful goal-setting, students are introduced to the SMART goal-setting framework—Specific, Measurable, Achievable, Relevant, and Time-bound goals, through structured workshops and advising sessions. Students complete their initial IDP during the first semester to communicate their goals related to coursework, skill development, research progress, and career exploration. These IDPs are then reviewed and discussed with their faculty mentors, updated annually, and used to guide ongoing mentoring conversations.

We analyzed student-submitted IDP goals for SMART alignment, examined faculty self-reflections on their mentoring practices using the IDP, and collected student perspectives through interviews and focus groups. Preliminary analyses found that graduate student IDPs included goals that were frequently relevant and achievable, but often lacked clarity around specificity, measurement, and to a lesser extent, timelines. First-year graduate students initially viewed the IDP as a requirement rather than a resource. However, over time, many began using it to structure conversations with advisors and clarify their priorities across research, skill development, and career exploration. The faculty reported a wide range of experiences in using the IDP, from seamless integration to viewing the IDP as redundant. Despite this wide range of perspectives, many faculty emphasized that the IDP was most effective when it supported ongoing conversations with their mentees. Mentors highlighted its value particularly in clarifying expectations, fostering student ownership, and encouraging student reflection on career goals.

This study contributes insights into the challenges and opportunities of successfully launching IDPs in a chemical engineering graduate program. Our findings highlight the importance of scaffolding the instruction and refinement of goal-setting skills early for graduate students, offering flexibility for IDP integration into various mentoring practices, and deliberately framing IDP documents as conversation starters rather than compliance documents. We also have found that the role of planned information sessions and reminders for both students and mentors and continuous evaluation to build a sustainable, value-added IDP process are essential.

1. Introduction

Graduate engineering education has not undergone a major overhaul in decades, even as STEM career pathways have shifted. Ph.D. graduates often start their careers in industry, translate their expertise across contexts, and frequently change jobs, yet many programs still default to preparing students primarily for academic careers [1]. This approach also underestimates that students enter graduate school with different starting points based on academic preparation and broader background experiences (e.g., socioeconomic and sociocultural context, prior work experience, and prior professional development), which can create barriers to inclusion and participation. National calls similarly emphasize the need to modernize graduate STEM education through a graduate enterprise more centered on graduate students and their development [2].

Over the past two decades, reports have also highlighted a related challenge. While STEM education research has expanded, the propagation of innovations into graduate programs remains uncommon, prompting calls for more systematic adoption of research-informed practices [2], [3], [4]. The CIRTL Network is one prominent example of a graduate STEM initiative focused on preparing future faculty in evidence-based teaching [5], yet diffusion challenges persist for many evidence-based approaches. To address these persistent propagation challenges, large-scale graduate education initiatives have increasingly turned to collective impact–informed implementation frameworks, which emphasize shared goals, coordinated infrastructure, and continuous cross-institutional learning in multi-institutional STEM change efforts [6]. Recent ASEE reports highlight the need for stronger propagation mechanisms, and diffusion theory suggests discontinuance can occur when implementers lack practical implementation knowledge and the underlying principles required for correct implementation [7], [8], [9].

Recent evidence suggests that IDPs can serve as powerful tools for enhancing graduate training when properly implemented. IDPs in structured mentoring programs effectively reduce identity-related anxiety for underrepresented trainees while increasing learner agency [10]. IDPs have also been shown to enhance mentoring support and career preparedness, creating a positive feedback loop for continued IDP use [11]. Mentor support for IDPs varies widely, and prior work cautions that IDPs may lose effectiveness when implementation is misaligned with existing mentoring practices, demonstrating that IDP implementation needs to accommodate varied mentor styles if a program wants IDPs to support authentic mentor-mentee interactions [12]

In response, to these national calls and emerging evidence, the Chemical Engineering department at the University of Pittsburgh launched a Personalized Learning Model (PLM) for graduate education that integrates: (1) individualized instructional goals through learner profiles, the CliftonStrengths® assessment, and Individual Development Plans (IDPs); (2) a task environment that includes modular coursework and professional development streams (industry, academia, entrepreneurship); and (3) scaffolding and assessment practices to support increasing independence and mastery [7], [13]. Our prior work introduced the PLM and early implementation insights, including baseline analyses of student IDP goal quality and faculty reflections on IDP use [7]. We later reported development of the PLM's Task Environment through modular, stackable coursework intended to increase flexibility while maintaining core preparation [13]. Within the PLM, the IDP provides an individualized yet replicable mechanism for establishing students' short- and long-term curricular, research, and professional goals, and for revisiting those goals over time. Recent work provides a complementary model for integrating career development through "Impact Training" that combines design thinking, communication, and innovation/entrepreneurship with graduate technical training, demonstrating the value of holistic professional development approaches [14].

This work engages multiple stakeholders in graduate education, including graduate students, faculty mentors, graduate programs, universities, and educational support units. Each has a distinct role in ensuring IDPs function as value-added mentoring tools rather than compliance documents. Within the broader PLM, the IDP functions as one of several complementary levers rather than a stand-alone intervention. Specifically, it serves as a reflective and planning mechanism that helps students articulate goals, monitor progress, and align learning experiences with their evolving academic and career interests, Therefore, the IDP supports personalization by making students' goals visible over time and facilitating intentional conversations that connect individual career needs to program-level expectations and opportunities.

This paper focuses on the IDP component of the PLM and reports on the experiences of graduate students and faculty mentors across the first three years of implementation. We analyze student-submitted IDP goals for alignment with the SMART framework, examine faculty self-reflections on mentoring practices connected to IDP use, and synthesize student perspectives from interviews and focus groups to understand how IDPs evolve from perceived requirements into tools that support meaningful mentoring conversations.

While IDPs are not a new tool in graduate education, the contribution of this work lies in examining how IDPs function as an implemented practice over time rather than focusing solely on IDP adoption or short-term outcomes. Specifically, this study contributes longitudinal evidence from the first three years of department-wide implementation, documents iterative design refinements informed by student and faculty feedback, and surfaces conditions under which IDPs shift from perceived compliance requirements to value-added mentoring infrastructure. In doing so, this work emphasizes practical insights for graduate programs seeking to sustain structured professional development practices within existing mentoring and administrative contexts.

2. Background

2.1 Incremental innovations and limited integration in graduate engineering education

In contrast to undergraduate engineering education, the pedagogy of graduate education has received comparatively little attention. A review of ASEE conference papers and CoNECD proceedings suggests that graduate engineering education includes many incremental advances, such as bridging programs, teaching preparation, interdisciplinary programs, industry engagement, professional communication development, and post-graduate preparedness initiatives, but that systematic, integrated, and structured delivery remains largely absent [15], [16], [17], [18], [19], [20]. Moreover, relatively few pedagogical approaches specific to graduate education are reported in this literature [19], [20]. This gap is consequential given national calls to modernize graduate STEM education and improve how educational innovations move from research to practice [2], [3], [4].

Recent efforts have begun to address these gaps through more comprehensive approaches. For example, implementing IDPs alongside faculty mentoring to support economically disadvantaged engineering students increased the number of student applications and awards for competitive fellowships [21]. This suggests that integrated approaches combining IDPs with other support structures can substantially improve graduate student outcomes.

2.2 Adding flexibility, structure, and scaffolding to personalize graduate education

Prior research on personalized or flexible graduate curricula suggests that flexibility is a useful ingredient but not sufficient on its own. For example, Ortiz describes movement toward a more personalized graduate curriculum [22]. Mistree and colleagues share a broader vision for personalized engineering education, connecting personalization with mass-customization principles and outlining how personalized learning can extend beyond course-level choices toward a holistic educational model [23], [24]. Building on this framing, the PLM described in this paper integrates modular coursework and structured professional development pathways (academia, industry, entrepreneurship) with goal-setting and reflection mechanisms intended to support individualized development at scale.

2.3 IDPs as a goal-setting and mentoring infrastructure within the PLM

Within the PLM, IDPs operationalize individualized instructional goals by prompting students to develop and revisit goals tied to training, research progress, and career development. Early in the first semester of the project, graduate students participated in a structured workshop and used CliftonStrengths® and the AAAS' myIDP platform to explore skills, interests, and values aligned with multiple career pathways [25], [26]. Students then declare an initial professional development stream while explicitly acknowledging that career plans may change, positioning the IDP as an iterative planning tool rather than a one-time compliance document. The model further frames the IDP as a mechanism to monitor progress and support recurring mentoring conversations each semester and during annual meetings.

Beyond the types of support provided, recent research emphasizes that *how* IDPs are implemented significantly impacts their effectiveness. Using an IDP combined with recurring conversations with mentors has been shown to be effective when mentoring relationships are positive and trainees are able to engage in career development activities [11]. However, research with computational science graduate students revealed that generic IDP tools often fail when students treat them as one-time compliance documents [27]. Recent work has documented graduate students' perceptions of IDP effectiveness, finding that while components such as mentor meetings and informational interviews are often viewed as beneficial, students also report challenges in participation and perceived utility [28]. Scaffolded activities focused on student agency, including envisioning future selves and practicing SMART goal-setting, dramatically improved adoption of IDPs to 55% of students compared to only 6% with traditional approaches [27]. Therefore, it seems likely that IDPs strengthen mentoring relationships when they support recurring feedback cycles between mentors and mentees and are integrated by the student for proactive career planning. Recent work further suggests that engagement with IDPs is not uniform across student populations, with motivation and perceived relevance shaping whether students meaningfully engage in the process. For example, [29] found that undergraduate STEM students' motivation was strongly associated with their level of engagement in IDP activities, highlighting the importance of contextual and developmental factors in IDP uptake.

Well-designed innovations are often abandoned if implementation knowledge and principles are not made explicit [9]. This motivates the present study's focus on early implementation, by examining student goal quality and stakeholder experiences over three years, we aim to identify what helps an IDP function as a living, supportive document and what conditions push it toward redundancy or perfunctory participation.

3. Methods

3.1 Setting and participants

The Chemical Engineering department at the University of Pittsburgh implemented a department-wide IDP process to support intentional, student-centered graduate training. After the initial year of the program, where all graduate students participated in a mandatory SMART goals/IDP workshop and were required to submit an IDP [7], subsequent cohorts consisted of first-year students who were required to attend, and a subset of advanced graduate students who chose to attend. First-year students completed the required SMART goals/IDP workshop and were required to submit an IDP. All other reflection activities were opt-in and recruited via email and in-person announcements in seminar. The graduate student cohort in this study included a total of 14 student participants who contributed qualitative data through interviews and focus groups. Quantitative analyses of IDP goal quality focus on seven first-year graduate students from the most recent cohort, for whom complete IDP submissions were available. Faculty reflections were collected from 11 faculty mentors who were primary research mentors of graduate students. Given small cohort sizes, demographic data were not collected or reported as a part of this study.

3.2 Data sources and timeline (Spring 2024–Summer 2025)

Graduate student perspectives were collected through a combination of individual interviews and focus groups conducted from Spring 2024 through Summer 2025. In the first round of data collection, four individual semi-structured interviews were conducted with graduate students to explore early perceptions of the IDP. Later, data collection shifted to small focus groups to facilitate discussion and reflection across students at similar stages of training and to efficiently capture a broader range of perspectives. Focus group data were collected over approximately 1.5 years, with 3–7 students participating per session depending on cohort size. All interviews and focus groups were conducted in person and followed a common semi-structured protocol with open-ended questions focused on IDP use, perceived value, timing and readiness, and mentoring interactions. Sessions were documented using detailed typed notes rather than audio transcription. A sample of interview and focus group questions are found in Appendix A.

Across this period, data sources included: (1) in-house student reflections via focus groups (10 participants) and individual interviews (four interviews; 4 participants); (2) 11 faculty-written reflections collected by email using a standardized prompt requesting candid feedback on the IDP and how faculty and students engaged with it; and (3) seven, first-year IDP submissions completed using a Gantt-style Excel template with tabs for Career Goals, Thesis Goals (aligned with myIDP's project management framework), and Professional Goals (aligned with myIDP's skills development framework).

3.3 Implementation refinements

Beginning with the cohort entering the graduate program in the Fall 2024, three modifications were implemented based on formative feedback: (1) separating the CliftonStrengths® activity from the SMART Goals/IDP workshop, (2) adding structured practice time and formative feedback on draft IDP goals, and (3) replacing AAAS' myIDP with a Gantt-style Excel IDP template aligned with the department's required thesis proposal timeline document and in a more familiar and user-friendly format. The SMART goals workshop introduced the SMART goals framework and purpose of IDPs over 90 minutes. Students practiced rewriting a sample of poorly framed goals, e.g. "Pass the comprehensive exam," using the SMART framework and provided peer review regarding any missing elements. New graduate students were then given 2 months to draft their first IDP based on a template provided by the department. An example of this IDP template is found in Appendix B. These refinements were in place for the first-year cohort whose IDP goal quality is reported here.

3.4 Qualitative analysis of student and faculty reflections

Faculty reflections were collected by email. Faculty mentors were asked to provide narrative reflections with the following prompt: "What we need from you is a few sentences or paragraphs of feedback on how you are experiencing the IDPs with your own students. We want to hear your impressions on the tool, how you and your students engage with it, pros, cons, etc. Please be candid so we can continue what is working and make adjustments to what might not be working." Responses were unstructured (free-response) to encourage candid feedback rather than constrained survey responses.

We used a hybrid deductive–inductive thematic analysis for graduate student and faculty data. For student qualitative data, the unit of analysis was a distinct idea or comment related to IDP use rather than the individual participant. During coding, a single participant could contribute multiple coded responses if they discussed multiple themes. However, repeated comments expressing the same idea by a single participant were coded once per theme to reduce overrepresentation by more vocal individuals. Student reflections were coded using a rubric with themes reflecting students' practical use of the IDP, mentoring interactions, perceived value, and areas for refinement. Faculty reflections were analyzed using the same framework used in a prior study (e.g., value, conversation framing, student difficulty with SMART goals, redundancy), with additional themes noted when mentioned by more than one respondent [7]. Credibility was supported through triangulation across student interviews, focus groups, faculty reflections, and IDP artifacts, as well as review of the hybrid coding framework by team members involved in data collection and student IDP discussions. Coded excerpts were audited to confirm consistency with themes that were initially established and iteratively refined.

3.5 SMART-elements coding of first-year IDP goals

Using a similar procedure as in [7], each goal was coded for presence (1) or absence (0) of each of the Specific, Measurable, Achievable, Relevant, and Time-bound elements from the SMART goal framework. The categories (Minimal, Average, Advanced) were defined by the research team based on the number of SMART elements present per goal. Thresholds were selected to distinguish between goals with limited SMART detail (0–1 elements), partially specified SMART goals (2–3 elements), and goals that included most or all SMART components (4–5 elements), consistent with prior work using SMART-element coding in graduate goal-setting contexts [7].

The unit of analysis included each goal with any associated tasks mentioned for that goal. Time-bound was coded as present if time language appeared in the goal/tasks or if the timeline was indicated in the Gantt chart. "Blank" goals for each category were treated as no submitted goal and assigned 0 SMART elements. For student-level comparisons, we calculated the average SMART elements per goal type and binned students as having Minimal (0.00–1.99), Average (2.00–3.99), or Advanced (4.00–5.00) SMART elements.

3.6 Human Subjects Institutional Review Board

This study was IRB-approved (IRB# 23070127). Participants provided verbal consent for interviews/focus groups; survey-style responses included the introductory script language at the beginning and were treated as implied consent by participation.

4. Results and Findings

4.1 Student reflections on IDPs as formative feedback

Student reflections were used to refine IDP implementation and workshop design. We coded student-comment "response counts" from interviews and focus groups: rising 2nd-years (7 students, 17 responses), 3rd-years (4 students, 10 responses), and 4th/5th-years (3 students, 14 responses), for a total of N = 41 responses from 14 students. Codes were assigned using a thematic rubric capturing the number of students who discussed: how they used the IDP for planning/tracking ("Using the IDP"), how the IDP shaped advisor conversations and feedback ("Working with Faculty Mentor and the IDP"), the perceived value and impact ("Helpfulness of the IDP"), the emotional/cognitive ease or difficulty of writing goals ("Ease of Writing the IDP"), the developmental fit for the student by program stage ("Timing and Readiness"), needs for additional supports and improvement ideas ("Support Needs and Suggestions"), and the perceived alignment with students' program/professional context ("Tool Fit and Alignment"). In Table 1, counts reflect the number of distinct coded responses associated with each theme rather than the number of individual students, as individual participants could contribute comments across multiple themes.

Table 1. Student reflection coded response counts on IDP use by theme and year-in-program (% total responses)

Theme	Rising 2nd-years (n=17)	3rd-years (n=10)	4th/5th-years (n=14)	Total Responses (N=41)
Using the IDP	9 (52.9%)	3 (30.0%)	4 (28.6%)	16 (39.0%)
Working with Faculty Mentor and the IDP	4 (23.5%)	5 (50.0%)	4 (28.6%)	13 (31.7%)
Helpfulness of the IDP	7 (41.2%)	2 (20.0%)	3 (21.4%)	12 (29.3%)
Ease of Writing the IDP	5 (29.4%)	2 (20.0%)	3 (21.4%)	10 (24.4%)
Timing and Readiness	4 (23.5%)	3 (30.0%)	3 (21.4%)	10 (24.4%)
Support Needs and Suggestions	4 (23.5%)	1 (10.0%)	5 (35.7%)	10 (24.4%)
Tool Fit and Alignment	5 (29.4%)	0 (0.0%)	3 (21.4%)	8 (19.5%)

Across cohorts, themes most frequently reflected students' use of the IDP as a planning/organizing tool (39.0% of all codes), followed by how the IDP intersected with advisor involvement, feedback, and expectation-setting (31.7%) and students' perceived value of the IDP (instrumental and/or conceptual helpfulness) (29.3%). References related to timing/readiness (24.4%) and support needs/suggestions (24.4%) further indicated that students often experienced goal-setting as a developmental task, becoming more valuable as their workload and research responsibilities increased. They also expressed that clearer scaffolding and practical support for translating goals into feasible plans was needed (Table 1).

Importantly, this reflection data was used to guide iterative changes to IDP implementation. Student feedback highlighted the need to: (1) reduce cognitive load during onboarding by separating CliftonStrengths® from SMART/IDP instruction; (2) add structured practice time and formative feedback on drafted goals; and (3) replace AAAS' myIDP, for which students often specifically expressed a dislike, with a Gantt-style Excel format that provided ease of use and aligned with their thesis proposal timeline document. We anticipated that these changes would support graduate students in writing clearer IDP goals and allow easier organization of the IDP into their thesis work. These refinements were implemented for the first-year cohort's IDP submission and whose initial goal quality is summarized in Table 2, enabling the quantitative goal analysis to be interpreted considering the feedback-driven redesign.

4.2 SMART-elements analysis of first-year IDP goals (Fall 2024)

Using the same SMART-element approach as [7], we categorized each first-year student's goals within each goal type based on the number of SMART elements present: Minimal (0–1.99), Average (2–3.99), Advanced (4–5). Table 2 shows the distribution of students across these bins for each goal type for the current first-year cohort (N = 7).

Table 2. First-year IDP goal quality (first submissions) by goal type using SMART-element bins (N = 7 students)

Goal type	Minimal (0–1.99)	Average (2–3.99)	Advanced (4–5)
Career	0 (0.0%)	4 (57.1%)	3 (42.9%)
Thesis (myIDP Project Management)	2 (28.6%)	2 (28.6%)	3 (42.9%)
Professional (myIDP Skills Development)	1 (14.3%)	1 (14.3%)	5 (71.4%)

As shown in Table 2, most students produced Advanced SMART Professional Goals (71.4%), with lower proportions for Thesis and Career goals (42.9% each). Compared to a prior evaluation of first-year SMART goals, where only 16.7% of students wrote Professional and Thesis Goals in the "Advanced" category and no students wrote Advanced Career Goals [7], this represents substantial improvement across all goal types.

However, this pattern across goal types is entirely consistent with first-year students' developmental stage. At the time of IDP submission (late Fall semester), students had joined research groups only a few months earlier and were primarily focused on coursework. They had not yet developed sufficient research domain knowledge to articulate specific, measurable thesis milestones. In contrast, professional skill development (e.g., "complete Python course," "attend 3 networking events") offers more predictable pathways accessible to novices and draws on existing self-knowledge rather than research expertise.

This developmental pattern, where students excelled at Professional goals but showed more variable performance on Thesis goals, directly motivated our decision to shift the SMART goals workshop from Fall to Spring semester for future cohorts, allowing students additional time to be integrated into their research topics before formalizing thesis milestones in their IDP. Taken together with the reflection findings (Table 1), these results suggest that the combination of improved instructional scaffolding and appropriate developmental timing can enhance students' ability to create actionable goals.

4.3 Faculty IDP Reflections

Faculty reflections (N = 11) echoed the themes reported in a prior paper [7], while also surfacing several new, actionable insights. Consistent with prior findings, most faculty described the IDP process as valuable for mentoring (n = 8, Table 3), particularly for promoting intentionality and creating space for individualized discussion. Additionally, many faculty mentors emphasized that the IDP is most effective when it frames advising conversations about goals, expectations, and progress rather than functioning as a stand-alone deliverable (n = 5, Table 3).

Faculty also reaffirmed a persistent implementation challenge identified previously. Students often require continued coaching to write meaningful SMART goals with sufficient specificity and measurable indicators (n = 4, Table 3). A smaller subset reiterated that IDPs can feel redundant when lab mentoring practices already include IDP-like structures (n = 2, Table 3).

Beyond these established themes, these faculty reflections surfaced several new considerations mentioned by more than one respondent. These new reflections are indicated in Table 3 with an "*". One new concern is that an overemphasis on completing the IDP spreadsheet can inadvertently promote a check-the-box/busy-work mindset, (n = 4, Table 3). Additionally, faculty also noted that usefulness of the IDP varies by stage of training, noting that early-stage graduate student's limited research understanding may hamper them in creating a viable IDP (n = 2, Table 3). This is consistent with the SMART goal quality from first-year graduate student IDPs related to their thesis, which has the largest proportion of "Minimal" and "Average" SMART elements (Table 2) compared to Career Goals and Professional Goals. Lastly, multiple faculty commented on the importance and difficulty of establishing a sustainable timeline for revisiting goals, particularly deciding when revisiting goals can realistically occur amid faculty time pressures (n = 2, Table 3). Therefore, to make IDP goal revisiting more sustainable, programs may need to schedule regular check-ins or tie them to existing advising routines, rather than leaving timing up to individual faculty.

Table 3: Faculty reflections on IDP use and implementation challenges by theme (N = 11 reflections). *, indicates additional themes observed in new data compared to those identified in [7].

Theme / Insight	Code Description	n (% reflections)
IDP is valuable for mentoring	Faculty view the IDP as useful for mentoring because it supports intentionality, individualized discussion, and planning	8 (72.7%)
IDP works best as a conversation tool (not a deliverable)	IDP is most effective when it frames advising conversations about goals, expectations, and progress rather than being a stand-alone product	5 (45.5%)
Students need coaching to write meaningful SMART goals	Students struggle to write specific, measurable SMART goals and benefit from continued guidance and feedback	4 (36.4%)
Risk of compliance / busy-work mindset*	Overemphasis on completing the spreadsheet may promote compliance behaviors unless framed as supporting mentoring conversations	4 (36.4%)
Redundant with existing lab mentoring structures	IDP may feel unnecessary in labs that already use structured mentoring systems similar to IDPs	2 (18.2%)
Developmental fit varies by stage*	IDP usefulness varies by stage of training; early-stage students have difficulty due to limited research clarity and competing coursework demands	2 (18.2%)
Need a sustainable cadence for revisiting goals*	Importance of establishing a regular rhythm (monthly/quarterly/mentoring schedule) to support follow-through and student ownership	2 (18.2%)

5. Implications for Engineering Education

The implications that follow are grounded directly in patterns observed across the qualitative and quantitative results. Specifically, student reflection themes (Table 1) highlight when and how IDPs were perceived as useful or burdensome; SMART-element goal analyses (Table 2) illustrate the effects of instructional scaffolding on goal quality; and faculty reflections (Table 3) surface implementation tensions related to redundancy, timing, and mentoring fit. Together, these findings inform the recommendations below for designing, framing, and sustaining IDPs as value-added mentoring infrastructure rather than compliance tools.

This study offers practical insights for graduate engineering programs seeking to implement IDPs as part of broader modernization efforts. Within the PLM, the IDP is intended to function not as a one-time participation product, but as a scaffolded infrastructure that supports individualized development at scale. Findings across three years of implementation suggest several implications for engineering educators and graduate program leaders.

5.1 Intentional framing helps prevent superficial IDP engagement

Both student and faculty reflections highlight a consistent tension; IDPs can easily become perceived as busy-work unless deliberately framed as a tool that adds value to mentoring conversations. Faculty expressed concern that overemphasis on completing the spreadsheet encourages a check-the-box mindset (Table 3), while student cohorts also initially viewed the IDP as a requirement rather than a resource. These findings align with diffusion theory, which suggests innovations are prone to discontinuance when implementation principles and practices are not clearly conveyed [9]. For graduate engineering programs, this underscores the importance of explicitly communicating the purpose of the IDP as a living document meant to prompt reflection, ownership, and discussion to both graduate mentors and mentees.

5.2 Scaffolding goal-setting early is essential, not optional

Consistent with our prior work [7], first-year graduate students often struggled to create goals that were specific and measurable, even when goals were relevant and achievable. However, this study provides additional evidence that targeted instructional refinements, including separating related onboarding activities, creating structured practice time, and adding formative feedback, were associated with measurably improved goal quality ([7] and Table 2). The shift from minimal/average SMART elements toward advanced-quality Professional Goals (71.4% advanced, Table 2) suggests that goal-setting is a learned skill that benefits from deliberate teaching, practice, and feedback, especially from their graduate mentors (Table 3). Additionally, first-year graduate students may have a better idea about the professional skills needed for their long-term career plans than about the goals for completing their graduate thesis project (Table 2), particularly early in graduate school when their project is still emerging. These findings have important implications for engineering graduate education, where many programs assume students already know how to define actionable milestones, timelines, and measures of progress for their thesis projects.

5.3 Tool design and institutional fit matter

Student feedback strongly motivated the replacement of AAAS' myIDP with an Excel-based Gantt template, cited by students as easier to use and aligned with departmental expectations for the thesis proposal. This change reflects that conceptually strong innovations can fail due to mismatches in usability or workflow integration. If IDPs are to be sustained within engineering departments, the tool must align with existing program structures, including thesis milestones, reporting expectations, and mentoring norms. Graduate programs should treat the IDP format as a flexible tool and select versions that integrate smoothly into ongoing training, rather than adding an extra system.

5.4 Flexibility for varied mentoring practices supports adoption

Faculty reflections indicate that mentors vary widely in how they structure mentoring, including groups that already employ IDP-like goal-setting practices. A rigid, uniform IDP implementation can therefore be experienced as redundant (Table 3). To support broader adoption, programs should design IDP processes that allow faculty flexibility in how they engage with the document, while maintaining a minimal shared structure that preserves program-level coherence and assessment. In practice, this suggests that implementation models should consider collecting information on how mentors work with their mentees in setting short- and long-term goals to inform what IDP format may already be in use within the department. Then, selecting a format that prioritizes shared outcomes and flexible pathways can ensure the new IDP process supports mentoring conversations regardless of mentoring style or strategy. Lastly, departments should invite feedback and be open to modifying the IDP process based on stakeholder insights.

5.5 IDPs are most impactful when paired with sustainable scheduling

Across student and faculty reflections, one recurring feature of effective IDP use is that it becomes valuable when revisited repeatedly through mentoring conversations. At the same time, faculty identified both time pressures and the need to determine the right frequency for revisiting the IDP as barriers to implementing IDPs (Table 3). This suggests that engineering departments should incorporate structured, sustainable rhythms for revisiting IDPs (e.g., each term or year, with mentor meetings linked to annual review or thesis milestone processes). Embedding the IDP within an existing departmental milestone or reporting structures may be more effective than adding new events, while still promoting goal follow-through and student ownership.

5.6 Limitations and context

Several limitations should be considered when interpreting these findings. First, this study reports on implementation within a single engineering department at an R1 institution, which may limit direct generalizability to other disciplinary or institutional contexts. Second, cohort sizes were small, and participation in interviews and faculty reflections was voluntary, which may bias findings toward individuals more engaged with mentoring and professional development. Third, although improvements in SMART goal quality were observed following implementation refinements, this study does not yet establish causal links between IDP use and longer-term outcomes such as time-to-degree, retention, or career placement. Consistent with recent research documenting variability in how students engage with and perceive IDPs, especially among different student groups (e.g., underrepresented minorities), our findings suggest that IDP adoption and impact may depend on individual motivation, training stage, and program context.

Finally, as reflected in both student and faculty data, IDP usefulness varies by stage of training and mentoring context, suggesting that even well-designed IDP processes may be less effective for early-stage students with emerging understanding of their research area or in groups with existing structured mentoring systems for career and project goal-setting. Taken together, these limitations reinforce the importance of studying IDPs as systemically implemented practices rather than static, optional tools, and motivate continued investigation into how timing, scaffolding, and institutional fit shape their effectiveness across graduate training contexts.

6. Conclusions and Future Work

This paper describes the implementation of an IDP process within a PLM for graduate chemical engineering education and synthesizes findings from the first three years of implementation. In this context, the IDP functioned as one of several complementary levers, supporting graduate students' active planning, reflection, and communication around academic and professional development. Across quantitative and qualitative data sources, results suggest that IDPs can serve as a meaningful mechanism for supporting intentional, student-centered development *when implemented with clear scaffolding, tool alignment, and explicit mentoring integration*. Rather than introducing a new mentoring tool, this work contributes evidence on how established practices such as IDPs can be adapted, refined, and sustained within a graduate engineering program. By focusing on implementation processes and stakeholder experiences across multiple cohorts, this study offers transferable insights for graduate programs navigating similar modernization and accountability pressures.

Importantly, after modifying the onboarding structure and adding guided practice and feedback, first-year graduate students produced more advanced-quality SMART goals than previously observed in their first IDP draft (Table 2 and [7]). This association indicates that even relatively small design changes, particularly those that reduce cognitive overload and provide formative feedback, can improve students' ability to translate abstract intentions into actionable professional and research development plans.

To build on these early implementation findings, we have made additional slight adjustments to the first-year workshop for SMART goals and IDP-writing. Both graduate students (Table 2) and faculty (Table 3) indicated that graduate students in their first term did not yet have the bandwidth and knowledge to write adequate SMART-goals, particularly regarding their own thesis research. Most first-year Ph.D. students in the University of Pittsburgh's Chemical Engineering department choose their research group in October and take 3 core graduate courses in the fall semester. Therefore, the first-year students who joined in the Fall 2025 semester will receive the SMART goals and IDP workshop in the Spring 2026 semester. We hope this change in the timing of professional development will lead to even more advanced SMART goals in students' first IDPs, particularly for thesis-related goals.

The next phase of work will focus on evaluating longer-term outcomes and strengthening the mechanisms that support sustained, value-added IDP use with graduate mentors and mentees. We plan to more directly link the professional development streams with IDPs, to ensure that students see the value, take advantage, and include these opportunities as a part of the broader PLM. Lastly, we will continue to examine how IDP engagement evolves over time, how it functions within mentoring conversations, and what scaffolds best support early-stage graduate students in writing actionable goals.

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APPENDIX A

Interview and Focus Group Protocols

1. How has your semester been going so far?
2. What accomplishments are you the most proud of?
3. What did you learn about yourself while taking the pre-IDP surveys and writing your IDP?
4. How has the process of writing your IDP been working for you? Are any parts of the IDP process not working for you?
5. Have you discussed your IDP goals with your faculty member?
6. What support or resources have you participated in for career development? Have they been helpful?
7. What questions do you have for me?

APPENDIX B

Example Individual Development Plan (IDP) Template for Dissertation or Thesis Goals

		2025	**2026**			**2027**			**2028**		
	Semester	1	2	3	4	5	6	7	8	9	10
SHORT-TERM GOALS (semester by semester)											
Goal 1:	**Match with a faculty advisor on a research project**										
Task 1	Meet with at least 3 faculty members to discuss projects by 10/10/25										
Task 2	Read relevant papers and those suggested by faculty; schedule follow up 10/20/25										
Goal 2:	**Pass the qualifying exam**										
Task 1	Prepare summary notes for all core classes										
Task 2	Give a practice qual to research group based on a previously assigned qual paper										
Goal 3:	**Demonstrate 2D Ga growth on spherical particles as verified by Raman Spectroscopy**										
Task 1	Grow buffer-layer graphene; verified by Raman spectroscopy on n= 20 particles										
Task 2	Directly mix Ga with high-purity SiC particles - complete CHet growth										
Task 3	Measure n = 20 particles with Raman spectroscopy										
LONG-TERM GOALS (years away)											
Complete proposal defense											
Complete one semester internship with semiconductor industry											