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Engineering Start-Up Packages: Mixed Methods Analysis of Composition and Implications for Early-Career Professional Formation

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Abstract

This paper is an evidence-based practice paper. In competitive research environments, many universities and engineering colleges utilize start-up or recruitment packages to attract potential candidates. These costs are distributed across multiple cost centers within the university ecosystem. Potential engineering faculty candidates may sign a probationary contract and are provided with role statements during onboarding processes. Within the role statement, research has been the primary area that is catalyzed with start-up funding. Typically, start-up funding has prescribed purposes by category. According to the 2019 American Society for Engineering Education (ASEE) Engineering Research Council (ERC) Startup Package Survey, "77.6% of the start-up packages were negotiated by categories." While start-up packages are well-known tools for recruitment in engineering, their composition, categories and cost-center distribution are less well described. **Methods:** Start-up packages (n=29) for assistant tenure-track engineering faculty hired between 2013-2019 within a midsize college of engineering at an emerging R1 were analyzed. The mixed methods study utilized descriptive analysis, themes and tree map charts to conceptualize and characterize the categories used. The study examined one question: How are the categories of assistant tenure track engineering faculty start-up packages different or similar across multiple departments? **Results:** The study contributes to the knowledge about early career engineering faculty professional formation. Specifically, the study revealed start-up packages as critical stimuli for the transition from graduate/postdoctoral student to paid assistant tenure track professor. Start-up package negotiations occurred where there are expectations and actions that are formative and not well described *a priori*. **Discussion:** Assistant tenure track professors had start-up packages that varied by department between 2013-2019. This study acknowledged that the seven cohorts did not all begin with the same start-ups within their six-year cycle. Some departments provided new candidates with less than $100,000 each while others invested over $430,000 per candidate. Based on the data, the survey and other secondary data examined some general recommendations were identified. Importantly, the data may be seen as a starting point for having informed conversations with others in the ecosystem and engineering faculty who are mentoring students and early career faculty. **Limitations:** The limitations of the study are that the data were sampled from early career faculty in the western US which may have different costs of living depending on the area. The data were collected as secondary data to demonstrate the significant investments institutions have in early career faculty and that this was a potential motivator and/or variable for grant writing and research.

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1. Introduction

1.1 Inception of the Study

This study was developed within a larger Action Research study published in [1]. The study contained four iterative cycles as a part of a study [2] which developed an on-demand, online intervention for providing professional development for early career faculty. In Cycle 0, the researcher interviewed five college and department staff members about factors influencing turnover and salary (n=4) was identified as the number one theme [1]. Within the interviews, participants discussed start-up packages, but few knew how the overall college managed and developed the packages. The gap in transparency was the inception and catalyzed the motivation for the study in this paper. The researcher determined that it was critical to assess if start-up packages may be a variable in motivating grant writing and research, but the study itself was a useful resource for discussion with faculty and administrators.

Since salary was a repeated theme by participants in Cycle 0 (n=5) and Cycle 1 (n=5) and linked to start-up packages, the researcher examined the national engineering trends for salary and placement as well as the limited number of studies on engineering start-up packages [1]. According to the National Science Board (NSB) and National Science Foundation (NSF) [3] between 2011–2019, slightly more than 90,000 engineering doctoral students graduated from US universities. While a select few entered the workforce in academia, there were other career pathways chosen by the doctoral graduates. In fact, the primary place of employment for doctoral holders has changed from being 90% in academia (i.e., 1980s) to 70% in academia in the present [3]. Table I demonstrated the median doctoral salaries in the engineering workforce in the US in 2019 across all sectors [3].

TABLE I

MEDIAN DOCTORAL ENGINEERING SALARIES ALL SECTORS FY 2019 [3]

Field	All Positions	Tenure/ Tenure Track	Postdoctoral	2 year or precollege institution	Government	Business or Industry
Engineering	$74,000	$87,000	$51,000	$73,000	$100,000	$119,000

Among the doctoral graduates who sought employment in academia, in 2021–22, a total of 7,706 reported as being assistant tenure track while another 5,020 were identified as non-tenure track [4]. Surprisingly, many candidates found themselves competing for a limited number of assistant tenure track and postdoctoral positions. Consequently, several transitioned to government positions such as national labs or agencies and within various sectors of business and industry, where they found numerous openings [3], [4]. For those acquiring academic positions, there was an additional caveat of a probationary employment contract typically based on a six-year cycle during which time assistant tenure track professors were required to demonstrate their innovation and scholarship, teaching and service [5], [6], [7].

The nuance of professional formation that this paper focused on was how the early career engineering faculty start-up packages are formative in the development of their research visions and enterprises [8], [9], [10]. This study leveraged and further contextualized findings in the 2019 ASEE ERC Start-up Survey [10] which included responses from 42 to 49 senior engineering faculty. There was an implicit understanding or a "feeling" that the start-up would be recouped via future research funding [1], [8], [10]. The National Science Foundation IUSE/PFE program has described professional formation as "the formal and informal processes and value systems through which an individual becomes an engineer [11]. This made the articulation, negotiation and acceptance of a start-up package potentially one of the earliest faculty professional formation skills accomplished within an engineer's professional role in academia beyond signing their employment contract. In many ways, it may be the first way that early career engineering faculty make critical decisions about their future research and professional formation.

2. Positionality

My positionality is unique in the context of the Engineering Community of Practice (ECoP) since I am a research development professional and mixed methods researcher who actively supports faculty grant success and professional development [12]. The data were collected as a part of my doctoral dissertation experience at Arizona State University as secondary data [1], [13]. I determined that they were a rich source for professional formation for early career engineering faculty and their potential mentors. The personal and professional lived experiences that I brought to this research were: 1) being a member who has spent ten years of her professional life working within an Engineering Community of Practice (ECoP) prioritizing early career engineering faculty and large proposals, 2) sharing over fifteen years' experience as a research development professional or grant writer, 3) being a researcher who has developed online and in-person interventions to support faculty research grant writing, 4) seeing the outcomes of decisions made related to early career engineering faculty professional formation and 5) as on who directly onboards each new faculty member in the ECoP by providing relevant grant writing and professional development resources [14], [15].

3. Background

Moving beyond the employment offer, the articulation of the role statement for a faculty member was central to professional formation. The role statement articulated at least three critical aspects of faculty life as well as promotion and tenure: 1) research, 2) teaching and 3) service [5], [6]. Within, the FY 2021 role statements of all tenure track faculty in a midsize college of engineering, "research was the largest component of the…. role statements (50%–80%), teaching

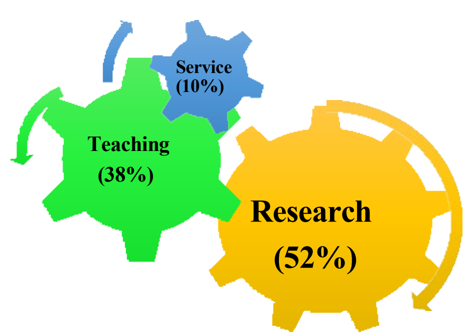

Fig. 1. *Early career Engineering Faculty Role Statement Mean Percentages* (Adapted from [1])

(15%–35%) and service (5%–20%)" [1]. Figure 1 demonstrates that early career engineering faculty in the fall 2021 had similar percentages in their mean role statement compositions.

As a result of the high percentage of research in the role statement, the start-up package was designed by the college, department and others to support a significant amount of research activities in the categorical items of the early career engineering faculty. There were times when the department chair worked actively with the candidate and other times when the candidate was asked to make a list of equipment and other items that might be needed. In the 2019 ASEE ERC survey, "77.6% of the respondents indicated that the start-ups were negotiated by category" [10]. Although the department chair was often the interface for the start-up negotiation, there were other cost centers involved in the provision of the start-up funding [1], [10]. This varied by individual candidate and the start-up was derived from the department, centers, college and the Office of the Vice President of Research [1], [10].

4. Methods

The two purposes of this research were to identify the characteristics of start-up packages and to assess if there was potential evidence of the connection of the start-up package to the research enterprise. The mixed methods research design for the early career start-up package analyses was guided by one question:

1. How are the categories of assistant tenure track engineering faculty start-up packages different or similar across multiple departments?

As a practitioner-researcher, I drew upon multiple theoretical perspectives, frameworks and worldviews to examine the problem related to early career faculty professional formation.

4.1 Data Collection

4.1.1 Context

The start-up packages were from a midsize college of engineering that had been routinely ranked among the top twenty on the NSF Higher Education Research and Development Survey (HERD) in engineering between 2013–2019 [16], [17], [18]. It has had between five and six departments during the time and 21 academic programs [1]. It was a Primarily White Institution (PWI) located in the western United States [19]. In 2021, there were 94 faculty members in the college, but only 31.91% or 30 were assistant tenure track professors [19]. Between 2013–2019, there were thirty-eight assistant tenure track faculty who were on staff or hired [20].

4.1.2 Data Collection Procedures

A Government Records Access Management Act (GRAMA) request was completed in the summer of 2021 to request a copy of the start-up packages for the assistant tenure track faculty in the midsize college of engineering [1], [13]. The GRAMA request was submitted to Legal Affairs in the Office of the Vice President of Research via their website protocol. Of the 38 engineering-faculty hired during the period, the university only sent copies of 29 start-up packages [1], [13]. The data were from biological engineering (BE), civil and environmental engineering (CEE), electrical and computer engineering (ECE), engineering education (EED) and mechanical and aerospace engineering (MAE). The data in Table II reported was without the start-up packages for nine research faculty in known departments which were primarily in engineering education, electrical and computer science engineering and civil and environmental engineering. Data were entered from 29 early career engineering start-up packages. Eighteen variable topics were identified within the 2013–2019 start-up packages and included both quantitative [21] and qualitative data [22]. This paper examines seven of the eighteen variables.

TABLE II

2013–2019 START-UP PACKAGE VARIABLES AND TYPES EXAMINED

Variable	Quantitative	Qualitative
Year		X (Categorical Data)
Total Start-Up Package	X	X
Department		X (Categorical Data)
Moving Expenses	X	
Professional Travel	X	
Equipment (>$5,000)	X	
Other (Supplies)	X	

In addition, descriptive coding [21] was used for the qualitative analysis of equipment and supplies to generate visualizations.

4.2 Data Tables

Between 2013–2019 the size of the start-up packages varied considerably by department as indicated by Figure 2.

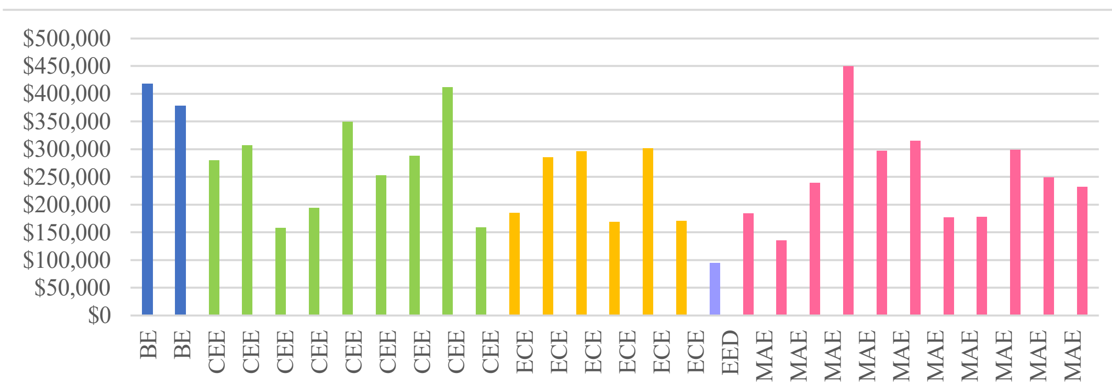

Fig. 2. *Start-Up Packages by Department between 2013–2019 (n=29)*

The highest individual start-up package was in the mechanical and aerospace engineering department. This start-up was $100,000 more than the mean of what MAE faculty received. When the researcher inquired further, it was noted that this was an experienced assistant tenure track faculty member switching institutions with a prior track record of grant funding. Therefore, within the institution and within the department the package size was an anomaly. It was believed the MAE candidate would successfully recoup the funding through grant development quickly and this belief was similar to those expressed in the 2019 ASEE ERC survey [10]. The lowest start-up package was in engineering education and was less than $100,000.

TABLE III

MEANS & STANDARD DEVIATIONS OF 2013–2019 START-UP PACKAGES BY DEPARTMENT * (n=28)

Department	Mean	Standard Deviation
BE	$398,418	± $28,257
CEE	$266,758	±$85,994
ECE	$234,747	±$65,735
MAE	$250,617	±$87,875

*Engineering Education not included due to GRAMA sample return

The start-up package means and standard deviations presented in Table III are the representative sample of the total start-up packages by department between 2013–2019. These dollar amounts do not include considerable lab and office spaces allotted as they were not quantified as a part of the package. They are typically discussed in negotiations as discussions occur, during interviews and as on-site tours are conducted.

Within Table III the means of the total packages and the standard deviations are described. Notably, the means vary from $234,747 to $398,418 in size but the standard deviations are perhaps the most interesting in CEE and MAE. The standard deviations of $85,994 within CEE cohort and $87,875 in the MAE cohort were large. ECE is close behind with a standard deviation of $65,735. MAE and ECE generated the most federal grant funding and CEE was third during the period [20]. The start-up package sizes don't reflect the federal grant funding acquired in many departments.

TABLE IV

MOVING EXPENSES MEANS & STANDARD DEVIATIONS OF 2013–2019 START-UP PACKAGES BY DEPARTMENT * (n=28)

Department	Mean	Standard Deviation
BE	$6,500	± $2,121
CEE	$9,286	±$951
ECE	$7,500	±$3,189
MAE	$9,182	±$4,622

*Engineering Education not included due to GRAMA sample return

The start-up packages including moving expenses among the negotiated costs ranged from zero dollars (n=5) up to $12,000 (n=1) per faculty member hired. Moving expense means also varied by department from $6,500 in biological engineering to a high of $9,286 in civil and environmental engineering. Mechanical and aerospace engineering had similar means for moving expenses to civil and environmental engineering. However, the standard deviation for moving expenses in mechanical and aerospace engineering was the largest. It was not communicated why moving expenses were not included in all the negotiated packages, but this may be an area of future study.

TABLE V

PROFESSIONAL TRAVEL MEANS & STANDARD DEVIATIONS BY DEPARTMENT * (n=28)

Department	Mean	Standard Deviation
BE	$10,000	± $2,828
CEE	$22,097	±$10,286
ECE	$11,083	±$4,903
MAE	$8,409	±$2,957

*Engineering Education not included due to GRAMA sample return

The means of professional travel were dramatically different by department. The highest standard deviation was in civil and environmental engineering. Biological engineering and mechanical and aerospace engineering had standard deviations that were closer in size.

TABLE VI

EQUIPMENT MEANS & STANDARD DEVIATIONS BY DEPARTMENT * (n=28)

Department	Mean	Standard Deviation
BE	$179,000	± $43,841
CEE	$95,399	±$78,648
ECE	$74,249	±$34,658
MAE	$101,455	±$86,390

*Engineering Education not included due to GRAMA sample return

Equipment was defined as items costing more than $5,000 per unit. The equipment means varied by department with the highest means being in biological engineering and mechanical and aerospace engineering. However, the standard deviations in civil and environmental engineering and mechanical and aerospace engineering had the largest spread. One potential explanation for the differences was that some faculty required more computational equipment than others.

TABLE VII

SUPPLIES CATEGORY MEANS & STANDARD DEVIATIONS BY DEPARTMENT * (n=28)

Department	Mean	Standard Deviation
BE	$59,250	± $27,224
CEE	$13,617	±$14,973
ECE	$7,887	±$5,074
MAE	$8,973	±$8,974

*Engineering Education not included due to GRAMA sample return

The supplies category included all items less than $5,000 per unit. This included supplies and two had services. The size of this category varied significantly by department. Biological engineering had the highest mean which was due to lab supplies and disposables. The second highest was in civil and environmental engineering which also had significant consumable lab supplies. Electrical and computer engineering and mechanical and aerospace engineering means were within $1,086 of each other.

4.3 Qualitative Data Observations

The start-up packages were coded using descriptive codes [22] in two variables or categories: 1) supplies and 2) equipment. Parameters were placed upon these terms before the items were coded. Items less than $5,000 per unit were considered supplies and those items that were greater than $5,000 per unit were considered equipment. None of the individual items were coded in both categories. Items were descriptive coded and most of the items identified were nouns that fit into one of the two categories [22]. For example, a Dell computer for $2,000 was coded as supplies while a CFD computer for $11,000 was coded equipment. Then, for each of the categories, theme-related components were identified within the start-up packages. Within supplies and equipment three themes emerged to describe the equipment and supplies in the start-up packages between 2013–2019: 1) advanced imaging, 2) advanced computation and 3) testing capabilities.

4.3.1 Supplies

The supplies for the start-up packages were diverse and distributed over multiple departments between 2013–2019. Figure 3 describes the eleven theme-related components within the supplies.

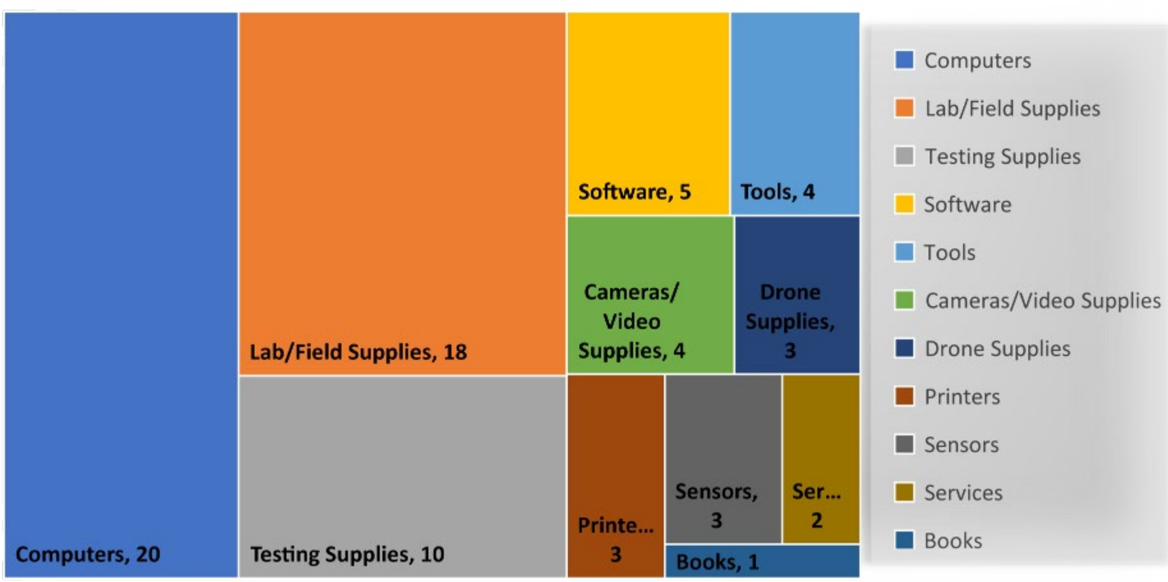

Fig. 3. *Detail Theme-components of Supplies in 2013–2019 Start-Up Packages*

Within the supplies, computers were the most frequent category of expenditure. Field/lab supplies and testing supplies were next, but the items were surprisingly simple requests among the seven cohorts.

4.3.2 Equipment

Figure 4 describes the fifteen theme-related components within the equipment.

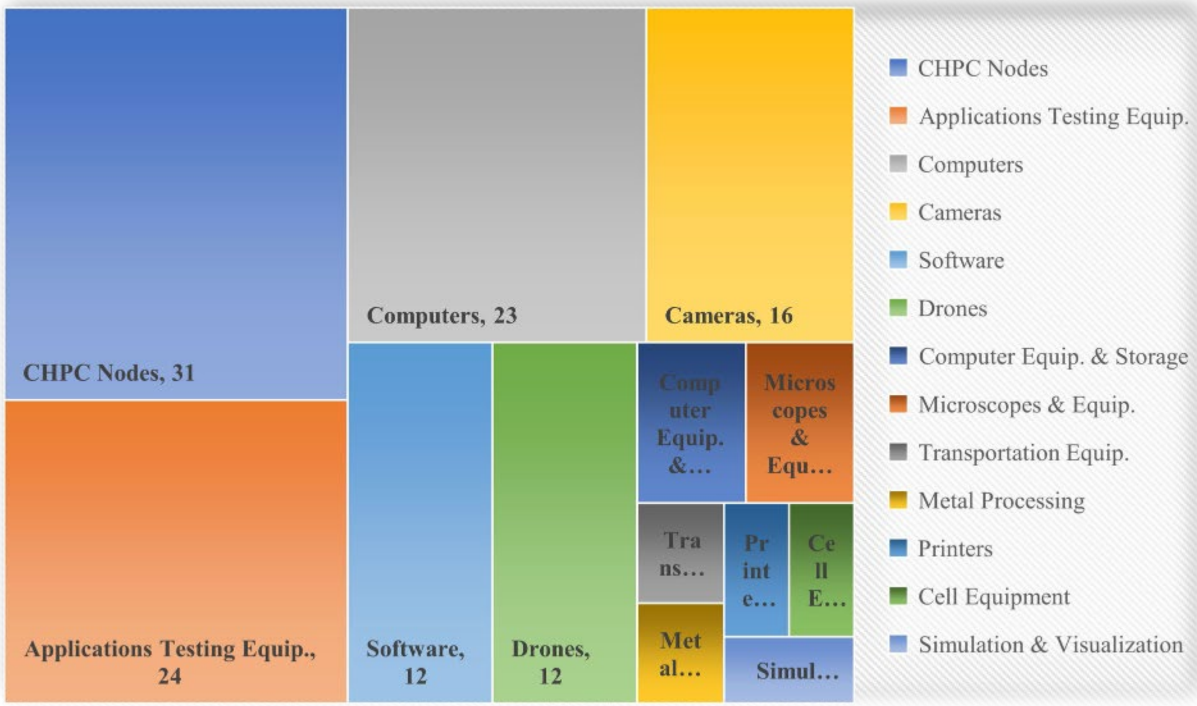

Fig. 4. *Detail Theme Components of Equipment in 2013–2019 Start-Up Packages*

The CHPC nodes, applications testing equipment and computers were the most prevalent equipment categories and expenditures in among the seven cohorts. The dominance of these expenses suggested potential for doing large purchases as a college or university to save costs.

5. Results

The mixed methods research study contributed to the knowledge surrounding the professional formation of early career engineering faculty and the development of their start-up packages. The data demonstrates that between 2013–2019 different cohorts of new hires within a midsize college of engineering negotiated different start-up packages with their department chairs. This was in alignment with the 2019 ASEE ERC Start-Up Survey [10] which reported that department chairs and others worked with early career faculty to develop the proposed start-up package. The package itself was typically funded across multiple entities within the university's ecosystem [10].

5.1 Quantitative Data from the Tables

The means and standard deviations for multiple variables were examined and selected categorical results were described. There is a clear pattern of subjectivity or flexibility in the start-ups. One observation is that although computers and CHPC nodes were prevalent in both equipment and supplies over the seven cohorts, no large-scale bundling of purchases was done to save overall costs annually. Many of the start-ups were completed in the spring semester for the fall. This suggests potential for bundling purchases. The engineering education data were not included in Table II–VII due to the GRAMA return sample. The total of the seven cohorts between 2013–2019 was $7,457,865.

5.2 Qualitative Data from Coding, Theme-Related Components and Themes

Three themes emerged from the descriptive coding and theme-related components within the start-up package categories of equipment and supplies. The total cost of the equipment was $2,448,948 and the total cost of the supplies was $440,903 for the start-up packages between 2013–2019 (n=29). The three primary themes were: 1) advanced imaging, 2) advanced computation and 3) testing capabilities. The supplies and equipment theme-related components were depicted graphically to demonstrate the range of items.

6. Discussion

The start-up packages represent seven cohorts of assistant tenure track faculty across five departments at an emerging R1 with high research expenditures. These were often negotiated by recent graduates and department chairs as a candidate was finalizing their new hire and/or onboarding materials. Since this occurs prior to direct experience leading and operating a research lab (i.e., engineering faculty professional formation), the act of negotiating a start-up package inherently assumes knowledge in several domains. For example, it assumes that the candidate has been exposed to the operating costs of a research lab in their field and that they have working knowledge of what the current costs for specific equipment, supplies and tuition and fees are. The start-up packages are not insignificant, ranging from just under $100,000 to over $485,000. There were expense restrictions and within these start-up packages the money from the vice president of research must be spent within the first few years or it will be swept (i.e., lost). For the data presented the total of the packages was nearly $7.5 million not including lab, office space, or academic salary and benefits. Nearly half of the total was for equipment and supplies. Importantly, the awards data for the period demonstrated that the start-up packages were excellent seeds for funding research programs [20].

From the data shared by the engineering faculty participants in [1], 2019 ASEE ERC survey participants [3], [8] and [10], it was evident that assistant tenure track faculty are highly skilled and valuable employees and perhaps more can be done to support the ecosystem related to the cost of doing business in academia with the recruitments and hiring of tenure track faculty. The recommendations may be helpful where policies are not known or transparent and there are differing *de facto* processes within the same ecosystem.

The following <u>**five recommendations**</u> may be helpful in supporting the professional formation of early career engineering faculty and/or developing an ECoP that supports them:

1. **Faculty/Department Chair**: Identify a senior administrator in the department who can discuss start-up package negotiation and composition with a graduate class.
2. **Faculty/Graduate Student**: Develop a draft start-up package using a real template from one of the candidate's choice schools.
3. **Graduate Student/Post-Doctoral Researcher/New Hire Candidate**: Acquire baseline costs for the field to implement a lab and talk to advisors about what they recommend.
4. **Department Chair/ Dean**: Ask recent graduates about their start-ups and what they would do differently and the same.
5. **Faculty**: Share individual deidentified start-ups with others so that new graduates will learn about the start-up market. Knowledge and transparency are empowering.

Very High Research (R1) and High Research Universities (R2) compete heavily for highly qualified research graduate and postdoctoral students transitioning to assistant tenure track faculty positions, particularly in engineering. The costs are significant. The following **five recommendations** may support the college/university in supporting early career faculty while reducing costs:

1. **Department Chair/Financial Officer/Purchasing**: Review line items in the start-up packages withing the three thematic categories including: 1) advanced imaging, 2) advanced computing and 3) testing capabilities to assess if a collective purchase of a particular item or group of items may be made. For example, within the start-up packages many of the new faculty requested multiple "name brand workstations for graduate students" and this is a necessary item. These could be purchased for a lower price as a bundle. The college/university has more purchasing power than an individual or department with their indexes.
2. **Department Chair/Financial Officer/Purchasing**: Review and discuss the start-up package costs with other department chairs to ensure that line items are reasonable and fair for the field.
3. **Dean/Provost**: Reward departments that support their faculty and staff with some of the line items and ensure that it is equitably distributed.
4. **Provost/Deans/Department Chair/Financial Officer/Purchasing**: Share individual recommendations for start-up package negotiations and cost saving with others. The ASEE community and individual universities will benefit from best practices in the field.
5. **ASEE members**: Share individuals' stories of when start-up negotiation went well and when it did not go well. The ECoP learns from each other.

6. Limitations

This study took place at a midsize college of engineering within the western US. The data presented are secondary data from a GRAMA request which provided (n=29) of the 38 early career engineering faculty start-up packages between 2013-2019. The data represents multiple departments including BE, CEE, ECE and MAE, but there was insufficient data for means and standard deviations for EED. Some data were not discussed due to sample size or other concerns about revealing the participants' identities. This paper is intended to be a starting point for the discussion of start-up packages and professional formation of early career engineering faculty and to encourage transparency and informed communication. Initially, the data were collected as secondary data to demonstrate the large investments some institutions have in early career engineering faculty as a motivation for grant writing and research in the academic research development ecosystem.

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