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Libraries' Role in Enabling New Engineering Research Investments: Working with Campus Research Administration Units

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Libraries' Role in Enabling New Engineering Research Investments: Working with Campus Research Administration Units

Abstract:

The role of libraries in academia is ever evolving with opportunities to influence research decisions at the highest level. University Libraries at Virginia Tech for multiple years now has been asked to support cutting-edge research investments with the goal of helping to galvanize complex, cross-disciplinary, and highly impactful research for years to come. With access to a variety of databases, software, and specialized experts, libraries can support and inform these research investments via discovery and analysis of: future and/or retrospective funding, research gaps and/or trends, market and industry trends, graduate programs, and more. At Virginia Tech, these research investments (Destination Areas) from the Office of Research involve engineering each year, covering areas such as AI, medical materials, and quantum navigation. This publication will present case studies (analyses and processes) for other librarians and/or research units to consider, leveraging the expertise of information sciences and academic libraries. The University Libraries, Virginia Tech have not only succeeded in this work, but enabled greater discovery of our talents and skills as research partners for the whole institution.

Key Words:
research offices, university initiatives, libraries, databases, funding, bibliographic mapping, interdisciplinary collaboration, strategic research tools; research intelligence; competitive intelligence; gap analysis

Introduction

In recent years, leadership at Virginia Tech have set strategic goals and initiatives[1] to increase our national and international reputation, increasing institutional support for expanding existing research and galvanizing new research. The University Libraries at Virginia Tech have contributed to many aspects of this effort, including: researcher metrics, collaboration support, and providing data and analyses for new research areas. One special effort, called "Destination Areas[2]", involved a call for internal proposals for seed funding from the Provost's Office on transdisciplinary research areas to help teams become national leaders with targeted support. University Library support for these Destination Areas was completed during September and October of the past two years.

The University Libraries at Virginia Tech have been involved in a variety of projects for the Provost and Office of Research in the past. Librarians, particularly from what is now the department of Research Impact and Intelligence (RII), have collaborated on many visible projects, demonstrating their expertise over the past decade and more. The director has a long-standing relationship with the tech transfer and corporate partnerships office and RII has provided valuable intelligence for many projects, including grants. As a result, leadership from the Provost's Office reached out during the first year of the Destination Areas for support to leverage the expertise of the libraries for this work. This was so successful that the request for support was repeated for a second year with an expanded list of areas. The libraries' support of the Destination Areas is expected to be an annual process, with some funding even going back to the libraries directly in the future.

As Virginia Tech has a large engineering school, these efforts have also involved the engineering librarian along with other subject specialists and experts in evidence synthesis, strategic research, data science, and research metrics. This past year alone there were over a dozen libraries' experts working on the Destination Areas to cover different parts of seven different internally funded grants. This publication focuses on how the libraries supported Destination Areas proposals and furthered their future competitiveness, highlighting replicable processes and expertise only libraries can bring to university-wide research projects. After a further introduction to the Destination areas and importance of this work for libraries, we cover examples from key aspects of this work: research landscapes (including gap analysis), funding, and research networks. Overall this publication seeks to highlight libraries' expertise, showing how we in libraries can contribute to university-level research initiatives, which so often include engineering.

[1] https://www.research.vt.edu/initiatives.html
[2] https://www.provost.vt.edu/destination_areas.html

Background

At Virginia Tech, Destination Areas are designed to leverage the expertise and assets that have been cultivated within the university to address compelling problems of global importance. Teams and their internal proposals are meant to be transdisciplinary communities that solve complex problems and will secure external funding, attract talented faculty and students, and facilitate greater impact for Virginia Tech at large. Topics range from tackling complex health, economic, and education disparities in rural environments to ecological and biocultural restoration projects. In 2024, seven teams were selected to submit a three-page proposal to the Provost's office for internal funding in two phases. Successful teams that win phase I awards are granted $50,000 to cover project development, travel, and graduate assistants over a six-month period. Successful phase I teams can apply for phase II funding, which allows for much greater internal funding over a five-year period and includes the potential for up to four new faculty lines to support that Destination Area.

To facilitate the success of team proposals, each team is provided a wide variety of internal university services, one of which is a gap analysis that allows researchers to understand in a data-driven manner the current research landscape of topics, external funding opportunities available, retrospective external funding awarded to similar projects, related existing patents, market and industry trends and reports, and academic and corporate related programs. The aim of the gap analysis is to understand more precisely the strengths and weaknesses of the proposing team so that projects are more competitive globally. Additionally, a gap analysis can provide intelligence on potential researcher recruits or collaborators who might fill existing and future needs. Both our Evidence Synthesis (ES) and Research Impact & Intelligence (RII) departments play a critical role in these gap analyses. RII was selected to lead the overall gap analyses due to prior successes and demonstrated expertise numerous members of the Office of Research and Innovation unit. Then, since literature reviews are often sought by the teams to understand the research landscape, ES was also included to provide evidence synthesis approaches, ideal for the needed precision in this work.

Gap analyses constitute a major component of "research intelligence," a central service of University Libraries' Research Impact & Intelligence department. Research Intelligence, or in some circumstances "competitive intelligence," involves extracting research and innovation data and analysis of data to enhance strategic decision making and is deeply related to and intertwined with research assessment and evaluation. Currently there are just a handful of "research intelligence" personnel in United States' academic library organizations, but many exist throughout Europe and Canada where research evaluation, research intelligence, and research impact are more centralized. Often European counterparts work in partnership with research offices, scientometrics researchers, and research policy experts. This European and Canadian model is the basis of "research intelligence" at Virginia Tech.

Besides bringing recognition to our University Libraries, this service and work with the Destination Areas demonstrates a model for institutions to fully leverage all faculty and staff towards large initiatives (global reputation). A brief survey of the literature demonstrates the advantages of these library-research office partnerships as well. Some libraries have already engaged in this work across the world, not just Europe and Canada [1], [2], [3]. These services not only improve research outcomes, but also can help ensure libraries' continued support by administrators [4].

This publication provides an overview and examples of gap analyses produced for Virginia Tech's Destination Areas last fall by the University Libraries. We describe research landscapes first by our ES department followed by work done by the RII department in funding and competitive research analyses. Each section additionally highlights tools utilized by our team and additional open options available even if we heavily rely on subscription databases and tools.

Research Landscapes

Not all questions can be addressed sufficiently with metadata alone. Sometimes, teams need to increase their understanding of the *content* of articles and other information sources to strategically position research agendas, frame a research need for grant proposals, inform the direction of a proposed intervention, etc. In these cases, the Virginia Tech Libraries leverages approaches from evidence synthesis methods such as scoping reviews, mapping reviews, and evidence gap maps. Although executing these methods in their entirety would not be feasible or appropriate given the need for a timely turnaround, adopting some of these approaches helps to decrease the likelihood of bias through practices like cherry-picking or systematic omission of relevant material by overlooking a vital resource, set of key terms, etc. To mitigate these potential harms, we take a systematic, transparent approach to gathering existing evidence ultimately improving the auditability and reproducibility of findings.

In 2024, the library team conducted a search for existing literature related to specific queries regarding resilient environmental infrastructure in urban environments. One of the defining characteristics of evidence synthesis methods not always practiced in strategic analytics is thorough documentation with the goal of procedural transparency. Thus, our team began with a set of shared working documents: a scope and term reference document, and a spreadsheet with two tabs for searchers to document findings and search strings, respectively.

Records were ranked as highly relevant (5 stars) to possibly relevant (3 stars) based on criteria provided by the research team. For each record, we documented the title, key sentences from the abstract or AI summary, publication date, reference type, publication URL or DOI, and search details such as through which tool (e.g., Scopus, Consensus, citation chasing with another

reference) the item was found, date found, limits applied while searching, and the associated search string. Full search strings were provided in the second tab of the spreadsheet and included notes regarding the usefulness of the search.

This level of transparency helped the library team to identify gaps and inconsistencies, and reduce risk of duplicate effort, allowing for more seamless course correction throughout the process. Research teams were provided with this documentation, accompanying results, so they could understand the steps we took and did not take. This approach allows research teams to better understand the boundaries of this exercise, encouraging responsible use of the library team's output, ultimately strengthening the integrity of subsequent research.

The purpose of this exercise was to locate specific, relevant records in a relatively transparent manner. The research team then used these records to inform their approach to designing and strategically positioning their interventions. In the following sections, approaches rely on less transparent methods for collecting a large number of records that are likely relevant due to a narrower set of key terms.

Databases & Tools

We collected literature through: (1) academic journal databases, (2) artificial intelligence (AI), and (3) citation chasing.

In evidence synthesis, literature is primarily gathered through the first resource - traditional academic journal databases. Databases included Engineering Village, Education Resource Complete (EBSCOhost), Environment Complete (EBSCOhost), Environmental Index (ProQuest), and Scopus. These scholarly databases remain useful for finding relevant information due to their scope of coverage and curation of vetted (e.g., peer reviewed) content. These database interfaces support systematic, transparent searching methods which improve reproducibility and auditability of results.

Although AI does not support transparent or reproducible searching, AI tools have become valuable for helping researchers and professionals find information quickly. We used *Elicit*[3], *Consensus*[4], and *Semantic Scholar*[5]. Given the requirements of this case, it was appropriate to search these tools casually using both keyword and Boolean approaches, as well as full sentence and question strings. We also leveraged the suggested questions provided by Consensus and Semantic Scholar to discover new terms and ways of conceptualizing our topics.

[3] https://elicit.com/
[4] https://consensus.app/
[5] https://www.semanticscholar.org/

Finally, highly-relevant records were processed through a citation chase using the *citationchaser*[6] shiny app [5]. Relying on data from Lens.org, this free tool rapidly locates all records cited by a reference (backward chase) and all records that have since cited that reference (forward chase). Examples of these searches are provided in the figures below (Figures 1 and 2).

Funding, Market, & Industry Analyses

As the Destination Areas' funding is intended to help galvanize research areas, principal investigators will need to seek their own funding in the future. As part of their proposals for phase II, demonstration of sustained future research funding was necessary.

By tracking the funders and opportunities in the last 3-5 years, we analyzed major funders in different domains such as government or foundations to understand the funding landscape. Grants by awardee institutions were also analyzed, including by corresponding programs, funding schemes, and specific funding directions. From this information, it is possible to track and analyze the highest funded research projects and teams, and to inform the strategic positioning of the teams' research given trends in relevant funding opportunities.

Some Destination Area teams also requested market and industry analysis to project consumer needs and locate other possible partnerships and/or funding sources. Market analysis was especially relevant for teams with the goal of product development such as medical devices, while industry was most relevant for those with workforce development goals. Depending on the breadth of the Destination Area, this can involve locating companies currently in the field who could be future competitors or collaborators.

Although funding, market, and industry analyses can be outside of usual subject liaison duties (except possibly business librarians), these are vital for supporting research at the university level. Due to Virginia Tech's advancement goals, these are critical to the Destination Areas to ensure continued development of research to patents to market, growing our global reputation.

[6] https://estech.shinyapps.io/citationchaser/

Example: Targeted Literature Landscape

Relevance	Relevance Rank	Title	Key sentences (if applicable)	Link	Date of Publication	Reference Type
Q2 Q3	★★★★★	A Participatory Design Case Study in Environmental Design Education	Students collaborated with community members to co-design park renovations through participatory workshops. Challenges included trust-building, time management, and navigating cultural differences. Participatory design enhanced student learning and increased community involvement in design processes.	https://doi.org/10.1145/3384772.33851	2020	Conference Paper
Q2	★★★★★	Building A Community Garden: A Collaborative Cross-Disciplinary Academic Community Engagement Project	(AI summary) A collaborative cross-disciplinary project using Academic Community Engagement (ACE) increased student engagement and developed a deeper sense of connection to the local community.	https://doi.org/10.1145/3384772.33851	2016	Article
Q2	★★★★★	CBEL in Practice: Case Study 4 Sustaining Community-Based Experiential Learning Projects Through Student-Led Initiatives	Student-led community-based experiential learning projects empower student teachers with agency and ownership, promoting long-term developmental growth through their involvement in these projects.	https://doi.org/10.1007/978-981-15-6003-3_7	2020	Article
Q2	★★★★★	Co-creating urban green infrastructure connecting people and nature: A guiding framework and approach.	(AI summary) Adaptive co-management of urban green infrastructure through Learning Alliances and Urban Learning Labs can improve the resilience of urban social-ecological systems, fostering social inclusion and sustainable development objectives.	https://doi.org/10.1016/j.jenvman.2018.09.083	2019	Article
Q2 Q1	★★★★★	Combination of Architectural, Environmental, and social aspects in stormwater management. A Case study of the university campus.	This paper presents three conceptions of the revitalisation of a part of campus of the Gdansk University of Technology with different approaches to stormwater management.	https://research-ebsco-com.ezproxy.lib.vt.edu/c/w5qwtr/viewer/pdf/ydkk5vdloz	August 2021	Journal Article
Q2 Q1 Q3	★★★★★	Community-Engaged Flood Mitigation and Ecological Restoration on a University Campus	Urban flooding is a major climate change risk mitigated by green infrastructure like tree plantings and restored natural buffers. We used participatory workshops to restore a creek bank with bioengineering and mixed planting methods. The project integrated perspectives across disciplines, emphasizing environmental justice and reconciliation.	https://doi.org/10.1088/2752-664x%2Fad5db3	2024	Journal Article
Q2	★★★★★	Contribution of an NGO to Environmental Education at a Primary School through the 'Project Garden Laboratory'	The 'garden laboratory' engages students in hands-on learning through gardening and environmental activities. Collaboration between the NGO and the school community transformed outdoor spaces into educational sites. The redesigned grounds serve as outdoor classrooms, enhancing experiential learning for students.	https://doi.org/10.11118/978-80-7509-963-1-0023	2024	Conference Article
Q3	★★★★★	Cues to care: A systematic analytical review	(from abstract) These underlying perceptual, cultural, and social mechanisms are immediate recognizability, communication of caring human intention or presence, and a consistency with local cultural traditions or social norms for landscape appearance. To identify trends and opportunities in CTC scholarship and implementation, we examine relationships among CTC and their mechanisms by reviewing literature citing any of the three foundational papers.	https://doi.org/10.1016/j.landurbplan.2020.103821	2020	Journal Article

Figure 1. Results of targeted literature landscape scan with relevance scores and publication information.

Search ID	Search String	Notes (e.g., good v. bad search / helpful, unhelpful)
1	(campus OR college* OR universit*) AND phytoremediation AND (urban* OR city OR cities OR municipal* OR metro* OR town*)	
2	10.17660/ActaHortic.2010.881.54	DOI for semantic scholar search
3	Continuing to explore from search 2 - used "related articles" feature in semantic scholar	
4	How does community-engaged green infrastructure co-design facilitate student experiential learning?	
5	("green campus" OR "sustainable landscape" OR "Green infrastructure") AND (("rain garden") OR "Bioretention basin*" OR "wetland*" OR ("green roof" OR "green roofs") OR ("green wall" OR "green walls") OR "Stream daylighting" OR "Stream restoration" OR "Urban forestry") AND (("mitigate flooding") OR ("reduce flood" OR "reduce flooding") OR "stream restoration" OR "Water security") AND ("Urban*" OR "town*" OR "City")	Helpful search, extracted a lot of articles and papers, dat 2014-2024
6	("green campus" OR "Ecosystem-Based Infrastructure" OR "sustainable landscape" OR "Green infrastructure" OR "Urban forestry" OR "Climate-Resilient Landscape System*") AND ("Ecological literacy" OR "Student engagement" OR "environmental art" OR "Experiential pedagogy" OR "Engagement-based learning" OR ("experiential learning"))	not that helpful search, found a few relevant articles, dat 2020-2024
7	(summary(Nature-Based Solution*) OR summary(Nature Based Solution) OR summary(Green infrastructure) OR summary(Green-infrastructure)) AND (summary(stream restoration) OR summary(Water security)) AND (summary(Urban*)) AND (summary(Resilient Landscape Infrastructure) OR summary(Climate-Resilient Landscape System*) OR summary(Adaptable Landscape Infrastructure))	Helpful search, extracted a few journal papers, dated fro
8	How does implementation of design strategies that bring together outdoor education and landscape restoration improve the relationship between community and ecosystem? (searched on consensus)	Its an average search, extracted a few papers relevant to question.
9	((green OR resilient OR bio retention OR storm water OR vegetation)) AND ((landscapes OR infrastructure OR socio-ecological OR habitat production OR biodiversity)) AND ((flooding OR storm water OR mitigation OR urbanization OR climate change))	ok for finding general information and case studies
10	("Nature-Driven Solution*" OR "Nature Driven Solution*" OR "Green infrastructure" OR "Green-infrastructure" OR ("rain garden") OR "Bioretention basin*" OR "wetland*" OR ("green roof" OR "green roofs") OR ("green wall" OR "green walls") OR "Stream daylighting" OR "Stream restoration" OR "Urban forestry") AND ("Community" OR "ecosystem*" OR "Communities" OR "student*" OR "citizen*" OR "relationship*") AND ("educat*" OR "learn*" OR "teach*" OR "class*" OR "classroom*")	Its an ok search, found a few good relevant articles, mos irrelevant.
11	("Nature-Driven Solution*" OR "Nature Driven Solution*" OR "Green infrastructure" OR "Green-infrastructure" OR "design strategies" OR "landscape restoration") AND ("Community" OR "ecosystem*" OR "environment*" OR "Communities" OR "student*" OR "outdoor education") AND ("relationship")	Its a good search, found some good relevant articles
12	SUMMARY(("Nature-Driven Solution*" OR "Nature Driven Solution*") OR ("Green infrastructure" OR "Green-infrastructure") OR ("green wall" OR "green walls) OR "design strategies" OR ("landscape restoration OR "Stream Restoration") AND (Community OR ecosystem* OR environment* OR Communities OR ecosystem* OR student* OR outdoor education) OR ("student*" OR "citizen*") AND ("relationship*"))	very helpful search, dated 2000-24
12	TITLE-ABS-KEY (("Nature-Driven Solution*" OR "Nature Driven Solution*") OR ("Green infrastructure" OR "Green-infrastructure") OR ("green wall" OR "green walls) OR " design AND strategies " OR (" landscape AND restoration OR "Stream Restoration") AND (community OR ecosystem* OR environment* OR communities OR ecosystem* OR student* OR outdoor AND education) OR ("student*" OR "citizen*") AND ("relationship*"))	very helpful search, dated 2000-24

Figure 2. Search string documentation from one database demonstrating the evolution of the search for this Destination Area.

Databases & Tools

We relied on multiple sources for finding past awarded funding and future opportunities including: Funding Institutional, Foundation Directory Online, USAspending.gov, and grants.gov. Other databases for market and industry analysis included MarketResearch.com and IBIS World. Out of all these databases, funding data tends to be the most accessible and can be readily found without any subscribed databases, while market and industry data might only be available for the most public of companies.

Funding Databases

Funding Institutional (FI) is one of Elsevier's research intelligence products that gathers current and past funding opportunities' data from across the world. The curated data ranges from small internal institutional funding and student travel grants to large NSF (National Science Foundation) and the European Commission's Horizon Europe. FI includes search options for current funding, awarded grants, and funders, however the search capabilities are more basic compared to Scopus. Often it is most efficient to search terms individually or only portions of a search statement (i.e. separate at the ORs) instead of inputting an entire complex search string. As a result, we exported all records found into a spreadsheet for further review after each individual search.

Foundation Directory Online focuses on foundations, corporate giving, and charities, which can be excellent sources of funding for some disciplines. The curated data includes grantmakers, grants, recipients, and even 990 tax forms as part of each grantmaker's financials. Foundation Directory is built around grantmakers with different overviews and options for more details: broad areas being funded, geographic distribution of recipients, and size of grants. As the search is fairly broad (arranged by subject area), when searching the Foundation Directory, we needed pick terms like "engineering" AND "biomedicine" versus "biomedical engineering." Descriptions of the funding available are not searchable, so searching topics like nanomedicine directly are not recommended since Foundation Directory will "guess" at subject areas. However, even with these search disadvantages, it is usually possible to narrow a search down to a feasible manual review number, as we did for these searches.

USAspending.gov and grants.gov are resources with official US government agency awards and funding opportunities respectively. Both databases are open access, making them a more feasible solution for institutions without regard to fiscal resources. Although government funding data is pulled into FI and Foundation Directory, the links in those resources direct back to the .gov sites and it can be advantageous to search them directly for targeted US grants. USAspending also includes government contracts, a source of funding that is not always well documented in other sources (a few are in Dimensions for instance). USAspending also has some useful visualizations produced by user searches such as grants funded over time and geographic distributions.

For industry and market research we utilized IBISWorld and MarketResearch.com, both subscribed databases that Virginia Tech has currently. IBISWorld provides industry reports with current performance, key companies, products and much more. MarketResearch.com provides some similar data and focuses on market outlook and performance with analyses at the company and product level. IBISWorld is organized around the North American Industry Classification System (NAICS) codes, which make searching for specific industries possible after finding possible NAICS from other sources like MarketResearch.com reports. Both databases do have general keyword searches, although are still similar to some of the funding databases listed above as they have less sophisticated search options. A more general approach with a feasible, but more lengthy manual review of results is also recommended for these databases. If an institution does not have subscription databases, sometimes general web searches can suffice to find industry information or the US Bureau of Labor Statistics.

Example: Retrospective Funding & Future Investments

One of the Destination Area teams requested a funding analysis and overview of the industry for their medical materials research area. We developed the searches in Funding Institutional, Foundation Directory, MarketResearch.com, and IBISWorld based on the requested keywords from the team and their initial proposal to our office of research. The team's goal was to cover initial funding through development of a product and learn about possible collaborators or competitors in their area. There were scant results, however, for foundations and charities, possibly due to this being a very technical Destination Area with the most funding interest held by government organizations.

Over half the grants found were from the National Institutes of Health (NIH), with the most results from those related to these health areas: cardiovascular, dental, arthritis and imaging. Many results were also from the National Science Foundation (NSF), especially their directorates for Mathematical & Physical Sciences plus Engineering. We also investigated specific materials specialties, finding how well the area has been supported over the past three years, finding that Johns Hopkins University was the most frequent recipient of grants (Figure 3). University of Michigan also had a continuing award from 1985 for an institutional training grant from NIH that was not included in Figure 3, but important information for the Destination Area team as they wish to galvanize this area here at its home institution.

After locating possible organizations for awards, the next step was to investigate the specific NIH and NSF programs relevant to the team. We performed this search via browsing the hierarchy on each organizations' pages and identifying the most relevant research foci, including those that also support mentoring and development.

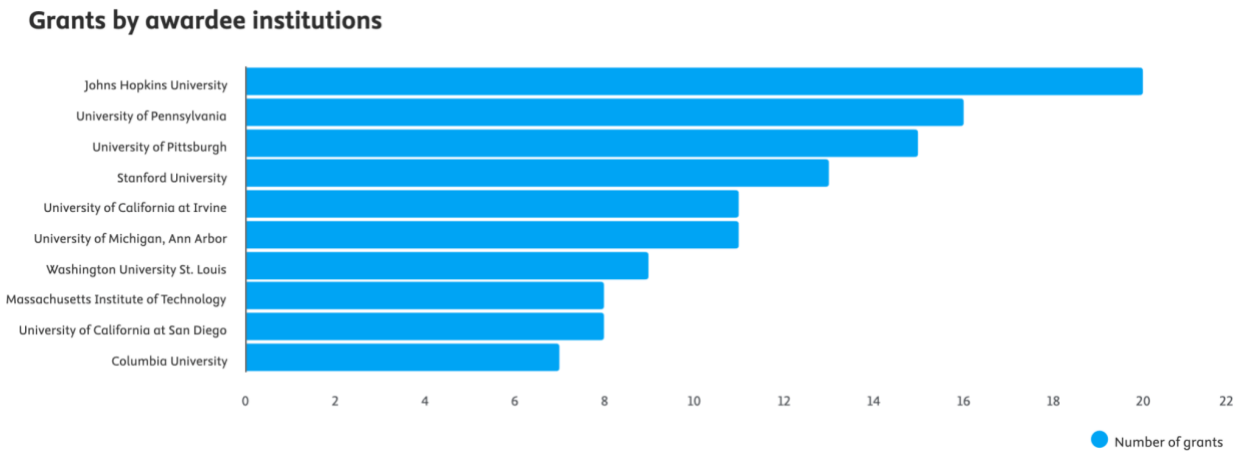

Figure 3: Recent awardees of materials and medicine related grants. Multi-year awards are not included if awarded longer than three years ago.

Last, we performed an overview of market and industry research in this area, searching both MarketResearch.com and IBISWorld for relevant reports. There were quite a number of possible markets with how broad this Destination Area was with the ones of most relevance being: Healthcare & Medical Devices and Materials Markets (for silicones and medical supplies). The research team was also interested in nanomaterials approaches, resulting in quite a long list of top companies (89) worldwide relevant to this Destination Area. These companies included those that even the general public might recognize the name: Abbott, Johnson & Johnson, and Pfizer. Each market was also investigated in further depth, such as the medical devices (Figure 4), which is only projected to grow due to the continuing technological developments and increasing needs of the US's elderly population.

Although some of the above information would be difficult to locate without the subscribed databases, any institution's librarian can start with open sources from the US government to find funding information. Market and industry information is more difficult and besides the US Labor Statistics, some major news companies cover this information (e.g. Forbes' lists).

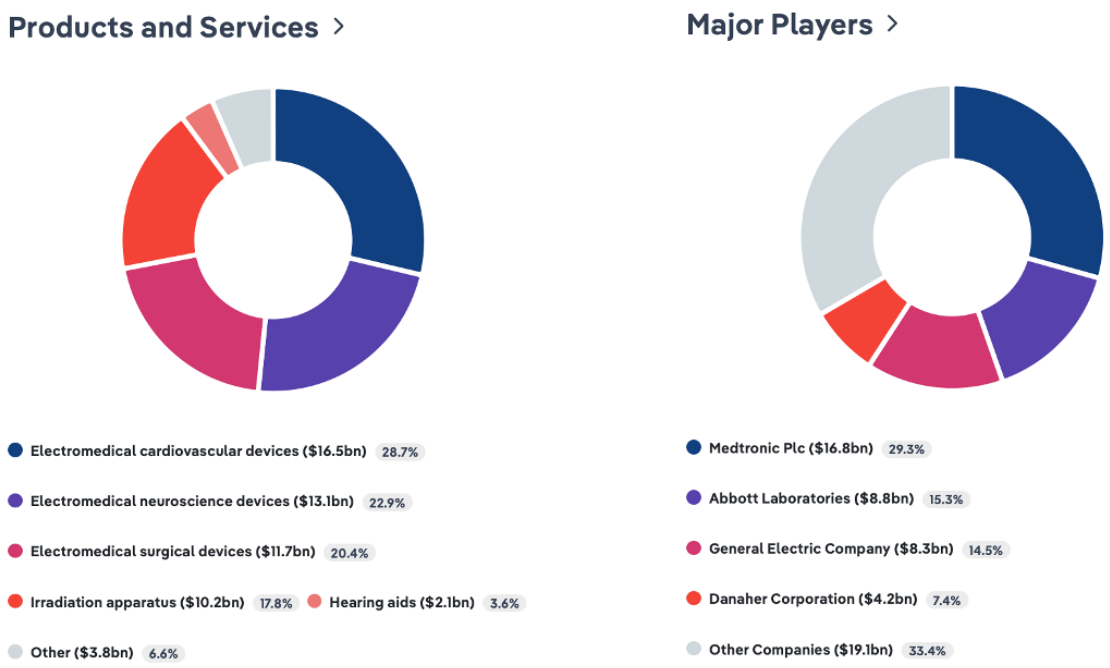

Figure 4: Medical device manufacturing in the USA. Products and companies comprising the market.

Research analysis: Units & Networks

At Virginia Tech, the Research Impact & Intelligence department typical fields requests for research analysis from colleges, departments, and institutes seeking to understand the impact, trends, and productivity of their units. We conduct research analysis using a variety of tools, both commercial and open source, including Elsevier's SciVal and Scopus, Clarivate Analytics' Web of Science and InCites, Digital Science's Dimensions, Tableau, and the free tools Publish or Perish and VOSviewer (discussed in a subsequent section). Much of the analysis involves working within these databases (e.g., Scopus, Web of Science) to identify scholarly works associated with faculty members, a process that can be time-consuming and tedious. Some units may also require altmetrics analysis to capture mentions across social media, news outlets, policy documents, patents, Wikipedia, online reference managers, post-publication peer review platforms, clinical guidelines, YouTube, and Q&A forums like Stack Overflow. The primary databases for altmetrics are Altmetric Explorer and Overton, which also focuses on policy documents in addition to altmetrics. The time required for analysis depends on the size of the unit, with larger units often requiring more time to process.

Much of this work involves identifying scholarly outputs associated with faculty, a process that requires careful attention to author disambiguation, name variants, and affiliations. Researcher identifiers such as ORCID iDs or Scopus Author IDs can aid this process but are not always

complete or error-free, so verification and manual cleanup are often necessary. Once a reliable set of publications is established, the data can be explored to uncover patterns in collaboration, topic areas, citation trends, and research outputs over time. Visualization tools can help communicate these findings, and metrics such as Field-Weighted Citation Impact (FWCI), citation counts, and scholarly output may be used to highlight areas of strength. However, these indicators should always be interpreted within context and with an understanding of their limitations. Metrics can be influenced by disciplinary norms, career stage, publication language, and database coverage, among other factors. When benchmarking is requested (tracking strategic research areas, Destination Areas in this case), we take care to frame results appropriately and, where possible, supplement quantitative data with qualitative insights.

Ultimately, the goal of research analysis is not to reduce scholarly contributions to a set of metrics, but to offer meaningful, contextualized information that can inform planning, support strategic initiatives, and foster reflection on scholarly activity and research impact.

Software & Tools

Research analysis can also involve a variety of software-based tools and coding in languages including Python or R. Unlike the proprietary/subscription resources listed above, many of these tools are open access or at least at a more accessible price point for many libraries. These software and tools also tend to have active support networks online with many YouTube videos, Reddit threads and even code packages on GitHub. Here we highlight some of the numerous software and tools used in research analysis.

VOSviewer: bibliometric analysis and data visualization
VOSviewer is a powerful free tool that has emerged in recent years, dedicated to the creation and visualization of bibliometric networks, such as author collaborations, keyword co-occurrence and citation analysis. It supports working with large datasets and generating intuitive visualization plots. In past projects, the medical materials research team has proposed the task of analyzing overall collaboration and publication trends in the field, including research dynamics and directions of internal and external authors and collaborators. Our goal was to provide strategic guidance for the team's subsequent research. During the analysis process, we used VOSviewer to map journal keywords and collaborator networks, clearly demonstrating the core and fringe keywords in the research and how they are related (Figures 5-7). This process provides important data support and reference for the team's research direction decisions, helping them to make more forward-looking strategic choices in future research.

SciVal API and Python: data retrieval
The SciVal API provides broad access to the research metrics and publication data of the Elsevier SciVal platform, supporting the retrieval of research results from around the world.

Combined with Python scripting, data retrieval and processing can be automated, greatly improving work efficiency. Research teams required our assistance in obtaining academic research data of the faculty members on campus, including the number of papers, citations, and h-index in the last 5 years, etc., to analyze the strengths and room for improvement in each research area. We mainly used Python as the data processing tool and common libraries such as Pandas and requests to design an efficient data retrieval and cleaning process. Our team successfully retrieved and processed hundreds of data records, integrated and cleaned the data through Python, and exported the results to CSV file format. The process effectively ensured the completeness and accuracy of the data set, providing a reliable data foundation for subsequent analysis and visualization.

Tableau: data visualization

Tableau is a leading data visualization tool that transforms complex data sets into interactive dashboards and visual reports that help users visualize key data metrics and trends. The tool is particularly important in bibliometric analysis to effectively demonstrate citation metrics, collaboration patterns, and trends in research outputs. Our library research team used this tool to support data-driven assessments of institutional research performance. With filtering and interactive features, researchers and faculty at Virginia Tech can easily explore research performance across disciplines and identify potential collaborations with on-campus and external institutions. With Tableau Desktop's data visualization capabilities, Virginia Tech decision-makers can intuitively analyze key data points and accurately assess the strengths and room for growth in their research areas, providing powerful data to support strategic decision-making.

Example: VOSviewer Maps

We conducted research gap analyses in support of Destination Areas in the fields of AI, medical materials, and quantum navigation. These analyses consisted of two key sections: 1) research activities within the organization, focusing on research group connections and internal collaborations, and 2) broader research landscape across external organizations. Below, we will use RII's analysis for the medical materials Destination Area research team as an example.

In analyzing research group connections, we extracted authors' data on keywords of publications and major co-authorships of active researchers in the university within the last 5 years. To ensure data accuracy and consistency, we applied thesaurus replacement in VOSviewer, standardizing synonymous terms and merging related keywords, like “mouse” and “mice”. This process enhances the clarity of the collaboration mapping and can reduce analysis errors due to keyword redundancy. Collaboration mapping was performed using VOSviewer as the main technical tool, which reveals the popular research topics in the field and the main contributing authors through the mapping display, providing a direction guide for subsequent research.

The publications' keyword visualization graph (Figure 5) helps identify the core research themes and "hot" areas of the research team by displaying the top keywords of the researchers' published academic results within the past five years. The graph is usually visualized based on metrics such as the frequency of keywords, clustering of themes, and number of scholarly outputs.

Co-authorship mapping (Figure 6) displays the collaboration network among researchers, revealing the overall structure and closeness of research collaboration within the university. By considering researchers as nodes and collaborations as edges, we constructed a visualization network reflecting academic collaborations. It demonstrates the density and structure of cooperation between different research groups.

Finally, in the analysis of researchers outside Virginia Tech, we mapped the authors (Figure 7) to analyze their research keywords and collaborators. This method is also used to select representative affiliations, funders, and topic clusters to provide strategic references for the research team. Representative authors who are strongly related to the analyzed field and have outstanding research results are extracted by screening the authors outside of Virginia Tech in the Scopus platform and sorting effectively according to the "documents by author".

In RII, VOSviewer is one of the most commonly used tools in the process of research network and citation analysis, however, researchers may need other tools when dealing with datasets of different sizes or specific analysis tasks. We also considered Gephi, an open-source tool that performs network analysis and visualization, supports large-scale networks, and offering greater flexibility in customizing graph layouts. Gephi can be employed to analyze our large-scale international collaboration networks extracted from Scopus data in the field of Biochemistry and Engineering. Also, R is an option via the bibliometrix package that provides a comprehensive framework for advanced performance metrics, including h-index trends over time, thematic evolution, and conceptual structure mapping. This package has been used to compare institutional research output and visibility across multiple academic departments over a 10-year span in other projects for our team. Other options including citespace, plotly, and CitNetExplorer can be applied to big datasets for hotspot discovery, author collaboration analysis, and citation history tracking.

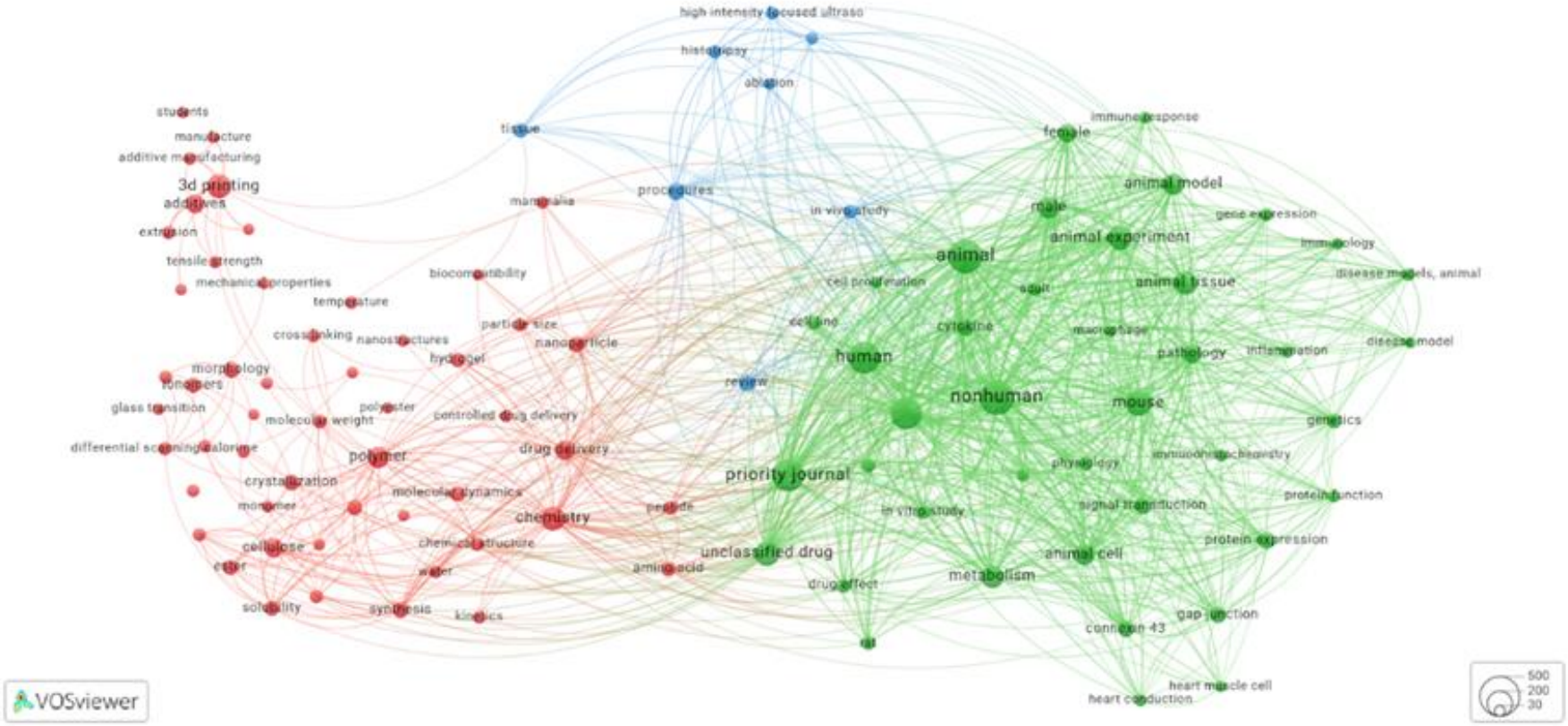

Figure 5: Top 100 Keywords from Virginia Tech's medical materials publications (2019-2024) visualized using VOSviewer, highlighting the most frequently occurring keywords in team publications (interactive version available here: Live Keyword Network)

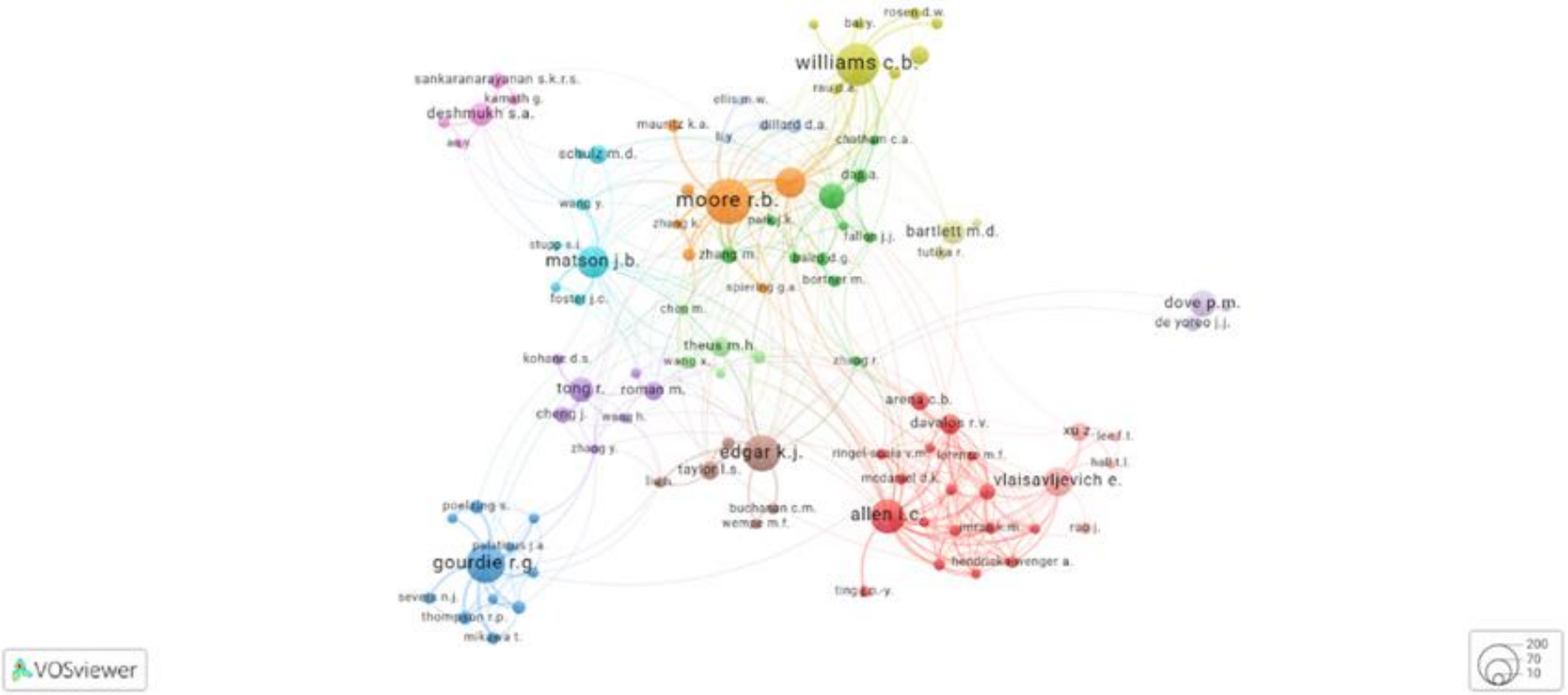

Figure 6: Top 100 most collaborative authors in medical materials at Virginia Tech (2019–2024) visualized using VOSviewer, illustrating collaborative relationships among team members based on co-authored publications (interactive version available here: Live Author Network)

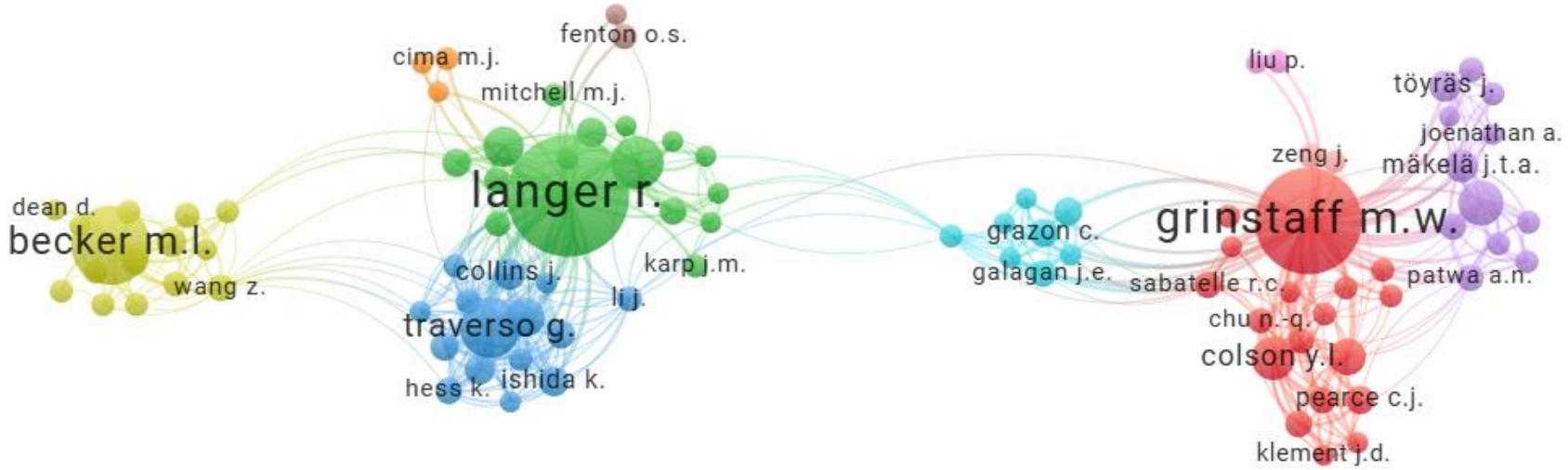

Figure 7: Top 100 most collaborative authors (2019–2024) visualized using VOSviewer, illustrating collaborative relationships among researchers outside Virginia Tech based on co-authored publications (interactive version available here: Live Author Network)

Conclusion & Outcomes

The Destination Areas required intensive work by the University Libraries as shown by the variety of support our experts team provided related to research landscapes, funding, and research networks. Not all seven research teams requested support in all areas and most only a couple with funding being most commonly requested. Although there can be limitations without funding for all the databases mentioned, we also highlight open resources that can be used for similar analyses such as grants.gov, US Bureau of Labor Statistics, and multiple R packages and tools.

There were also additional requests by Destination Area research teams that we did not cover in this publication as they required less intense work and/or did not require librarianship expertise. For example, some of the teams requested support in finding programs similar to theirs and especially for teaching or training aspects, these were not reflected in the publication data (occasionally in the funding data). Instead, general web searches via Google or others were sufficient. Overall, the seven teams were very grateful for our work, resulting in requests after the timeline for direct work on the Destination Areas and researchers selected for additional funding from the Provost's Office.

As we look towards next academic year’s call for Destination Areas, our University Libraries can expect some funding from the Office of Research for our participation. We did receive some minor funding this year, but none the year before, showing the increasing importance of this work. As our institution continues to expand their engineering research, we expect continued involvement of the engineering librarian in the Destination Areas and possibly a new librarian for our engineering-oriented research institutes. Here at Virginia Tech, the perception of the University Libraries has shifted to where we are becoming partners for large research endeavors and highly respected for our expertise.

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