DIRECT PROGRAM EVALUATION HIGHLIGHTS
Year 2
AUGUST 2018
FOCUS AREAS

- Data science tool use for clean energy research
- Data science knowledge and skill
- STEM career success
- Course and training alignment
- Interdisciplinary connections
DATA SCIENCE TOOL
USE FOR CLEAN
ENERGY RESEARCH

How capable do you feel about your ability to apply data science to your research?
Data science tool use for clean energy research?

- Awareness
- Diagnostic skills
- Network
- Faculty
- Teaching Assistants
“So now, I've graduated essentially from using scikit-learn to using full blown packages … and so I get to be a lot more flexible in the applications of data science in my research … a part of that was from the DIRECT projects that I worked on … where I got really familiar with making convolutional neural networks in Keras.”

-Trainee
“We can use neural network techniques to analyze ... more complex data, and also we can include many more parameters in the data analysis procedure. So, I think we had the minimum ... amount of using data science and now actually [it has] become very extensive ... I would say more than 50% of my research projects involve some sort of data science techniques.”

-Faculty
“... the knowledge that if I need ... a data science tool that I can know where to look and know there is such a vibrant community out there that has a lot of solutions to problems instead of me having to create something ... I needed data from a paper, and instead of having to contact the authors or something along those lines, I could just use an interpolation software ... That's something I learned about in class, in the NRT traineeship.”

-Trainee
What experiences help students gain confidence in communicating data science to varied audiences?
How has DIRECT contributed to …

Data science knowledge and skill?

• Projects
• Data science methodology
• Software engineering
• Courses
• Conversations
• Stand ups
“So, what [the DIRECT trainee] had learned in the data science program has sort of spread to some of the other group members. So, [the trainee is] definitely able to talk about how the data science can be used, what types of tools can be used when, this sort of thing.”

-Faculty
“I think it's cool to be able to educate people about the fact that [data science is] not just machine learning, but there's data processing, there's data analysis, there is machine learning involved in it, but there's also the whole idea of proper coding and software engineering, that I think people often forget about.”

-Trainee
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-Trainee
“I had enough knowledge to ask [computer science majors] particular questions about that, what they used, if they're going to do anything differently. So, basically be able to carry on a conversation with experts relative to me and ask the right questions.”

-Trainee
“I don't have a data science knowledge base personally, so, you know the tools that we are starting to use are really entirely a function of what [the trainee] has learned.”

-Faculty
“We are now dedicated to open data and open software publishing. All papers include the data and analysis software that we used to make each figure.”

“The student has been trying to convince me that machine learning can help estimate parameters. While this may be true, I am yet to see it doing better than traditional approaches.”

-Faculty
“The peak experience is almost completely attributed to my being involved with the DIRECT program, because I knew nothing about software engineering before I joined, and now I'm able to build software in a matter of 3 months, so pretty much every aspect I would attribute to the program. It really has just allowed me to have this experience on every level.”

-Trainee
STEM CAREER SUCCESS

• How aware are you currently of energy data science career opportunities for students?

• Based on your experiences, how aware are prospective employers of the DIRECT program's value?

• What was your level of confidence in your ability to attain attractive job/career prospects after completing your PhD when you began your DIRECT traineeship? Currently?
STEM Career Success?

- Software engineering skills
- Machine learning techniques
- Data Science Certificate
- Python packages
DIRECT trainees’ confidence level in their ability to communicate about data science increased from not at all/somewhat confident at the beginning to confident/very confident after 6 months in the program.

<table>
<thead>
<tr>
<th>Ability to attain competitive job opportunities ($n=43$)</th>
<th>Communicating about data science ($n=46$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.7</td>
<td>2.5 - 2.8</td>
</tr>
<tr>
<td>Not at all confident</td>
<td>Confident</td>
</tr>
<tr>
<td>2.5</td>
<td>3.2</td>
</tr>
<tr>
<td>Somewhat confident</td>
<td>Very confident</td>
</tr>
</tbody>
</table>

Not at all confident | Somewhat confident | Confident | Very confident
COURSE AND TRAINING ALIGNMENT

• How effective are the DIRECT courses at preparing trainees for their capstone projects?
• What skills, concepts, or knowledge required for student research and career competitiveness are not being supplied by SEDS and DSMCER?
Program course alignment?

- Prepared for capstone
- Open source coding practices
- Data science diagnostics
- Project-based learning
- Teaching assistants
“I thought that there was a nice balance between method, showcasing which methods are available and sort of teaching people like, ‘Hey, if you want to try to do something, try to find a method first. If you're using Pandas, it's probably there to get it better than you're going to do it, so I think don't reinvent the wheel.’”

- Trainee
INTERDISCIPLINARY CONNECTIONS

Increase understanding of how interdisciplinary connections between trainees and faculty change over time.
Interdisciplinary connections

- Network doubled
- Cross-departmental ties decreased
### Interdisciplinary connections

**Year 2 connectivity**

<table>
<thead>
<tr>
<th>Year 2 Network Relationships</th>
<th># of Network Members</th>
<th># of Ties</th>
<th>Avg # of Ties/Person</th>
<th>% of Cross-Dept Ties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research collaboration</td>
<td>75</td>
<td>201</td>
<td>2.1</td>
<td>38% (-3%)</td>
</tr>
<tr>
<td>Tools collaboration</td>
<td>74</td>
<td>311</td>
<td>3.5</td>
<td>44% (-4%)</td>
</tr>
<tr>
<td>Conversations</td>
<td>78</td>
<td>565</td>
<td>5.9</td>
<td>46% (-2%)</td>
</tr>
<tr>
<td>Across relationships</td>
<td>84</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Interdisciplinary connections

Sociogram Legends

<table>
<thead>
<tr>
<th>Network Member Category Identification</th>
<th>Network Member Department Identification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trainees</td>
<td>Chemical Engineering</td>
</tr>
<tr>
<td>Faculty</td>
<td>Chemistry</td>
</tr>
<tr>
<td>External</td>
<td>Electrical Engineering</td>
</tr>
<tr>
<td>Other Students</td>
<td>Human Centered Design &amp; Engineering</td>
</tr>
<tr>
<td>Other Faculty</td>
<td>Material Science and Engineering</td>
</tr>
<tr>
<td></td>
<td>Optimum Energy</td>
</tr>
<tr>
<td></td>
<td>PNNL</td>
</tr>
</tbody>
</table>

Legend:
- Yellow: Trainees
- Purple: Faculty
- Green: External
- Orange: Other Students
- Lilac: Other Faculty
Year 1 conversation network
Year 2 conversation network
Year 1 tool collaboration network
Year 2 tool collaboration network
Year 1 research collaboration network
Year 2 research collaboration network
DIRECT’s program **strengths** to build on:

- Design and implementation
- Data science tool use increase
- Increased communication about data science
- Increased confidence in future jobs/careers
- Project-based learning curriculum
DIRECT’s program **opportunities** for improvement:

- Refine capstone project
- Refine communication training
- Boost awareness of program in industry
- Consider adding project management training
- Consider adding software carpentry for non-computer science majors to the course sequence
Preparing for Year 3

Share lessons learned with stakeholders

Gather & analyze credible, actionable evidence

Share findings and use to develop program

Re-focus the evaluation

Theory-driven evaluation cycle