Board 394: Sustaining and Scaling the Impact of the MIDFIELD project at the American Society for Engineering Education (Year 1)

Dr. Susan M Lord, University of San Diego

Susan Lord is Professor and Chair of Integrated Engineering at the University of San Diego. She received a BS from Cornell University in Materials Science and Electrical Engineering (EE) and MS and PhD in EE from Stanford University. Her research focuses on the study and promotion of equity in engineering including student pathways and inclusive teaching. She has won best paper awards from the Journal of Engineering Education, IEEE Transactions on Education, and Education Sciences. Dr. Lord is a Fellow of the IEEE and ASEE and received the 2018 IEEE Undergraduate Teaching Award. She is a coauthor of The Borderlands of Education: Latinas in Engineering. She is a co-Director of the National Effective Teaching Institute (NETI).

Dr. Matthew W. Ohland, Purdue University, West Lafayette

Matthew W. Ohland is the Dale and Suzi Gallagher Professor and Associate Head of Engineering Education at Purdue University. He has degrees from Swarthmore College, Rensselaer Polytechnic Institute, and the University of Florida. His research on the longitudinal study of engineering students and forming and managing teams has been supported by the National Science Foundation and the Sloan Foundation and his team received for the best paper published in the Journal of Engineering Education in 2008, 2011, and 2019 and from the IEEE Transactions on Education in 2011 and 2015. Dr. Ohland is an ABET Program Evaluator for ASEE. He was the 2002–2006 President of Tau Beta Pi and is a Fellow of the ASEE, IEEE, and AAAS.

Dr. Richard A. Layton,

Richard A. Layton is Professor Emeritus of Mechanical Engineering at Rose-Hulman Institute of Technology. He received a B.S. from California State University, Northridge, and an M.S. and Ph.D. from the University of Washington. With Matthew Ohland, Layton is a co-founding developer of the CATME Smarter Teamwork system and the midfieldr R package for working with student unit records. He is a co-author of the Engineering Communications Manual, Oxford Univ. Press, 2017. He currently consults as a data visualization specialist using R.

Dr. Marisa K. Orr, Clemson University

Marisa K. Orr is an Associate Professor in Engineering and Science Education with a joint appointment in the Department of Mechanical Engineering at Clemson University.

Mr. Russell Andrew Long, Purdue University, West Lafayette

Russell Long, M.Ed. was the Director of Project Assessment at the Purdue University School of Engineering Education (retired) and is Managing Director of The Multiple-Institution Database for Investigating Engineering Longitudinal Development (MIDFIELD).

Dr. Catherine E. Brawner, Research Triangle Educational Consultants

Catherine E. Brawner is President of Research Triangle Educational Consultants. She received her Ph.D.in Educational Research and Policy Analysis from NC State University in 1996. She also has an MBA from Indiana University (Bloomington) and a bachelorâ€™

Dr. Joseph Roy, American Society for Engineering Education (ASEE)

Joseph Roy has over 15 years of data science and higher education expertise. He currently directs three national annual data collections at the ASEE of colleges of engineering and engineering technology that gather detailed enrollment, degrees awarded, research expenditures, faculty headcounts, faculty salary and retention data for the engineering community. He is PI of a NSF Advanced Technological Education

funded grant to build a national data collection for engineering-oriented technician degree and certificate programs at 2-year institutions. Prior to joining the ASEE, he was the senior researcher at the American Association of University Professor and directed their national Faculty Salary Survey. He also developed a technical curriculum to train analysts for a national survey of languages in Ecuador while he was at the University of Illinois as a linguistic data analytics manager and member of their graduate faculty. He has a B.S. in Computer Science & Mathematics, a M.S. in Statistics from the University of Texas at San Antonio and a Ph.D. in Linguistics from the University of Ottawa.

Sustaining and Scaling the impact of the MIDFIELD project at the American Society for Engineering Education (Year 1)

Abstract

A substantial investment by the National Science Foundation (NSF), including awards from Engineering Education and Centers in the Engineering Directorate and the Division of Undergraduate Education in the Education and Human Resources Directorate, has led to the creation and study of the Multiple Institution Database for Investigating Engineering Longitudinal Development (MIDFIELD). This large database of student records has yielded groundbreaking research on student pathways by a small interdisciplinary team of researchers. The team has shown that while individual engineering programs may have poor graduation rates, a multi-institutional view reveals that engineering programs as a whole graduate a larger fraction of students than other groups of disciplines [1]. The team has also shown that women and men have similar graduation rates in engineering, likely a result of efforts to make engineering education a welcoming environment for women and the high academic credentials of the women who do study engineering [2]. As with the overall graduation rate, individual institutions and programs can and do have outcomes that depart from this aggregate perspective. A comprehensive study of student pathways in various engineering disciplines provided practitioners with rich information specific to their disciplinary context [3, 4, 5, 6, 7, 8, 9, 10]. The team has also designed a variety of metrics that have provided researchers and practitioners with an improved understanding of student pathways [11]. The quality of the data source and the research team is attested by these substantial findings, multiple best paper awards, and other recognitions [1, 5, 6, 11, 12, 13]. An overview of MIDFIELD and research using it can be found in [14].

This paper provides updates on transitioning MIDFIELD to the American Society for Engineering Education (ASEE), documentation of institutional policies, and supporting a growing community of researchers in using the database including the second offering of the MIDFIELD Institute. This work is supported by the NSF Division of Engineering Education and Centers.

Transitioning of MIDFIELD to ASEE

MIDFIELD aims to be self-sustaining. Thus, we are developing a partnership with the American Society for Engineering Education (ASEE) that will separate data collection, database management, dataset distribution, and data archiving from the MIDFIELD research team. Institutions may be more willing to share data in this manner rather than going through a specific institution such as Purdue University, which has hosted the database since it (along with its architects) moved from Clemson in 2006. Archiving and maintaining the data collection at ASEE ensures that the current dataset will be preserved, that it will grow to include a larger and more diverse set of institutions, and that the dataset will be more accessible. This will ensure that these insights are able to continue and, through ASEE's national platform, influence multiple national stakeholders. Greater access will also enable replication of earlier studies – both for validation and to ensure the findings are robust as new institutions provide data.

During the initial phase of the transfer, the ASEE team discussed a proposed outline of activities to merge ASEE and MIDFIELD data collections with a number of stakeholder groups including the Engineering Deans Council Data Committee and the ASEE National Data Collections advisory board. Based on initial feedback, the project roadmap was modified to not merge ASEE's Profiles data collection and MIDFIELD data collection to allow institutions to retain control over all business rules associated with reporting for the public facing Profiles survey that may conflict with the detailed MIDFIELD data collection.

Documentation of Institutional Policies

MIDFIELD continues to maintain a website [15]. In addition to collecting student record information, through prior funding we have compiled academic policy information for each partner institution and many prospective partners. We have collected and coded catalogs from each partner institution to align with the time period of the data collected. For each partner institution and for each year they have contributed data to the MIDFIELD database, university catalogs were coded with respect to institutional policies pertinent to engineering students, such as admissions and satisfactory academic progress. Policy summaries have been completed for 40 institutions and are available to the public through MIDFIELD website [16]. The codebook is also available through the website and the NVivo project files can be made available to researchers who wish to include institutional context with their study of MIDFIELD variables and outcomes.

Expanding the Network of Researchers

Another important goal of this project is educating the broader research community, expanding the network of researchers capable of conducting this research, and sharing of innovative research methods in addition to the actual data. For these activities, we have created an R data package, ***midfielddata***, that provides a stratified sample of MIDFIELD data as a publicly available practice data set [17]. The practice data can be accessed and manipulated using ***midfieldr***, an R package that provides tools for studying MIDFIELD student unit record data [18].

The second MIDFIELD Institute was held August 3-5, 2022 with an optional help session on Tuesday August 2, 2022. Based on a survey we conducted of possible participants, we decided to host this workshop online using Zoom. We met for 4 hours per day from 1 pm to 5 pm Eastern Time with breaks approximately once per hour. The institute attracted 27 participants who registered and attended, representing 22 institutions. The agenda included

Wednesday August 3 Day 1, 1 pm – 5 pm

1-2 Introduction of Facilitators and MIDFIELD

2-3 Exploring data structure

3 -5 Guided Practice: overview of analysis procedure. Participants should check-in before they leave. Put possible research areas/questions in the chat. Indicate if open to working with someone else or prefer to work by themselves.

Thursday August 4 Day 2, 1 pm – 5 pm

1:00 – 1:30 Metaphors and Metrics

1:30 – 2:30 Guided Practice (finish stickiness)

2:30 – 3:30 Data visualization

3:30 – 5:00 Selecting your question with feedback from team members/consulting Which of the datasets do you think you will need?

Friday August 5 Day 3, 1 pm – 5 pm

1:00 – 2:00 Data Visualization: Expanding your graphical repertoire

1:30-2:30 Work on your research question (consulting with the MIDFIELD team)

3:30 – 4:30 Show us your progress, discussion

4:30 – 4:45 Wrap-up/Conclusions

Evaluation
At the conclusion of the workshop, participants were invited to complete a Likert-style survey. Eleven participants responded. Two participants reported not having installed R at the start of the workshop while the other nine had installed R, RStudio, midfieldr, and midfielddata. Participants were asked several questions and the distribution of their responses are shown in Figure 1. The top scale assists counting total agreement; the bottom scale assists counting total disagreement. The chart illustrates that respondents has a high level of agreement on all questions with only one "disagree" on each of 5 questions and no "strongly disagree" at all.

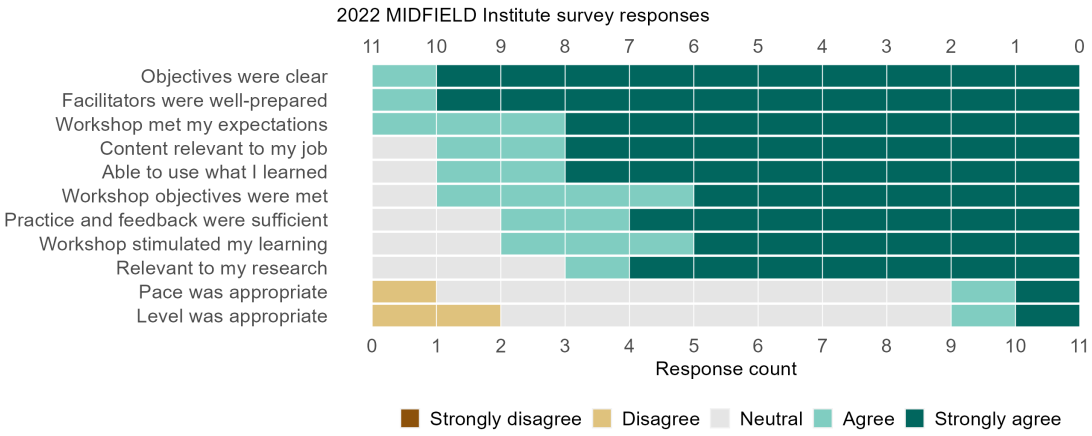

Figure 1. Post-workshop survey result from 2022 MIDFIELD Institute.

When asked what the most valuable about the workshop, participants shared

- The fantastic step-by-step tutorial really made it easy to understand how to parse through the data set. Appreciated all the perspectives provided and slides illustrating the different uses.
- Having so much time to ask questions (all types of questions) and being able to learn from others' questions. Also having time to work during the workshop helped so we could ask questions and get help right when we needed it. The presenters were excellent. I liked hearing the "how-to" parts about MIDFIELD and R and then also hearing examples of successful research papers that used the MIDFIELD data. And I will always remember the graph/chart presentations from Richard. My new favorite quote is the one from Edward Tufte about accessing the subtle and the difficult and "the revelation of the complex!" Thank you all for a great workshop!
- I also think the workshop worked very well (or was designed to work very well!) in an online format.
- Understanding what is and isn't available in MIDFIELD data and the kinds of questions it can be used to answer. It's one thing to read or hear about MIDFIELD in the wild, but you don't really get a handle on things that way. It's also nice to have the MF team in situ because they can say, "Yes, and..." and "No, because..."
- The logic flow demonstrated in the sample code to do things like narrow down to a focal population, connect to certain CIP codes, etc.
- Learn how to utilize MIDFIELD to answer the research questions and how to create meaningful data visualization to tell the story
- The data visualization guidance.
- Having multiple experts to ask questions and a hands-on approach on educational data.

In response to what was the least valuable part of the workshop, seven participants had no response or said "nothing." Two participants expressed frustration with R and two with the level of interaction of some of their breakout groups.

Participants provided several ideas for improving the workshop including logistics such as scheduled breaks or more time for R before the workshop so it could focus on MIDFIELD. Five participants had no suggestions. Others suggested:

- I loved the tutorials - the pre-workshop exercises. I just wish I had known to start them a week or so before the workshop, so the material could sink in. I signed up late, so that part is my fault. But it could be mentioned in promotional materials that the workshop will involve a couple of days of preparation time if you haven't used R or SAS or SPSS, etc. to let the material start to sink in. It took me a long time to complete the tutorials, but I learned a lot so it was worth it. I also really liked being able to be in a specific breakout room, with specific people. My room was AWESOME! I didn't know we could request that, so mentioning that near the beginning of the workshop would be good.
- The R novices needed more explicit guidance. It was great that copy-able code was provided, but there were not enough explanations for what the code did (like in-code commenting). I'm a pretty advanced R user but unfamiliar with the data.table syntax, and it took me quite a bit of effort to really decode all the steps in the case study. Also, there were times on days 1 and 2 when the instructions given were not entirely clear. The

language the speakers used didn't always line up with the things on the agenda and number of webpages I had to work across to follow along was too high. For example, on day 1, my group worked through the whole case study because we didn't realize that the last part was going to be the first thing on day 2.

- Setting aside the portion on data visualization, I think there are two separate MIDFIELD bodies of knowledge: 1) The overall structure of the data, what's included, what isn't and how that might relate to the research question someone has; 2) How to actually use the data to start answering questions. I think the workshop does a good job of 1). It was clear that some people had misconceptions about what MIDFIELD could answer … and they were resolved. I think 2) is really hard in a 3-day workshop. The R operations aren't intuitive and it's probably really hard for a newbie to make much sense of them. So, I think I'd probably spend more time thinking about storyboarding how someone might use MF to approach a question. That was touched on during Thurs, but something like: To answer X, you need to know Y. You could get Y by combining Z and Q. Z is in MIDFIELD, but Q would need to come from outside. I think that might have been more helpful on Thurs am than the R exercise. But I think there are good nuggets in the R exercises. They're worthwhile, but to really understand the scripts takes time.
- I think the data visualization was impactful for many people. It really could be separate, though it wouldn't really be a "MIDFIELD" workshop. Maybe having people come in with a graph from their work and think about how the things Richard talked about could be used to make the graph better would be an alternative to the second R script session.
- I think this was effective online. Some discussion might have been easier in person, but having access to chat is really nice b/c it allows you to ask questions/comment without interrupting the speaker.
- And chocolate would be nice.

Feedback from this evaluation will be used to improve subsequent offerings.

Dissemination and Products

Note that materials from the MIDFIELD Institute are available including the agenda, slides, and self-paced tutorials [19].

To raise awareness of MIDFIELD, we hosted a booth at the Exhibition of the 2022 *ASEE Annual Conference and Exhibition* in June 2022. In addition, the MIDFIELD data collection was highlighted in presentations for the Institutional Research & Analytics initiatives for 2023-24 and presented across multiple audiences by project personnel.

To reach audiences in engineering education in the USA and Europe and those who do institutional research, we have presented at several venues. In June 2022, we presented a paper at the 2022 *Annual Conference of the European Association for Education in Electrical and Information Engineering* (EEAIEE) in Portugal exploring domestic and international students in electrical engineering and information technology [20]. In September 2022, we presented a workshop and paper at the *Southern Association for Institutional Research* (SAIR) *Conference* in New Orleans, LA [21 , 22]. In October 2022, we presented a paper about international and

domestic students in the five most popular engineering disciplines, chemical, civil, electrical, industrial, and mechanical, at the *Frontiers in Education* (FIE) conference in Sweden [23].

Acknowledgments

We are grateful for the support of the National Science Foundation through Grants 2142087 and 214903.

References

[1] M. W. Ohland, S. D. Sheppard, G. Lichtenstein, O. Eris, D. Chachra, and R. A. Layton, "Persistence, engagement, and migration in Engineering," *J. Eng. Ed.,* vol. 97, no. 3, pp. 259-278, 2008.

[2] S. M. Lord, M. M. Camacho, R. A. Layton, R. A. Long, M. W. Ohland, and M. H. Wasburn, "Who's persisting in engineering? A comparative analysis of female and male Asian, Black, Hispanic, Native American and White students," *J. Women Minorities Science Eng.,* vol. 15, no. 2, pp.167-190, 2009.

[3] M. Pilotte, M. W. Ohland, S. M. Lord, R. A. Layton, and M. K. Orr, "Student Demographics and Outcomes in Industrial Engineering," *International Journal of Engineering Education*, vol. 33, no. 2A, pp. 506-518, 2017.

[4] M. K. Orr, S. M. Lord, R. A. Layton, and M. W. Ohland, "Student Demographics and Outcomes in Mechanical Engineering in the U.S.," *International Journal of Mechanical Engineering Education*, vol. 42, no. 1, pp. 48-60, 2014. https://doi.org/10.7227/IJMEE.42.1.5

[5] S. M. Lord, R. A. Layton, and M. W. Ohland, "Trajectories of Electrical Engineering and Computer Engineering Students by Race and Gender," *IEEE Transactions on Education*, vol. 54, no. 4, pp. 610-618, 2011. 10.1109/TE.2010.2100398

[6] S. M. Lord, R. A. Layton, and M. W. Ohland, "Multi-institution Study of Student Demographics and Outcomes in Electrical and Computer Engineering in the U.S.A.," *IEEE Transactions on Education*, vol. 58, no. 3, pp. 141-150, 2015. 10.1109/TE.2014.2344622

[7] C. E. Brawner, S. M. Lord, R. A. Layton, M. W. Ohland, and R. A. Long, "Factors Affecting Women's Persistence in Chemical Engineering," *International Journal of Engineering Education*, vol. 31, no. 6A, pp. 1431-1447, 2015.

[8] S. M. Lord, R. A. Layton, M. W. Ohland, C. E. Brawner, and R. A. Long, "A Multi-institution Study of Student Demographics and Outcomes in Chemical Engineering," *Chemical Engineering Education*, vol. 48, no. 4, pp. 223-230, 2014.

[9] M. K. Orr, N. M. Ramirez, S. M. Lord, R. A. Layton, and M. W. Ohland, "Student choice and persistence in Aerospace Engineering," *Journal of Aerospace Information Systems (JAIS)*, vol. 12, no. 4, pp. 365-373, 2015.

[10] M. W. Ohland, S. M. Lord, and R. A. Layton, "Student Demographics and Outcomes in Civil Engineering in the U.S.," *Journal of Professional Issues in Engineering Education and Practice*, vol. 141, no. 4, pp. 1-7, 2015.

[11] S. M. Lord, M. W. Ohland, R. A. Layton, and M. M. Camacho, "Beyond Pipeline and Pathways: Ecosystem Metrics," *Journal of Engineering Education*, vol. 108, no. 1, pp. 32–56, 2019. https://doi.org/10.1002/jee.20250

[12] M. W. Ohland, C. E. Brawner, M. M. Camacho, R. A. Layton, R. A. Long, S. M. Lord, and M. H. Wasburn. "Race, gender, and measures of success in Engineering Education," *J. Eng. Educ.,* vol. 100, no. 2, pp. 225-252, 2011. https://doi.org/10.1002/j.2168-9830.2011.tb00012.x

[13] 2013 Betty Vetter Award for Research https://www.wepan.org/wepan-awards Date Accessed April 10, 2023

[14] S. M. Lord, M. W. Ohland, M. K. Orr, R. A. Layton, R. A. Long, C. E. Brawner, H. Ebrahiminejad, B. A. Martin, G. D. Ricco, and L. Zahedi, "MIDFIELD: A Resource for Longitudinal Student Record Research," *IEEE Transactions on Education*, vol. 65, pp. 245-256, 2022. https://doi.org/10.1109/TE.2021.3137086

[15] MIDFIELD Website https://engineering.purdue.edu/MIDFIELD Date Accessed February 5, 2023

[16] https://midfield.online/policy-summary/ Date Accessed January 30, 2023

[17] R. Layton, R. Long, and M. Ohland, midfielddata: Sample of MIDFIELD Student Unit Record Data. R package version 0.1.3, 2018. https://github.com/MIDFIELDR/midfielddata Date Accessed January 30, 2023

[18] R. Layton, R. Long, and M. Ohland (2018). midfieldr: Tools for Studying MIDFIELD Student Unit Record Data in R. https://github.com/MIDFIELDR/midfieldr Date Accessed January 30, 2023

[19] Detailed information about MIDFIELD Institute including slides and tutorials are available at https://midfieldr.github.io/2022-midfield-institute/agenda.html Date Accessed January 30, 2023

[20] S. M. Lord, R. A. Long, R.A. Layton, M. W. Ohland, and M. K. Orr, (2022, June 29 - July 1). International students in undergraduate electrical and information engineering programs in the USA. 31st *Annual Conference of the European Association for Education in Electrical and Information Engineering* (EAEEIE), Coimbra, Portugal.

[21] M. K. Orr, M. W. Ohland, J. Roy, and R. A. Long, (2022, October 1). Undergraduate longitudinal data: Introduction to MIDFIELD. A workshop at *Southern Association for Institutional Research (SAIR) Conference*, New Orleans, LA.

[22] J. Roy, M. K. Orr, R. A. Long, and M. W. Ohland, (2022, October 3). Engineering education & COVID-19 emerging national trends. *Southern Association for Institutional Research (SAIR) Conference*, New Orleans, LA.

[23] S. M. Lord, R. A. Long, R.A. Layton, M. K. Orr, M. W. Ohland, and C. E. Brawner, (2022, October 8-11). Academic outcomes of international students in chemical, civil, electrical, industrial, and mechanical engineering in the USA. *IEEE/ASEE Frontiers in Education Conference*, Uppsala, Sweden.