

# Curriculum Vitae

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## CONTACT INFORMATION

University of Wisconsin – Madison  
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## FORMAL EDUCATION

- 2010 - 2013 Human-Computer Interaction HCI Institute, Carnegie Mellon University, Pittsburgh, PA, USA;  
Degree: Ph.D.;  
Ph.D. Certificates from Associate in Program for Interdisciplinary Education Research (PIER) and from the Pittsburgh Science of Learning Center (PSLC).  
Thesis title: *Conceptual learning with multiple graphical representations: Intelligent tutoring systems support for sense-making and fluency-building processes.*
- 2008 - 2010 Human-Computer Interaction HCI Institute, Carnegie Mellon University, Pittsburgh, PA, USA  
Degree: Master of Science
- 2004 - 2009 Psychology at the Albert-Ludwigs-University Freiburg, Germany;  
Degree: Dipl.-Psych., equivalent to combined Bachelor and Master of Science

## ACADEMIC POSITIONS

- Since 2022 Chair of the Learning Sciences Program in the Department of Educational Psychology, University of Wisconsin – Madison
- Since 2019 Associate Professor in the Department of Educational Psychology, University of Wisconsin – Madison
- Since 2014 Affiliate Professor in the Department of Computer Sciences, University of Wisconsin – Madison
- Since 2013 Director of the Learning, Representations, & Technology Lab, University of Wisconsin – Madison
- Since 2013 Principal Investigator at the Wisconsin Center for Education Research, University of Wisconsin – Madison
- 2013 - 2019 Assistant Professor in the Department of Educational Psychology, University of Wisconsin – Madison

## HONORS & AWARDS

- 2021 International Society of the Learning Sciences Early Career Award, awarded to exceptionally outstanding and innovative contributions of scholarly activities in the early stages of their career.

- 2021 Fellow of the Teaching Academy at the University of Wisconsin – Madison, awarded to individuals who have demonstrated teaching excellence.
- 2019 NAEd/Spencer Postdoctoral Fellowship
- 2018 Best Student Paper Nomination at the 13th International Conference of the Learning Sciences (ICLS 2018), with doctorate student Sally Wu
- 2018 NAEd/Spencer Postdoctoral Fellowship Semifinalist
- 2018 VIP (Visiting International Professor) fellowship by the Ruhr-Universität Bochum, Germany to outstanding scientists from around the globe to foster long-lasting international collaborations.
- 2017 CAREER award by the National Science Foundation
- 2016 Best Paper Nomination at the 9th International Conference on Educational Data Mining (EDM 2016)
- 2013 Best Paper Nomination at the 2013 SIGCHI Conference on Human Factors in Computing Systems (CHI 2013)
- 2013 Best Paper Award at the 6th International Conference on Educational Data Mining (EDM 2013)
- 2013 Siebel Scholar, Class of 2013: Awarded annually for academic excellence and demonstrated leadership to 85 top students from the world's leading graduate schools.
- 2009 Best Student Paper Award at the 14th International Conference on Artificial Intelligence in Education (AIED 2009)

## PUBLICATIONS

(bold indicates my own name; italicized names indicate students)

### ***Publications in Journals (peer Reviewed)***

1. **Rau, M. A.** & Beier, J. (in press). Exploring the effects of gesture-based collaboration on students' benefit from a perceptual training. *Journal of Educational Psychology*.
2. *Herder, T.* & **Rau, M. A.** (in press). Representational-competency supports in an educational video game for undergraduate astronomy. *Computers & Education*.
3. *Dorris, M.* & **Rau, M. A.** (in press). Conceptual challenges exhibited by naïve undergraduate students in the context of atomic orbital energy diagrams. *Journal of Chemical Education*.
4. **Rau, M. A.** & *Herder, T.* (2021). Under which conditions are physical vs. virtual representations effective? Contrasting conceptual and embodied mechanisms of learning. *Journal of Educational Psychology* 113(8), 1565–1586. <https://doi.org/10.1037/edu0000689>
5. **Rau, M. A.**, *Zahn, M.*, Misback, E., *Herder, T.*, & Burstyn, J. (2021). Adaptive support for representational competencies during technology-based problem solving in chemistry. *Journal of the Learning Sciences*, 30(2), 163-203. <https://doi.org/10.1080/10508406.2021.1888733>

6. Wu, S. P., VanVeen, B. & **Rau, M. A.** (2020). How drawing prompts can increase cognitive engagement in an active learning engineering course. *Journal of Engineering Education*, 109(4), 723-742. <https://doi.org/10.1002/jee.20354>
7. Donhauser, A., Küchemann, S., Kuhn, J., **Rau, M.**, Malone, S., Edelsbrunner, P., & Lichtenberger, A. (2020). Making the invisible visible: Visualization of the connection between magnetic field, electric current, and Lorentz force with the help of augmented reality. *The Physics Teacher*, 58(6), 438-439. <https://doi.org/10.1119/10.0001848>
8. **Rau, M. A.**, Keesler, W., Zhang, Y., & Wu, S. (2020). Resolving design tradeoffs of interactive visualization tools for educational technologies. *IEEE Transactions on Learning Technologies*, 13(2), 326-339. <https://doi.org/10.1109/TLT.2019.2902546>
9. **Rau, M. A.**, (2020). Comparing multiple theories about learning with physical and virtual representations: Conflicting or complementary effects? *Educational Psychology Review*, 32, 297-325. <https://doi.org/10.1007/s10648-020-09517-1>
10. Mason, B., **Rau, M. A.**, & Nowak, R. (2019). Modeling implicit knowledge about visual representations with similarity learning methods. *Cognitive Science*, 43(9), e12744. <https://doi.org/10.1111/cogs.12744>
11. Wu, S. P., & **Rau, M. A.** (2019). How students learn content in science, technology, engineering, and mathematics (STEM) through drawing activities. *Educational Psychology Review*, 31(1), 87-120. <https://doi.org/10.1007/s10648-019-09467-3>
12. Wu, S. P., Corr, J. & **Rau, M. A.** (2019). How instructors frame students' interactions with educational technologies can enhance or reduce learning with multiple representations. *Computers & Education*, 128, 199-213. <https://doi.org/10.1016/j.compedu.2018.09.012>
13. **Rau, M. A.**, & Wu, S. P. W. (2018). Combining instructional activities for sense-making processes and perceptual-induction processes involved in connection-making among multiple visual representations. *Cognition and Instruction*, 36(4), 361-395. <https://doi.org/10.1080/07370008.2018.1494179>
14. **Rau, M. A.** (2018a). Making connections among multiple visual representations: How do sense-making competencies and perceptual fluency relate to learning of chemistry knowledge? *Instructional Science*, 46(2), 209-243. <https://doi.org/10.1007/s11251-017-9431-3>
15. **Rau, M. A.** (2018b). Sequencing sense-making support and fluency-building support for connection making among multiple visual representations. *Journal of Educational Psychology*, 110(6), 811-833. <https://doi.org/10.1037/edu0000229>
16. Wu, S. P. W., & **Rau, M. A.** (2018). The effectiveness and efficiency of adding drawing prompts to an interactive educational technology when learning with conventional visual representations. *Learning and Instruction*, 55, 93-104. <https://doi.org/10.1016/j.learninstruc.2017.09.010>
17. **Rau, M. A.** (2017). Conditions for the effectiveness of multiple visual representations in enhancing STEM learning. *Educational Psychology Review*, 29(4), 717-761. <https://doi.org/10.1007/s10648-016-9365-3>
18. **Rau, M. A.** (2017). A framework for discipline-specific grounding of educational technologies with multiple visual representations. *IEEE Transactions on Learning Technologies*,

- 10(3), 290-305. <https://doi.org/10.1109/TLT.2016.2623303>
19. **Rau, M. A.** (2017). How do students learn to see concepts in visualizations? Social learning mechanisms with physical and virtual representations. *Journal of Learning Analytics*, 4(2), 240–263. <https://doi.org/10.18608/jla.2017.42.16>
  20. **Rau, M. A.** (2017). Do knowledge-component models need to incorporate representational competencies? *International Journal of Artificial Intelligence in Education*, 27(2), 298-319. <https://doi.org/10.1007/s40593-016-0134-8>
  21. **Rau, M. A., Aleven, V., & Rummel, N.** (2017). Making connections among multiple graphical representations of fractions: sense-making competencies enhance perceptual fluency, but not vice versa. *Instructional Science*, 45(3), 331-357. <https://doi.org/10.1007/s11251-017-9403-7>
  22. **Rau, M. A., Aleven, V., & Rummel, N.** (2017). Supporting students in making sense of connections and in becoming perceptually fluent in making connections among multiple graphical representations. *Journal of Educational Psychology*, 109(3), 355-373. <https://doi.org/10.1037/edu0000145>
  23. **Rau, M. A., Bowman, H. E., & Moore, J. W.** (2017). An adaptive collaboration script for learning with multiple visual representations. *Computers & Education*, 109(C), 38-55. <https://doi.org/10.1016/j.compedu.2017.02.006>
  24. **Rau, M. A., & Matthews, P. G.** (2017). How to make ‘more’ better? Principles for effective use of multiple representations to enhance student learning. *ZDM - Mathematics Education*. 49(4), 491-496. <https://doi.org/10.1007/s11858-017-0846-8>
  25. **Rau, M. A., Kennedy, K., Oxtoby, L., Bollom, M., & Moore, J.,** (2017). Unpacking “active learning” interventions: A combination of flipped classroom and collaboration support is more effective but collaboration support alone is not. *Journal of Chemical Education*, 94(10), 1406–1414. <https://doi.org/10.1021/acs.jchemed.7b00240>
  26. **Rau, M. A.** (2015). Enhancing undergraduate chemistry learning by helping students make connections among multiple graphical representations. *Chemistry Education Research and Practice*, 16, 654-669. <https://doi.org/10.1039/C5RP00065C>
  27. **Rau, M. A., Aleven, V., & Rummel, N.** (2015). Successful learning with multiple graphical representations and self-explanation prompts. *Journal of Educational Psychology*, 107(1), 30-46. <https://doi.org/10.1037/a0037211>
  28. **Rau, M. A., Michaelis, J. E., & Fay, N.** (2015). Connection making between multiple graphical representations: A multi-methods approach for domain-specific grounding of an intelligent tutoring system for chemistry. *Computers and Education*, 82, 460-485. <https://doi.org/10.1016/j.compedu.2014.12.009>
  29. **Rau, M. A., Aleven, V., Rummel, N., & Pardos, Z.** (2014). How should intelligent tutoring systems sequence multiple graphical representations of fractions? A Multi-Methods Study. *International Journal of Artificial Intelligence in Education*, 24(2), 125-161. <https://doi.org/10.1007/s40593-013-0011-7>
  30. **Rau, M. A., Aleven, V., & Rummel, N.** (2013). Interleaved practice in multi-dimensional learning tasks: which dimension should we interleave? *Learning and Instruction*, 23, 98-

114. <https://doi.org/10.1016/j.learninstruc.2012.07.003>

### ***Publications in Proceedings (Peer Reviewed)***

31. **Beier, J. P., & Rau, M. A.** (2022). Embodied Learning with Physical and Virtual Manipulatives in an Intelligent Tutor for Chemistry. In V. Dimitrova, N. Matsuda, & M. M. D. T. Rodrigo (Eds.), *Artificial Intelligence in Education. AIED 2022. Lecture notes in computer science* (pp. 103-114). Springer.
32. **Herder, T., & Rau, M. A.** (2022). Supporting representational competencies in an educational video game: What does and doesn't work. In V. Dimitrova, N. Matsuda, & M. M. D. T. Rodrigo (Eds.), *Artificial Intelligence in Education. AIED 2022. Lecture notes in computer science* (pp. 280-283). Springer.
33. **Rau, M. A., & Zahn, M.** (2022). Nonverbal collaboration on perceptual learning activities with chemistry visualizations. In V. Dimitrova, N. Matsuda, & M. M. D. T. Rodrigo (Eds.), *Artificial Intelligence in Education. AIED 2022. Lecture notes in computer science* (pp. 231-235). Springer.
34. **Rho, J., & Rau, M. A.** (2022). Preparing future learning with novel visuals by supporting representational competencies. In V. Dimitrova, N. Matsuda, & M. M. D. T. Rodrigo (Eds.), *Artificial Intelligence in Education. AIED 2022. Lecture notes in computer science* (pp. 66-77). Springer.
35. **Rho, J., Rau, M. A., & VanVeen, B.** (2022). Investigating growth of representational competencies by knowledge-component model. In A. I. Cristea & C. Brown (Eds.), *Proceedings of the 15th International Conference on Educational Data Mining (EDM 2022)* (pp. 346-352). International Educational Data Mining Society.
36. **Beier, J. P., & Rau, M. A.** (2022). The role of visual representations in impasses during collaborative problem solving in undergraduate chemistry. In Chinn, C., Tan, E., Chan, C., & Kali, Y. (Eds.), *Proceedings of the 16th International Conference of the Learning Sciences - ICLS 2022* (pp. 1888-1889). International Society of the Learning Sciences.
37. **Ramly, C. M., Sen, A., Kale, V. P., Rau, M. A., & Zhu, X.** (2021). Digitally training graph viewers against misleading bar charts. In *Proceedings of the 43rd annual meeting of the Cognitive Science Society, CogSci 2021* (pp. 1928-1934). Lawrence Erlbaum.
38. **Rau, M. A., Moore, J. & Burstyn, J.** (2020). Do affordances of classroom furniture affect learning in undergraduate active-learning courses? In M. Gresalfi & I. S. Horn (Eds.), *The interdisciplinarity of the Learning Sciences (ICLS) 2020* (Vol. 2, pp. 967-974). International Society of the Learning Sciences.
39. **Rau, M. A., Sen, A., & Zhu, X.** (2019). Using machine learning to overcome the expert blind spot for perceptual fluency trainings. In M. E. Isotani S., Ogan A., Hastings P., McLaren B., Luckin R. (Ed.), *Artificial Intelligence in Education. AIED 2019. Lecture notes in computer science* (Vol. 11625, pp. 406-418). Springer.
40. **Rau, M. A., & Schmidt, T.** (2019). Disentangling conceptual and embodied mechanisms for learning with virtual and physical Representations. In M. E. Isotani S., Ogan A., Hastings P., McLaren B., Luckin R. (Ed.), *Artificial Intelligence in Education. AIED 2019. Lecture notes in computer science* (Vol. 11625, pp. 419-431). Springer.

41. **Rau, M. A., Zahn, M., Misback, E., & Burstyn, J.** (2019). Adaptive support for representation skills in a chemistry ITS is more effective than static support. In M. E. Isotani S., Ogan A., Hastings P., McLaren B., Luckin R. (Ed.), *Artificial Intelligence in Education. AIED 2019. Lecture notes in computer science* (Vol. 11625, pp. 432-444). Springer.
42. **Rau, M. A., & Patel, P.** (2018). A collaboration script for nonverbal communication enhances perceptual fluency with visual representations. In J. Kay & R. Luckin (Eds.), *Rethinking learning in the digital age. Making the Learning Sciences count (ICLS) 2018* (Vol. 1, pp. 272-279). International Society of the Learning Sciences.
43. **Rau, M. A., & Zahn, M.** (2018). Sequencing support for sense making and perceptual fluency with visual representations: Is there a learning progression? In J. Kay & R. Luckin (Eds.), *Rethinking learning in the digital age. Making the Learning Sciences count (ICLS) 2018* (Vol. 1, pp. 264-271). International Society of the Learning Sciences.
44. **Sen, A., Puray, P., Rau, M.A., Mason, B., Nowak, R., Rogers, T., & Zhu, X.** (2018). Machine beats human at finding the optimal sequence of visual representations for students' learning of perceptual fluency. In K. E. Boyer & M. Yudelson (Eds.), *Proceedings of the 11th International Conference on Educational Data Mining* (pp. 137-146). International Educational Data Mining Society.
45. **Wu, S. P. & Rau, M. A.** (2018). Collaboration scripts should focus on shared models, not on drawings, to help students translate between representations. In J. Kay & R. Luckin (Eds.), *Rethinking learning in the digital age. Making the Learning Sciences count (ICLS) 2018* (Vol. 1, pp. 504-511). International Society of the Learning Sciences. **Best Student Paper Nomination.**
46. **Rau, M. A., & Wu, S. P. W.** (2017). Educational technology support for collaborative learning with multiple visual representations in chemistry. In B. K. Smith, M. Borge, E. Mercier & K. Y. Lim (Eds.), *Making a difference: Prioritizing equity and access in CSCL, 12th International Conference on Computer Supported Collaborative Learning (CSCL) 2017* (Vol. 1, pp. 79-86). International Society of the Learning Sciences.
47. **Sharma, K., Jermann, P., Dillenbourg, P., Rau, M., Pardos, Z., Schneider, B., D'Angelo, S., Gergle, D., & Prieto, L.** (2017). CSCL and eye-tracking: Experiences, opportunities and challenges. In B. K. Smith, M. Borge, E. Mercier & K. Y. Lim (Eds.), *Making a difference: Prioritizing equity and access in CSCL, 12th International Conference on Computer Supported Collaborative Learning (CSCL) 2017* (Vol. 2, pp. 727-734). International Society of the Learning Sciences.
48. **Wu, S. P. W., & Rau, M. A.** (2017). How technology and collaboration promote formative feedback: A role for CSCL research in active learning interventions. In B. K. Smith, M. Borge, E. Mercier & K. Y. Lim (Eds.), *Making a difference: Prioritizing equity and access in CSCL, 12th International Conference on Computer Supported Collaborative Learning (CSCL) 2017* (Vol. 1, pp. 279-286). International Society of the Learning Sciences.
49. **Rau, M. A.** (2016). Social, perceptual, and conceptual factors of learning with multiple external representations in educational technologies. In C.-K. Looi, J. Polman, U. Cress & P. Reimann (Eds.), *Proceedings of the International Conference of the Learning Sciences (ICLS) 2016* (Vol. 2, pp. 1378-1379). International Society of the Learning Sciences.

50. **Rau, M. A.** (2016). Pattern mining uncovers social prompts of conceptual learning with physical and virtual representations. In S. Barnes, M. Chi & M. Feng (Eds.), *Proceedings of the 9th International Conference on Educational Data Mining* (pp. 478-483). International Educational Data Mining Society.
51. **Rau, M. A., Mason, B., & Nowak, R.** (2016). How to model implicit knowledge? Use of metric learning to assess student perceptions of visual representations. In T. Barnes, M. Chi & M. Feng (Eds.), *Proceedings of the 9th International Conference on Educational Data Mining (EDM 2016)* (pp. 199-206). Raleigh, NC: International Educational Data Mining Society. **Best Paper Nomination.**
52. **Rau, M. A., & Pardos, Z. A.** (2016). Adding eye-tracking AOI data to models of representation skills does not improve prediction accuracy. In S. Barnes, M. Chi & M. Feng (Eds.), *Proceedings of the International Conference on Educational Data Mining (EDM 2016)* (pp. 622-623). International Educational Data Mining Society.
53. **Rau, M. A., Wu, S. P., & Schuberth, J.** (2016). Sequencing physical representations with human tutors and virtual representations with a computer tutor in chemistry. In C.-K. Looi, J. Polman, U. Cress & P. Reimann (Eds.), *Proceedings of the International Conference of the Learning Sciences (ICLS) 2016* (Vol. 2, pp. 1173-1174). International Society of the Learning Sciences.
54. *Peterson, J., Pardos, Z., Rau, M. A., Swigart, A., Gerber, C., & McKinsey, J.* (2015). Understanding student success in chemistry using gaze tracking and pupillometry. In C. Conati, N. Heffernan, A. Mitrovic & M. F. Verdejo (Eds.), *Artificial Intelligence in Education. AIED 2015. Lecture notes in computer science* (pp. 358–366). Springer.
55. **Rau, M. A.** (2015). Why do the rich get richer? A structural equation model to test how spatial skills affect learning with representations. In J. G. Boticario, O. C. Santos, C. Romero, M. Pechenizkiy, A. Merceron, P. Mitros, J. M. Luna, C. Mihaescu, P. Moreno, A. Hershkovitz, S. Ventura & M. Desmarais (Eds.), *Proceedings of the 8th International Conference on Educational Data Mining (EDM 2015)* (pp. 350-357). International Educational Data Mining Society.
56. **Rau, M. A., & Wu, S. P. W.** (2015). ITS support for conceptual and perceptual processes in learning with multiple graphical representations. In C. Conati, N. Heffernan, A. Mitrovic & M. F. Verdejo (Eds.), *Artificial Intelligence in Education. AIED 2015. Lecture notes in computer science* (pp. 398–407). Springer.
57. **Rau, M. A., & Evenstone, A. L.** (2014). Multi-methods approach for domain-specific grounding: An ITS for connection making in chemistry. In S. Trausan-Matu et al. (Ed.), *Proceedings of the 12th International Conference on Intelligent Tutoring Systems* (pp. 426-435). Springer.
58. **Rau, M. A., Aleven, V., & Rummel, N.** (2014). Sequencing sense-making and fluency-building support for connection making between multiple graphical representations. In J. L. Polman, E. A. Kyza, D. K. O’Neill, I. Tabak, W. R. Penuel, A. S. Jurow, K. O’Connor, T. Lee & L. D’Amico (Eds.), *Learning and becoming in practice: The International Conference of the Learning Sciences (ICLS) 2014* (Vol. 2, pp. 977-981). International Society of the Learning Sciences.
59. **Rau, M. A., Aleven, V., Rummel, N., & Rohrbach, S.** (2013). Why interactive learning

- environments can have it all: Resolving design conflicts between competing stakeholder goals. In *Proceedings of the SIGCHI conference on human factors in computing systems* (pp. 109-118). ACM. **Best Paper Nomination.**
60. **Rau, M. A.**, Alevan, V., & Rummel, N. (2013). Complementary effects of sense-making and fluency-building support for connection making: A matter of sequence? In H. C. Lane, K. Yacef, J. Mostow & P. Pavlik (Eds.), *Artificial Intelligence in Education. AIED 2013. Lecture notes in computer science* (pp. 329-338). Springer.
  61. **Rau, M. A.**, Alevan, V., & Rummel, N. (2013). How to use multiple graphical representations to support conceptual learning? Research-based principles in the Fractions Tutor. In H. C. Lane, K. Yacef, J. Mostow & P. Pavlik (Eds.), *Artificial Intelligence in Education. AIED 2013. Lecture notes in computer science* (pp. 762-765). Springer.
  62. **Rau, M. A.**, Scheines, R., Alevan, V., & Rummel, N. (2013). Does representational understanding enhance fluency or vice versa? Searching for mediation models. In S. K. D’Mello, R. A. Calvo & A. Olney (Eds.), *Proceedings of the 6th International Conference on Educational Data Mining (EDM 2013)* (pp. 161-169). Memphis, TN: International Educational Data Mining Society. **Best Paper Award.**
  63. Carlson, R., Genin, K., **Rau, M.**, & Scheines, R. (2013). Student profiling from tutoring system log data: When do multiple graphical representations matter? In S. K. D’Mello, R. A. Calvo & A. Olney (Eds.), *Proceedings of the 6th International Conference on Educational Data Mining (EDM 2013)* (pp. 12-20). International Educational Data Mining Society.
  64. Hayashi, E., **Rau, M. A.**, Neo, Z. H., Tan, N., Ramasubramanian, S., & Paulos, E. (2012). TimeBlocks: mom, can I have another block of time? *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 1713-1716). ACM.
  65. Matlen, B., Atit, K., Goksun, T., **Rau, M.**, & Ptouchkina, M. (2012). Representing space: Exploring the relationship between gesturing and geoscience understanding in children. In C. Stachniss, K. Schill & D. Uttal (Eds.), *Spatial Cognition VIII* (Vol. 7463, pp. 405-415). Springer.
  66. **Rau, M.**, Alevan, V., Rummel, N., & Rohrbach, S. (2012). Sense making alone doesn’t do it: Fluency matters too! ITS support for robust learning with multiple representations. In S. Cerri, W. Clancey, G. Papadourakis & K. Panourgia (Eds.), *Intelligent Tutoring Systems* (Vol. 7315, pp. 174-184). Springer.
  67. **Rau, M. A.**, & Pardos, Z. A. (2012). Interleaved practice with multiple representations: Analyses with knowledge tracing based techniques. In Yacef, K., Zaïane, O., Hershkovitz, H., Yudelson, M., and Stamper, J. (Eds.), *Proceedings of the 5th International Conference on Educational Data Mining (EDM 2012)*. (pp. 168-171). International Educational Data Mining Society.
  68. **Rau, M. A.**, & Scheines, R. (2012). Searching for variables and models to investigate mediators of learning from multiple representations. In Yacef, K., Zaïane, O., Hershkovitz, H., Yudelson, M., and Stamper, J. (Eds.), *Proceedings of the 5th International Conference on Educational Data Mining (EDM 2012)*. (pp. 110-117). International Educational Data Mining Society.
  69. **Rau, M.**, Rummel, N., Alevan, V., Pacilio, L., & Tunc-Pekkan, Z. (2012). How to schedule multiple graphical representations? A classroom experiment with an intelligent tutoring



- system for fractions. In J. van Aalst, K. Thompson, M. J. Jacobson & P. Reimann (Eds.), *The future of learning: Proceedings of the 10th International Conference of the Learning Sciences (ICLS 2012)* – Volume 1, Full Papers (pp. 64-71). International Society of the Learning Sciences.
70. Feenstra, L., Aleven, V., Rummel, N., **Rau, M. A.**, & Taatgen, N. (2011). Thinking with your hands: Interactive graphical representations in a tutor for fractions learning. *Artificial Intelligence in Education. AIED 2011. Lecture Notes in Computer Science* (pp. 453-455). Springer.
71. **Rau, M. A.**, Aleven, V., & Rummel, N. (2010). Blocked versus interleaved practice with multiple representations in an intelligent tutoring system for fractions. In V. Aleven, J. Kay, & J. Mostow (Eds.), *Proceedings of the 10th International Conference of Intelligent Tutoring Systems* (pp. 413-422). Springer.
72. **Rau, M. A.**, Aleven, V., & Rummel, N. (2009). Intelligent tutoring systems with multiple representations and self-explanation prompts support learning of fractions. In V. Dimitrova, R. Mizoguchi, & B. du Boulay (Eds.), *Proceedings of the 14th International Conference on Artificial Intelligence in Education* (pp. 441-448). IOS Press. **Best Student Paper Award.**

### Chapters in Books

73. Koedinger, K. R., **Rau, M. A.**, & McLaughlin, E. A. (in press). Different goals imply different methods: A guide to adapting instructional methods to your context. In C. E. Overson, C. M. Hakala, L. L. Kordonowy, & V. A. Benassi (Eds.), *In their own words: What scholars want you to know about why and how to apply the science of learning in your academic setting*. Society for the Teaching of Psychology.
74. **Rau, M. A.** (in press). Adaptive support for representational competencies during technology-based problem solving in STEM. Jiao, P., McLaren, B., Alavi, A. H., Ouyang, F. (Eds.), *Artificial intelligence in STEM education: The paradigmatic shifts in research, education, and technology*. CRC Press Taylor & Francis Group.
75. **Rau, M. A.** (2020). Cognitive and socio-cultural theories on competencies and practices involved in learning with multiple representations. Van Meter, P., List, A., Lombardi, D., & Kendeou (Eds.), *Handbook of learning from multiple representations and perspectives*. Routledge.
76. **Rau, M. A.** & Moore, J. (2020). Flipped classrooms and collaborative support in chemistry. Mintzes, J. J. & Walter, E. M. (Eds.), *Active learning in college science: The case for evidence-based practice* (pp. 567-582). Springer.
77. **Rau, M. A.** (2018). Supporting representational competences through adaptive educational technologies. In K. Halverson Daniel (Ed.), *Towards a framework for representational competence in science education* (pp. 103-132). Springer.
78. **Rau, M. A.** (2016). Supporting students' learning with multiple visual representations. In J. C. Horvath, J. Lodge & J. A. C. Hattie (Eds.), *From the laboratory to the classroom: Translating the learning sciences for teachers* (pp. 155-171). Routledge Press.

### RESEARCH SUPPORT

2022 - 2025 Principal Investigator on: *Digitally inoculating viewers against visual misinformation with a perceptual training*, together with Co-Investigator Jerry

Zhu (University of Wisconsin – Madison, Department of Computer Sciences);  
Funder: National Science Foundation, Research on Emerging Technologies  
for Teaching and Learning (RETTL), #2202457;  
Amount: **\$849,761.**

Description: The project builds on prior research on representational competencies to develop and test the effectiveness of a perceptual training that teaches viewers to recognize misleading graphs and to adjust their perception of these graphs accordingly.

2019 - 2023 Principal Investigator on: *Learning internal visualization skills for complex engineering concepts in active learning classes*, together with Co-Investigator Barry VanVeen (University of Wisconsin – Madison, Department of Electrical and Computer Engineering);  
Funder: National Science Foundation, Improving Undergraduate STEM Education (IUSE), #1933078;  
Amount: **\$300,000.**

Description: This project investigates whether support for representational competencies enables students to internally visualize complex engineering concepts that are presented via symbolic representations.

2020 - 2023 Co-Investigator on: *An investigation of the use of representations in early childhood*, together with Principal Investigator Hala Ghouseeini (University of Wisconsin – Madison, Department of Curriculum and Instruction);  
Funder: Center for Research on Early Childhood Education, University of Wisconsin – Madison;  
Amount: **\$29,997.**

Description: This project seeks to understand how young students (age 4-6) use representations in early mathematics experiences and how teachers support students' use of representations.

2017 - 2023 Principal Investigator on: *CAREER: Intelligent representations: How to blend physical and virtual representations by adapting to the individual student's needs in real time*;  
Funder: National Science Foundation, Cyberlearning, #1651781;  
Amount: **\$598,399.**

Description: This project investigates the complementary strengths of tangible and virtual representations to leverage conceptual and haptic learning experiences to enhance high-school and college students' learning of foundational chemistry concepts.

2019 - 2021 Principal Investigator on: *Collaboration support for learning with visual representations in undergraduate chemistry*;  
Funder: National Academy of Education / Spencer Postdoctoral Fellowship;  
Amount: **\$70,000.**

Description: This project compared individual to collaborative learning to reveal whether and how collaboration affects students' benefit from supports for representational competencies, and how this affects domain learning.

- 2016 - 2019 Principal Investigator on: *EXP: Modeling perceptual fluency with visual representations in an intelligent tutoring system for undergraduate chemistry*, together with Co-Investigators Jerry Zhu (University of Wisconsin – Madison, Department of Computer Sciences) and Rob Nowak (University of Wisconsin – Madison, Department of Electrical and Computer Engineering);  
Funder: National Science Foundation, Cyberlearning, #1623605;  
Amount: **\$549,392.**  
Description: This project investigated ways of using machine learning to assess students' perceptual knowledge about visual representations that are commonly used in chemistry instruction and to model the acquisition of perceptual knowledge over time.
- 2016 - 2019 Principal Investigator on: *Supporting chemistry learning with adaptive support for connection making between graphical representations in a cognitive tutoring system*, together with Co-Investigator Judith Burstyn (University of Wisconsin – Madison, Department of Chemistry);  
Funder: National Science Foundation, Improving Undergraduate STEM Education (IUSE), #1611782;  
Amount: **\$599,829.**  
Description: This project developed technology-based supports for representational competencies for chemistry instruction and tested whether these supports enhance students' learning of chemistry concepts.
- 2015 - 2020 Co-Investigator on: *LUCID: A project-focused cross-disciplinary graduate training program for data-enabled research in human and machine learning and teaching*, together with Principal Investigator Tim Rogers (University of Wisconsin – Madison, Department of Psychology) and Co-Investigators Martha Alibali (University of Wisconsin – Madison, Department of Psychology), Rob Nowak (University of Wisconsin – Madison, Department of Electrical and Computer Engineering), Jerry Zhu (University of Wisconsin – Madison, Department of Computer Sciences);  
Funder: National Science Foundation / NSF Research Traineeship (NRT) Data-Enabled Science and Engineering, #1545481;  
Amount: **\$2,999,737.**  
Description: This project trained graduate students from computer science, engineering, cognitive psychology, and education sciences, with the goal of promoting a common knowledge base that allows these students to work productively across traditional boundaries on both basic research questions and practical, real-world problems.
- 2016 - 2017 Principal Investigator on: *Adaptive support for connection making among multiple visual representations in chemistry*;  
Funder: Wisconsin Alumni Research Fund (WARF), University of Wisconsin – Madison;  
Amount: **\$45,227.**  
Description: This project investigated the purposes and ways in which chemistry students and teachers use visual representations and which difficulties arise in the

context of learning and teaching with visual representations.

2015 - 2016 Co-Investigator on: *Active learning*, together with Principal Investigator John Moore (University of Wisconsin – Madison, Department of Chemistry);  
Funder: Innovation Grant Funding System, University of Wisconsin – Madison;  
Amount: **\$7,060.**

Description: This project developed an active learning intervention for an introductory undergraduate chemistry course and evaluated the intervention by comparing it to a traditional learning intervention.

2015 - 2016 Principal Investigator on: *Intelligently combining physical and virtual representations in educational technologies*;  
Funder: Wisconsin Center for Education Research (WCER) Faculty Research Support Award, University of Wisconsin – Madison;  
Amount: **\$6000.**

Description: This project investigated which characteristics of a learning activity and of students' prior knowledge determine how they interact with tangible and virtual representations in the context of chemistry learning.

2015 - 2016 Principal Investigator on: *Intelligent representations: How to integrate physical and virtual representations by adapting to the individual student's needs in real time*;  
Funder: Wisconsin Alumni Research Fund (WARF), University of Wisconsin – Madison;  
Amount: **\$42,073.**

Description: This project investigated how different sequences of tangible and virtual representations affect students' learning of chemistry concepts.

2014 - 2015 Principal Investigator on: *Learning with multiple, interactive graphical representations in organic chemistry*;  
Funder: Wisconsin Alumni Research Fund (WARF), University of Wisconsin – Madison;  
Amount: **\$53,642.**

Description: This project investigated representational competencies involved in students' learning with visual representations in chemistry.

2014 - 2015 Principal Investigator on: *CAP: Student Travel Support for the 7th International Conference on Educational Data Mining*;  
Funder: National Science Foundation, Cyberlearning, #1445401;  
Amount: **\$20,000.**

Description: This project funded participants in the Educational Data Mining Young Researcher Track, which helps young researchers broaden their perspectives on educational data and how to mine and analyze it for assessment purposes and to learn more about how people learn.

## TEACHING

### **Courses**

2022 *Research and Practice of Learning with Visual Representations in STEM* at the

- Department of Educational Psychology (EDPSYCH 506).
- 2022 *Conversations and Visualizations in Learning Analytics* at the Department of Educational Psychology (EDPSYCH 615).
- 2021 *Learning Analytics Theory and Practice* at the Department of Educational Psychology (EDPSYCH 525).
- 2014 - 2022 *Introduction to Learning Sciences II*, taught every Spring Semester at the Department of Educational Psychology (EDPSYCH 796).
- 2013 - 2022 *Introduction to Learning Sciences I*, taught every Fall Semester at the Department of Educational Psychology (EDPSYCH 795).
- 2016 - 2019 *Major Area Paper - A Course on Academic Writing*, taught every Spring Semester at the Department of Educational Psychology (EDPSYCH 711).
- 2018 *Intermediate Topics in Chemistry: Visual Representations of Foundational Concepts in General Chemistry* (CHEM 375).
- 2016 *Human-Computer Interactions* at the Departments of Computer Sciences, Psychology, and Educational Psychology (CS/PSYCH 770, EDPSYCH 711).
- 2015 *Eye-tracking Research* at the Department of Educational Psychology (EDPSYCH 711).
- 2015 *Educational Data Mining and Learning Analytics* at the Department of Educational Psychology (EDPSYCH 711).
- 2014 *Design of Intelligent Tutoring Systems* at the Department of Educational Psychology (EDPSYCH 711).
- 2012 *Applications of the Classical Learning Theories* at the Institute of Educational Research, Ruhr-Universität Bochum, Germany.
- 2012 *Computer-Supported Collaboration* at the Institute of Educational Research, Ruhr-Universität Bochum, Germany.
- 2012 *Teaching and Learning with Multimedia* at the Institute of Educational Research, Ruhr-Universität Bochum, Germany.
- 2011 *How to Create Computer-Based Learning Materials: Principles and Practices* at the Institute of Educational Research, Ruhr-Universität Bochum, Germany.

### ***Workshops, Seminars, & Lectures***

- Rau, M. A. (2022). *Adaptive technology support for learning with interactive visualizations in STEM*. Workshop talk at the 2022 Meeting of the Cognitive Development Society, Madison, WI, April 2022.
- Rau, M. A. (2022). *Combining physical and virtual manipulatives in STEM instruction*. Lecture for the Wisconsin Society of Science Teachers, Wausau, WI, April 2022.
- Rau, M. A. & Luu, R. (2021). *The role of visual representations in learning, identity, and equity*. Workshop at the Professional Learning and Community Education, University of Wisconsin – Madison, October 2021.

Rau, M. A. (2021). *Eye-tracking data as diagnostic tool to assess learning, knowledge, and problem solving*. Lecture in Individual Learning and Problem Solving, Ruhr-Universität Bochum, Germany, June 2021.

Rau, M. A. (2021). *Adaptive technology support for learning with interactive visualizations in STEM*. Seminar for Education Data Science Undergraduate Fellowship at the University of California in Berkeley, March 2021.

Rau, M. A. & Zhu, X. (2021). *Digitally inoculating graph viewers against misleading bar charts*. Talk given at the Human, Animal, and Machine Learning: Experiment and Theory (HAMLET) Seminar, University of Wisconsin – Madison, March 2021.

Rau, M. A. (2020). *Individual and collaborative learning of representational competencies in college chemistry*. Seminar talk in the Educational Psychology Institute at the Ruhr-Universität Bochum, Germany, January 2020.

Rau, M. A. (2019). *Using machine learning to overcome the expert blind spot for perceptual fluency trainings*. Lecture for the LUCID graduate training program for data-enabled research in human and machine learning and teaching, University of Wisconsin – Madison, August 2019.

Rau, M. A. (2019). *Teasing apart conceptual and embodied mechanisms of learning chemistry concepts with virtual and physical representations*. Lecture in the Interdisciplinary Training Program Seminar, University of Wisconsin – Madison, March 2019.

Rau, M. A. (2019). *Teasing apart conceptual and embodied mechanisms of learning chemistry concepts with virtual and physical representations*. Seminar talk in the Educational Psychology Institute at the Ruhr-Universität Bochum, Germany, March 2019.

Rau, M. A. (2019). *Publishing international research: From idea to paper(s)*. Seminar in the School of Education International Publication Workshop, University of Wisconsin – Madison, March 2019.

Rau, M. A. (2018). *Log data of intelligent tutoring systems*. Lecture in Individual Learning and Problem Solving, Ruhr-Universität Bochum, Germany, June 2018.

Rau, M. A. (2018). *How to support students in building intuitions about visual representations in chemistry?* Seminar talk at the Learning Sciences Research Institute at the University of Illinois at Chicago, February 2018.

Rau, M. A. (2017). *Vlogging about your research*. Seminar for the LUCID graduate training program for data-enabled research in human and machine learning and teaching, University of Wisconsin – Madison, October 2017.

Rau, M. A., Zahn, M., & Schuster, H. (2017). *Learning with representations in educational technologies*. Lecture at the Fall 2017 Board of Visitors Meeting, University of Wisconsin – Madison, September 2017.

Rau, M. A. (2017). *The use of educational data mining to investigate students' learning with visual representations*. Seminar talk at Harvard, Cambridge, MA, June 2017.

Rau, M. A. (2017). *Using educational technologies to help students acquire representational competencies: Research on math and chemistry learning*. Seminar talk at the University of California in Berkeley, March 2017.

- Rau, M. A. (2017). *How can adaptive educational technologies help students learn with visual representations?* Seminar talk at Stanford University, CA, March 2017.
- Moore, J., Rau, M. A., Kennedy, K., Oxtoby, L. (2016). *Flip your general chemistry classroom the easy way.* Webinar for Cengage Learning, November 2016.
- Rau, M. A. (2016). *How to support learning with visual representations: Research on elementary-school fractions and undergraduate chemistry learning.* Seminar talk at the Human, Animal, and Machine Learning: Experiment and Theory (HAMLET) Seminar, University of Wisconsin – Madison, November 2016.
- Rau, M.A. (2016). *Conceptual and perceptual competencies in learning with visual representations: Lessons learned from research on elementary-school fractions and undergraduate chemistry learning.* Seminar talk at the Program of Interdisciplinary Educational Research at Carnegie Mellon University, Pittsburgh, PA, October 2016.
- Rau, M.A. (2016). *Q&A – Things I wish I had known before becoming an assistant professor.* Graduate student seminar at Carnegie Mellon University, Pittsburgh, PA, October 2016.
- ShIPLEY, T., Uttal, D., Rau, M. A. (2016). *Research at the interface of discipline-based educational research and cognitive science.* Workshop at the Earth Educators Rendezvous, Madison, WI, July 2016.
- Rau, M. A. & Moore, J. (2016). *Evaluating an active learning intervention in Chem 109.* Seminar talk at the Department of Chemistry Teacher's Meeting, University of Wisconsin – Madison, February 2016.
- Rau, M. A. (2016). *Learning with visual representations: An intelligent tutoring system for chemistry.* Seminar for the Learning Understanding Cognition Intelligence and Data Science Graduate Training Program, University of Wisconsin – Madison, January 2016.
- Rau, M. A., Zhu, X., Sen, A., Nowak, R., & Mason, B. (2015). *Modeling perceptual fluency with visual representations in an intelligent tutoring system for undergraduate chemistry.* Seminar talk at the Human, Animal, and Machine Learning: Experiment and Theory (HAMLET) Seminar, University of Wisconsin – Madison.
- Rau, M. A. (2015). *Translational research in educational psychology.* Lecture in Education Policy Across the Disciplines for the Interdisciplinary Training Seminar in Education Sciences, University of Wisconsin – Madison, September 2015.
- Rau, M. A. (2014). *Multimedia learning principles.* Workshop at Thomas Jefferson Middle School, Madison, WI, January 2014.
- Rau, M. A. (2014). *Educational technologies.* Lecture in Human-Computer Interactions at the Computer Sciences Department, University of Wisconsin – Madison, November 2014.
- Hubbard, E., Matthews, P., & Rau, M. A. (2014). *Leveraging the rational brain to promote fractions competence.* Lecture at the Wisconsin Center for Education Research 50th anniversary meeting, October 2014.
- Rau, M. A. (2014). *Searching for mediation models in intelligent tutoring systems data: Representational understanding enhances representational fluency - but not vice versa.* Lecture in Models of Education Research for the Doctoral Research Program, University of Wisconsin –

Madison, March 12, 2014.

Rau, M. A. & Scheines, R. (2013). *Causal model search in educational research*. Workshop on Case Studies of Causal Discovery with Model Search at Carnegie Mellon University, Pittsburgh, PA, October 2013.

## CONTRIBUTIONS TO SCIENTIFIC COMMUNITY

### *Professional Activities*

#### *Member of Editorial Boards*

Learning and Individual Differences (since 2022)  
Journal of Educational Psychology (since 2022)  
International Journal of Artificial Intelligence in Education (since 2020)  
Unterrichtswissenschaft (German Journal on Instructional Science) (since 2019)

#### *Member of Program Committees*

Artificial Intelligence in Education  
Educational Data Mining (Senior member)  
EATEL Summer School on Technology Enhanced Learning  
International Conference on Artificial Intelligence in Education  
International Conference on Educational Data Mining  
ACM Conference on Intelligent User Interfaces

#### *Society Memberships*

International Artificial Intelligence in Education Society  
International Educational Data Mining Society, Publicity Chair for EDM 2018  
International Society of the Learning Sciences, Member of Communication Committee since 2016, Co-chair of Communication Committee since 2018  
American Educational Research Association  
Organizing Committee of the 40th Annual Meeting of the Cognitive Science Society

#### *Grant Review Activities*

German National Science Foundation (Deutsche Forschungsgemeinschaft, DFG, 2022)  
National Science Foundation, CISE Directorate (2015, 2019)  
Institute of Education Research (2017, Principal Member 2018-2021)  
Canada Foundation for Innovation (2014)

#### *Peer-Review Activities for Journals and Books*

Journal of Learning and Instruction  
Journal of the Learning Sciences  
International Journal of Artificial Intelligence in Education  
International Journal of Science and Technology Education  
International Journal of Technology-Enhanced Education  
IEEE Transactions on Learning Technologies  
Journal of Computers and Education  
Chemistry Education Research and Practice  
ZDM - Mathematics Education  
Meetings of the Cognitive Science Society  
International Conference on Artificial Intelligence in Education



International Conference on Educational Data Mining  
International Conference on Intelligent Tutoring Systems  
ACM Special Interest Group on Human-Computer Interaction  
Routledge Taylor & Francis

### ***Committees at the University of Wisconsin – Madison***

#### *University / School of Education Committees*

Global Education Committee: Academic years 2014/15, 2015/16, 2016/17, 2017/18, 2018/19  
Education Graduate Research Scholars committee (Ed-GRS): Academic years 2015/16, 2016/17  
Faculty Senate: Academic years 2014/15 (alternate), 2015/16, 2016/17 (alternate)  
Organizing committee of the Wisconsin Ideas in Education Series (WIES): Academic years 2014/15, 2015/16

#### *Departmental Committees*

Chair of the Learning Sciences Program (since 2022)  
Curriculum Committee (since 2022)  
Diversity Steering Committee (since 2022)  
Recruitment, Admissions, Fellowships, and Awards Committee (Educational Psychology):  
Academic years 2014/15, 2015/16, 2018/19, Chair in academic years 2020/21, 2021/22  
Faculty/Staff Honors Committee (Educational Psychology): Academic years 2013/14, 2016/17, 2017/18  
Chair Election Committee (Educational Psychology): Academic year 2017/18

#### *Student Advising*

Rosanne Luu (Educational Psychology, since 2021)  
Jihyun Rho (Educational Psychology, since 2020)  
Joel Beier (Educational Psychology, since 2019)  
Claudia Matta (Educational Psychology, 2019-2022)  
Hanall Sung (Educational Psychology, 2019-2020)  
Tiffany Herder (Educational Psychology, since 2018)  
Purav Patel (Educational Psychology, 2017-2018)  
Blake Mason (Electrical & Computer Engineering, 2016- 2020, coadvised with Robert Nowak)  
Ayon Sen (Computer Sciences, 2016-2020, coadvised with Jerry Zhu)  
Nadia Al-Tabaa (Educational Psychology, 2016)  
Sally Wu (Educational Psychology, since 2014)

#### *Member of Master Committees*

Catherine Dornfeld-Tissenbaum (Educational Psychology – Learning Sciences)  
Amanda Evenstone (Educational Psychology – Learning Sciences)  
Yunji Park (Educational Psychology – Human Development)  
Kelsey Schenck (Educational Psychology – Learning Sciences)  
Zachari Swiecki (Educational Psychology – Learning Sciences)  
Sally Wu (Educational Psychology – Learning Sciences)

*Member of Prelim and PhD Committees*

Gol Arastoopour (Educational Psychology – Learning Sciences, graduated 2017)  
Milijana Buac (Language Acquisition and Bilingualism, graduated 2019)  
Jaclyn Brown (Chemistry, graduated 2014)  
Catherine Dornfeld-Tissenbaum (Educational Psychology – Learning Sciences, graduated 2018)  
Brian Gibson (Computer Sciences, graduated 2015)  
Brendan Eagan (Educational Psychology – Learning Sciences, graduated 2020)  
Amanda Evenstone (Educational Psychology – Learning Sciences, graduated 2020)  
Tiffany Herder (Educational Psychology – Learning Sciences)  
Laura Hobbes Legault (Computer Sciences, graduated 2018)  
Jordan Thevenow-Harrison (Educational Psychology – Human Development, graduated 2018)  
Nicole Martin (Educational Psychology – Learning Sciences, graduated 2019)  
Claudia Matta (Educational Psychology – Learning Sciences, graduated 2022)  
Joe Michaelis (Educational Psychology – Learning Sciences, graduated 2019)  
Elizabeth Pier (Educational Psychology – Human Development, graduated 2017)  
Lindsay Reiten (Curriculum & Instruction, graduated 2017)  
Angela Samosorn (Curriculum & Instruction, graduated 2019)  
Allison Sauppé (Computer Sciences, graduated 2015)  
Ayon Sen (Computer Sciences)  
Zachari Swiecki (Educational Psychology – Learning Sciences, graduated 2020)  
Elizabeth Toomarian (Educational Psychology – Human Development, graduated 2019)  
Nate Wheeler (Curriculum & Instruction, graduated 2022)  
Sally Wu (Educational Psychology – Learning Sciences, graduated 2019)