Tips and Best Practices in Medical Education: Integrating Foundational and Clinical Sciences across the Medical Curriculum

https://doi.org/10.29060/TAPS.2025-10-2/TT002

Since the time of the Flexner report, it has been accepted that science is the foundation of clinical practice (Finnerty et al., 2010; Flexner, 1910; Grande, 2009; Haramati et al., 2024; Lindsley et al., 2024; Slivkoff et al., 2019; Weston, 2018; Woods et al., 2006). However, the methods traditionally used to teach sciences to medical students have been questioned in the post-Flexner era (AAMC-HHMI Committee, 2009; Cooke et al., 2010; Fulton et al., 2012; Slivkoff et al., 2019). For nearly 100 years, the foundational sciences were taught in a discipline-oriented fashion, primarily through passive learning approaches (lectures), and largely separated from clinical practice (AAMC-HHMI Committee, 2009; Flexner, 1910). Consequently, in the pre-clerkship phase, scientific details were often overtaught and disconnected from clinical applications. This approach frequently required students to "re-learn" their foundational sciences in the setting of patient care. The disconnect between science and medicine was further exacerbated in the later phases of medical training by physicians who taught in a manner that emphasized pattern recognition over scientific underpinnings. We have come to understand that these pedagogical approaches to medical education were neither efficient nor optimal.

Adult learning theory has provided strong evidence that medical trainees are better at learning, applying information to new circumstances, and making informed clinical decisions when the foundational and clinical sciences are taught side-by-side in an integrated fashion (Bandiera et al., 2018; Bucklin et al., 2021; Kulasegaram et al., 2015; Kulasegaram et al., 2013; Lisk et al., 2016; Mylopoulos & Woods, 2014). Learning is also heighted when active rather than passive approaches are employed. In the pre-clerkship phase, small group active learning sessions (problem-based learning, team-based learning, case-based learning, etc.) provide outstanding platforms for integrating foundational and clinical sciences (Bucklin et al., 2021). Similarly, in the clinical workplace, practitioners can integrate science and medicine by probing or explaining the underlying basis of disease and treatment or employing other forms of active learning (Dahlman et al., 2018; Daniel et al., 2021; Hashmi et al., 2024; Spencer et al., 2008).

Some have questioned the need for pre-clerkship science education in medical schools, professing that the heart of medical education is the clinical experience (Emanuel, 2020). However, in the post-genomic era, this perspective would seem to be the antithesis of modern medical practice (AAMC-HHMI Committee, 2009; Haramati et al., 2024). Now more than ever, to ensure the best quality of care for their patients, physicians need to understand the scientific underpinnings of their actions.

If we truly believe that science is the foundation of clinical practice, we should not teach either in isolation. As a first step, we need to stop thinking about foundational and clinical sciences as being separate. I would argue that they are both on the spectrum of "biomedical sciences," represent two sides of the same coin, and should be taught in an integrated fashion across the entirety of the medical school curriculum. Although this integration has been (or is being) addressed in the pre-clerkship phases at most medical schools, it has proven more challenging in the clinical phases (Brauer & Ferguson, 2015; Pettepher et al., 2016; White & Ghobadi, 2022). While science and medicine are inherently intertwined, interactions between the two in the latter phases of training are often more casual than causal. It is time for the foundational and clinical sciences to be integrated across the continuum of medical training to ensure that future physicians have the skills necessary to provide the highest caliber of care for their patients.

Acknowledgements

Work in the author's laboratory is funded in part by NIH grants R01 GM126363 and R01 AI170546. The author is grateful to Dr. Emily Bird for critical reading of the manuscript and insightful comments.

Declaration of Interest

The author declares no conflict of interest.

References

Bandiera, G., Kuper, A., Mylopoulos, M., Whitehead, C., Ruetalo, M., Kulasegaram, K., & Woods, N. N. (2018). Back from basics: integration of science and practice in medical education. *Medical Education*, *52*(1), 78-85. https://doi.org/10.1111/medu.13386

Brauer, D. G., & Ferguson, K. J. (2015). The integrated curriculum in medical education: AMEE Guide No. 96. *Medical Teacher*, *37*(4), 312-322. https://doi.org/10.3109/0142159X.2014.970998

Bucklin, B. A., Asdigian, N. L., Hawkins, J. L., & Klein, U. (2021). Making it stick: Use of active learning strategies in continuing medical education. *BMC Medical Education*, *21*(1), Article 44. https://doi.org/10.1186/s12909-020-02447-0

AAMC-HHMI Committee (2009). *Scientific foundations for future physicians*.

Cooke, M., Irby, D. M., & B'Brien, B. C. (2010). *Educating physicians: A call for reform of medical school and residency*. Jossey-Bass.

Dahlman, K. B., Weinger, M. B., Lomis, K. D., Nanney, L., Osheroff, N., Moore, D. E., Jr., Estrada, L., & Cutrer, W. B. (2018). Integrating foundational sciences in a clinical context in the post-clerkship curriculum. *Medical Science Educator*, *28*(1), 145-154.

Daniel, M., Morrison, G., Hauer, K. E., Pock, A., Seibert, C., Amiel, J., Poag, M., Ismail, N., Dalrymple, J. L., Esposito, K., Pettepher, C., & Santen, S. A. (2021). Strategies from 11 U.S. medical schools for integrating basic science into core clerkships. *Academic Medicine*, *96*(8), 1125-1130. https://doi.org/10.1097/ACM.0000000000003908

Emanuel, E. J. (2020). The inevitable reimagining of medical education. *JAMA*, *323*(12), 1127-1128. https://doi.org/10.1001/jama.2020.1227

Finnerty, E. P., Chauvin, S., Bonaminio, G., Andrews, M., Carroll, R. G., & Pangaro, L. N. (2010). Flexner revisited: The role and value of the basic sciences in medical education. *Academic Medicine*, *85*(2), 349-355. https://doi.org/10.1097/ACM.0b013e3181c88b09

Flexner, A. (1910). *Medical education in the United States and Canada: A report to the Carnegie Foundation for the Advancement of Teaching*. The Carnegie Foundation for the Advancement of Teaching.

Fulton, T. B., Ronner, P., & Lindsley, J. E. (2012). Medical biochemistry in the era of competencies: Is it time for the Krebs cycle to go? *Medical Science Educator*, *22(*1), 29-32. https://doi.org/10.1007/BF03341749

Grande, J. P. (2009). Training of physicians for the twenty-first century: Role of the basic sciences. *Medical Teacher*, *31*(9), 802-806. https://doi.org/10.1080/01421590903137049

Haramati, A., Bonaminio, G., & Osheroff, N. (2024). Professional identity formation of medical science educators: An imperative for academic medicine. *Medical Science Educator*, *34*(1), 209-214. https://doi.org/10.1007/s40670-023-01922-9

Hashmi, S., Riaz, Q., Qaiser, H., & Bukhari, S. (2024). Integrating basic sciences into clerkship rotation utilising Kern's six-step model of instructional design: Lessons learned. *BMC Medical Education*, *24*(1), Article 68. https://doi.org/10.1186/s12909-024-05030-z

Kulasegaram, K., Manzone, J. C., Ku, C., Skye, A., Wadey, V., & Woods, N. N. (2015). Cause and effect: Testing a mechanism and method for the cognitive integration of basic science. *Academic Medicine*, *90*(11 Suppl), S63-S69. https://doi.org/10.1097/ACM.0000000000000896

Kulasegaram, K. M., Martimianakis, M. A., Mylopoulos, M., Whitehead, C. R., & Woods, N. N. (2013). Cognition before curriculum: Rethinking the integration of basic science and clinical learning. *Academic Medicine*, *88*(10), 1578-1585. https://doi.org/10.1097/ACM.0b013e3182a45def

Lindsley, J. E., Abali, E. E., Asare, E. A., Chow, C. J., Cluff, C., Hernandez, M., Jamieson, S., Kaushal, A., & Woods, N. N. (2024). Contribution of basic science eeducation to the professional identity development of medical learners: A critical scoping review. *Academic Medicine*, *99*(11), 1191-1198. https://doi.org/10.1097/ACM.0000000000005833

Lisk, K., Agur, A. M. R., & Woods, N. N. (2016). Exploring cognitive integration of basic science and its effect on diagnostic reasoning in novices. *Perspectives on Medical Education*, *5*(3), 147-153. https://doi.org/10.1007/s40037-016-0268-2

Mylopoulos, M., & Woods, N. (2014). Preparing medical students for future learning using basic science instruction. *Medical Education*, *48*(7), 667-673. https://doi.org/10.1111/medu.12426

Pettepher, C. C., Lomis, K. D., & Osheroff, N. (2016). From theory to practice: Utilising competency-based milestones to assess professional growth and development in the foundational science blocks of a pre-clerkship medical school curriculum. *Medical Science Educator*, *26*(3), 491-497. https://doi.org/10.1007/s40670-016-0262-7

Slivkoff, M. D., Bahner, I., Bonaminio, G., Brenneman, A., Brooks, W. S., Chinn, C., El-Sawi, N., Haight, M., Hurtubise, L., McAuley, R. J., Michaelsen, V., Rowe, B., Vari, R. C., & Yoon, M. (2019). The role of basic science in 21st century medical education. *Medical Science Educator*, *29*(3), 881-883.

Spencer, A. L., Brosenitsch, T., Levine, A. S., & Kanter, S. L. (2008). Back to the basic sciences: An innovative approach to teaching senior medical students how best to integrate basic science and clinical medicine. *Academic Medicine*, *83*(7), 662-669. https://doi.org/10.1097/ACM.0b013e318178356b

Weston, W. W. (2018). Do we pay enough attention to science in medical education? *Canadian Medical Education Journal*, *9*(3), e109-e114.

White, B., & Ghobadi, A. (2022). Models of clinical integration into basic science education for first-year medical students. *Medical Teacher*, *45*(3), 333-335. https://doi.org/10.1080/0142159X.2022.2134002

Woods, N. N., Neville, A. J., Levinson, A. J., Howey, E. H., Oczkowski, W. J., & Norman, G. R. (2006). The value of basic science in clinical diagnosis. *Academic Medicine*, *81*(10 Suppl), S124-S127. https://doi.org/10.1097/00001888-200610001-00031

Written By

Neil Osheroff
Department of Biochemistry,
Vanderbilt University School of Medicine,
United States of America;
Department of Medicine (Hematology/Oncology),
Vanderbilt University School of Medicine,
United States of America