Building Scientific Confidence in BME Undergraduates via Inquiry-guided Biomaterials Laboratory

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Statement of Purpose: Inquiry-guided instruction has been shown to be a more effective teaching strategy than traditional instruction strategies. More specifically, research shows that inquiry-guided courses lead to improved critical thinking, increased ability for independent inquiry, increased responsibility for one's own learning, and intellectual growth (Lee, et al. 2004) as compared to traditional, lecture-based instruction. In inquiry-based instruction, students work in a self-directed manner to explore and interpret outcomes based on investigation of their own questions (Prince and Felder, 2006). Here, we describe a cost-effective, sustainable introductory biomaterials laboratory for undergraduates using inquiry-guided instruction at a large public university.

Methods: The four laboratory components focus on 1) the structure and function of poly (methyl methacrylate) commonly used as bone cement, 2) the structure and function of alginate hydrogels commonly used for drug delivery, 3) metal toxicity using brine shrimp as model system with applications to medical device toxicity, and 4) cell adhesion with respect to different surfaces to explore *in vivo* reactions to biomaterials. Each of the four individual lab components lasted for two to three weeks. During the first week, students are provided with a list of available materials pertaining to the lab component and worked with group members and the instructor to devise and test a custom hypothesis instead of using "cookie cutter" laboratory manuals. In the second week, students performed experiments to test their hypotheses. During the last week of the module, student performed statistical analysis appropriate for their custom experimental design. Each lab has been scaled so that it may be completed in 90 minutes. This allows for multiple mini-sessions in the allotted lab period, resulting in smaller groups and a variety of different hypotheses to be tested. Further, this course design allowed students at large institutions to have a more personal, hands-on experience. This laboratory was developed for 120 students meeting during the same three hour block.

To assess this intervention, a mix method approach was adopted, including faculty vignettes and a student knowledge and value survey called the Scientific Literacy and Student Value in Inquiry-guided Lab Survey (SLIGS). The SLIGS is comprised of two portions: Part A investigating scientific literacy and Part B investigating student value of the inquiry-guided pedagogy. Both parts were assessed for validity using factor analysis and reliability using Cronbach's alpha. Data were analyzed with Mann-Whitney U tests for non-parametric statistics.

Results: The SLIGS had excellent internal consistency (Cronbach's alpha >0.8). All questions factored as anticipated with the exception of one per part. Questions that did not factor were excluded. The scientific literacy portion showed high levels of confidence both pre- and post-intervention (76% and 89% respectively, $n_{pre} = 155$ and $n_{post} = 93$). Further, there was a statistically significant increase in confidence in seven of the nine categories including explanation of scientific outcomes (79% to 95%), assessment of experimental methodology (75% to 96%), and design of experiment (69% to 95%). With respect to the survey portion pertaining to the value of inquiry-guided labs, students showed a high level of interest [73% mid-semester (M); $n_{pre} = 131$ and 81% at the end of semester (E); $n_{post} = 93$]. Further, they felt that the labs were of utility value (77%-M and 85%-E), and did not require too much in terms of emotional and time costs (71%-M and 71%-E). Lastly, there was a statistically significant improvement in mid- to end-of-semester assessments in several categories, including student engagement, relevance to the real world, and the desire to see other inquiry-guided labs.

Total cost per student for the four modules was less than $35 per student. More specifically, each module cost less than $15, $5, $5, and $10 per student respectively. Examples of hypotheses for each of the modules are as follows: In lab module 1, students hypothesized that inclusion of salt additives would affect the Young's modulus of poly (methyl methacrylate). In lab module 2, students hypothesized that acidic swelling fluid would result in less swelling than more neutral swelling fluid using research studies linking hydrogels for drug delivery to physiological pHs. For lab module 3, students hypothesized that Cobalt particles would be result in higer levels of toxicity than Nickel particles. Finally, in lab module 4, students hypothesized that gelatin and poly L-lysine would increase cell adhesion as compared to glass coverslips. Laboratory handouts, list of materials, and student value survey are available through the authors.

Conclusions: In summary, this laboratory is not only sustainable due to low cost and time requirements but also adopts the evidence-based practice of inquiry-based instruction. Moreover, assessment showed student improvement in scientific literacy and favorable student attitudes in terms of interest, utility, and emotional and time costs.

References:

1. Lee, V.S., ed., Teaching and Learning through Inquiry, 2004
2. Prince, M. and Felder, R. JEE, 2006; 95: 123-138.