Classroom Journal Club: Collaborative Study of Contemporary Primary Literature in the Biomechanics Classroom

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Introduction

University undergraduate engineering education primarily focuses on the fundamentals of engineering and its practical applications. Little time is devoted to the process of scientific discovery, dissemination of scientific results to the broader community, or the benefits of a peer-review process. At the undergraduate level, scientific results are often presented as a carefully curated and distilled collection of facts [1] without acknowledging the sense of discovery experienced by researchers, the trials and tribulations of the research process, or how these results are communicated. This disconnect from the excitement of scientific discovery contributes to student attrition [2]. Furthermore, young engineers educated in this paradigm may thus be ill-prepared to disseminate their discoveries as they begin their careers. One way to address these gaps is to use student-selected primary literature in the classroom.

The undergraduate biomechanics classroom is well-positioned to introduce students to primary literature, which is plentiful due to the field’s rapid advancements. Undergraduate introductory courses in biomechanics appeal to students from diverse academic backgrounds at all levels, though most are in engineering and/or science majors. A well-designed introductory biomechanics course permits all students to succeed, regardless of their mechanics background. Many students are motivated to study a particular injury, medical condition, or treatment that is beyond the scope of their course permits all students to succeed, regardless of their mechanics background. However, just reading primary literature to understand the science behind the mechanics necessarily need a priori depth of technical knowledge about biomechanics; reading primary literature in fact increases technical knowledge [4].

Using a classroom journal club (described in this paper) to introduce students to the peer-reviewed scientific literature can both bring a sense of scientific discovery and dissemination into the classroom and allow students to customize their learning experience. The idea of a classroom journal club stems from the longstanding tradition of group study and discussion of peer-reviewed, recently published academic literature. In medicine, journal clubs originated as a cost-saving measure in the face of rising periodical costs [3]. They are still used by professionals to discuss cutting edge research results; in medicine, this often informs physician decisions about patient treatments. Participation in a journal club increased medical knowledge in 88% of medical residents [4], bridged the gap between research and clinical practice [3], and improved critical appraisal skills [5]. The classroom journal club translates the success of clinically oriented journal clubs to the undergraduate classroom.

The classroom journal club presented in this paper requires students to select, read, and discuss one article in a small group during class time. Pedagogical success of these discussions requires well-defined goals set prior to the discussion of the publications [4] and student preparation for the meeting [6]. To effectively participate in a journal club discussion, students must have basic reading skills and knowledge of the scientific method, but do not necessarily need a priori depth of technical knowledge about biomechanics; reading primary literature in fact increases technical knowledge [4].

The Education Committee of the Bioengineering Division of the American Society of Mechanical Engineers fosters the sharing of best practices in bioengineering education, with particular emphasis on easy-to-implement activities to enhance student learning. This paper details one easy-to-implement way to address the gap in pedagogy by engaging students with primary literature in an undergraduate-level introductory biomechanics course. This classroom journal club has been implemented, and this paper presents results from three cohorts of student surveys. The
expectation was that student perceptions about journal club would not vary with cohort.

Methods

A journal club activity was implemented during three consecutive years of teaching biomechanics (course number ES/ME 380—Special Topics: Biomechanics at Clarkson University, during the Fall semesters of 2011, 2012, and 2013). The course was an upper-division introductory biomechanics course at a primarily undergraduate private university in the U.S., with a typical enrollment of 30–35 students. Course content was centered around orthopedic biomechanics with an overall emphasis on the structure–function relationship of biological tissues and rudimentary modeling of musculoskeletal forces. In addition to the classroom journal club and the capstone project of a literature review, other assessments included an exam, a fracture fixation analysis, and simulation.

The overall learning objective for the classroom journal club was for students to develop proficiency in locating, reading, analyzing, and discussing current peer-reviewed publications of biomechanics research. As a further professional preparation tool for undergraduates, a classroom journal club encourages students to improve individual reading and synthesis skills. These skills are critical to lifelong learning. For the course described here, these skills were also essential to the capstone assignment of a literature review. Ancillary pedagogical goals included increasing student engagement and journal readership, and exposing students to the breadth of research topics in the field of biomechanics.

Throughout the semester, students worked in self-selected groups of 3–4 for the guided classroom journal club discussions. For each discussion, each group was tasked to choose and read an article from the peer-reviewed biomechanics literature. Discussion during class time to evaluate its scientific merit and interpretation of its results followed. This process was repeated during class on Fridays (a total of eight) throughout the semester. The preparation, structure, and assessment methods are detailed below.

Measures were taken to ensure that students were equipped to search the peer-reviewed academic literature. During the first week of class, the university’s Reference Librarian demonstrated how to search for articles using databases (e.g., PubMed, Engineering Village, and Web of Science (now Web of Knowledge)) and access the articles via local resources or interlibrary loan. An associated homework assignment required students to find articles about biomechanical topics of personal interest in both hardcopy and electronic format. The course instructor gave a brief primer on the peer-reviewed publication process early in the semester, and encouraged students to evaluate research studies within the context of the scientific research process. This primer included a discussion of authorship standards within the field of biomechanics and common journals such as the Journal of Biomechanical Engineering.

Student Roles for Journal Club Discussion. The structure of journal clubs [4,5] is essential to student engagement. While all students were expected to read the group’s article in advance of the discussion, additional preparation was required on a role-specific basis (described below, and summarized in Table 1).

To ensure active participation and student preparation, the authors designed four roles. Each student was assigned one of these roles (described below): gatherer, questioner, answerer, or historian. Students rotated among the roles approximately equally throughout the semester in a self-selected order. In each group, the gatherer chose the article and posted it to the course management software (Moodle, Moodle Pty Ltd., Perth, Australia) by the established deadline of 3 days prior to the in-class discussion. The gatherer could choose any recent (less than 10 yrs old) article about any aspect of biomechanics from any peer-reviewed journal. Students were especially encouraged to choose articles on topics of personal interest or on their chosen topic for the literature review assignment. S/he also posted an 8–12 sentence summary of the article prior to the in-class discussion, in preparation to lead the discussion. Prior to the in-class discussion, the questioner posed at least two questions about the article to Moodle; these could then be used as a starting point for the group’s discussion. The answerer posted answers to these questions following the in-class discussion. For groups with four students, the historian investigated the authors of the article with a focus on their collaboration and publishing history and posted a summary of relevant information prior to the in-class discussion. Safeguards ensured that discussions could proceed if any student failed to do their part. If the gatherer failed to post the article by the deadline, the teaching assistant assigned an article to the group. If the questioner failed to post questions, the group was tasked with identifying both questions and answers during their in-class discussion. Posts to Moodle were accessible to all students in the course. In keeping with good assessment practices in cooperative learning [8], this formal preparation structure permitted individual assessment (described below) and fostered a starting point for the in-class discussions.

In-Class Discussions. Each week, approximately 20–25 min were devoted to journal club. This equated to approximately 1/2 of a class period. Each student was required to bring either a hard- or electronic-copy of their group’s article to refer to during the discussion. An instructor (professor or teaching assistant) also read each article in advance and joined each group for 4–5 min during the discussion time period. During this time, students were encouraged to ask clarifying questions of the instructor related to the article’s technical aspects. The instructors qualitatively assessed student preparation by asking targeted questions to the students, such as asking students to define scientific terms used. At the conclusion of the discussion time, one student from each group was randomly selected to briefly (30 s or less) summarize their article to the class; this exposed all students to the breadth of biomechanical research topics.
Student Assessment. Students were assessed individually by instructors via posts to MOODLE and documented participation in each group discussion. Table 1 summarizes the point-accruing scheme based on student role. Journal club performance was worth 15% of the course grade, with 12 points earned per week over the 8 weeks of journal club for a total of 96 points. A student earned two additional points each time s/he was randomly selected to summarize the group’s article for the class. All students had this opportunity at least twice to summarize the article ensuring that each student could earn 100 points total. Note that students were assessed individually; the group discussion could continue effectively in the absence of any single student, per the instructions (described above).

Research Data Collected. With Institutional Review Board approval from Clarkson University, voluntary anonymous student surveys regarding the classroom journal club were collected at the end of the course, during the same period as students wrote teaching evaluations. Student demographics are given in Table 2. Most students were studying either mechanical or chemical engineering; graduate students could complete additional work to earn graduate credit. Student perceptions about journal club were surveyed as part of the normal course evaluation process; the survey questions are shown in Fig. 1(b). All questions asked students to answer on a five-point Likert scale (with 5 = “strongly agree”). After tabulating results, one-way analysis of variances (ANOVA)s for each question were conducted (Microsoft Excel, Microsoft, Redmond, WA), with “cohort” as a factor.

Results

In total, the classroom journal club exposed each student to eight articles through the course of the semester, including at least five chosen by their peers; over the 3-yr period, 216 articles were read by students as a direct result of the classroom journal club. Additional articles were read by students for the other course requirements, so this number is a minimum bound. Along with the Journal of Biomechanical Engineering, students most often selected articles from the Journal of Biomechanics and Clinical Biomechanics. Survey response rate was high with an average completion rate of 85% per cohort. From survey responses, students consistently identified the classroom journal club as a rewarding learning experience and recommended that it be kept as part of the course. A summary of the Likert scale ratings is in Fig. 1. Overall, these results indicate that students perceived significant educational benefit from the collaborative learning experience in a classroom journal club. Most students identified learning about the publishing and peer-review process as an asset to the preparation of their literature review. Most survey respondents (average: 66%) indicated that they discussed classroom journal club topics with their peers outside of the classroom. As expected, the results of the ANOVA (p-values shown in Fig. 1) indicate that there is not a significant difference between student responses across the three cohorts.

Furthermore, topics taught in the course lecture were perceived as relevant to classroom journal club discussions. Figure 2 shows the distribution of topics in student-selected articles, along with the same distribution of course lecture topics; most articles (average: 68% per cohort) were related to course lecture topics, but the distribution varied from cohort to cohort. The substantial amount of articles about other topics indicates that students also use the classroom journal club to further explore topics of interest which may be inspired by course lectures. Anecdotally, sports injuries are a uniformly popular topic among student-selected articles. Students seem to seek applications of the structure–function relationship of biologic tissues to injury.

Discussion

The majority of student-selected articles were related to course topics. This implies that students actively sought out relevant scientific studies to gain deeper knowledge of lecture topics. For example, students chose an article about the application of functional electrical stimulation after an in-class introduction to electromyography [9]. Remarkably, the proportions of student-selected articles were not the same as the proportions of topics lectured (Fig. 2, top charts compared to bottom).

Incorporating the classroom journal club into a biomechanics class exposes students to primary literature beyond what they might read if their primary motivation for a literature search is for a class project or their individual term paper. For example, a student writing a paper about bone fractures learned about the effects of strain rate on fracture, and laboratory creation of fractures, by choosing appropriate articles [10,11]. Another student, investigating the kinematics of elbow pitching as a broad topic, learned about the use of biplanar fluoroscopy to evaluate elbow joint kinematics [12]. Most students (66% on average) reported discussing topics they learned about in journal club with their peers outside of the classroom, indicating a good student engagement both in

**Table 2** Class demographics

<table>
<thead>
<tr>
<th>Cohort 1</th>
<th>Cohort 2</th>
<th>Cohort 3</th>
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</thead>
<tbody>
<tr>
<td>Percentage of chemical eng.</td>
<td>40</td>
<td>71</td>
</tr>
<tr>
<td>Percentage of mech. eng.</td>
<td>43</td>
<td>26</td>
</tr>
<tr>
<td>Percentage of other STEM</td>
<td>17</td>
<td>13</td>
</tr>
<tr>
<td>Percentage of graduate students</td>
<td>3</td>
<td>3</td>
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Fig. 1 Student survey results (five-point Likert scale) (a) and survey questions (b). p-values indicate no significant difference in student responses from year to year.
Beyond exposure to a number of journal articles, key educational benefits to this collaborative learning exercise include customized content depth compared to a traditional lecture. With the team-centered approach, students work collaboratively to peer-educate on the relevant principles; for example, a mechanical engineer may clarify questions about a stress–strain graph for a chemical engineer. The course instructor benefits from this pedagogical tool alongside the students. Instructors broaden their own perspective by preparing for discussions (e.g., reading the student-selected articles, which are often outside of the instructor’s particular research area) [5]. The instructors also reported that student-selected articles contained useful information relevant to ongoing research, often in articles about peripherally related topics. Furthermore, student access of electronic journals for class purposes increases the use of the university’s subscription, indicating the importance of biomechanics to the university. Relevant to future course development, the specific topics selected by students may influence course planning to include popular topics.

The classroom journal club is an active learning technique and encourages creative thinking in students. The activity is synergistic with modern-day best practices in undergraduate pedagogy [16,17]. Fostering creativity in engineers is essential to tackling today’s grand challenges in engineering [18]. The classroom journal club promotes creativity and higher-level thinking skills.

Compared to other methods of using primary literature in undergraduate courses, the classroom journal club requires a minimal amount of preparation from the instructor and a moderate amount of class time. For example, the CREATE method of engaging students with primary literature [1] focuses on a series of articles from the same laboratory, asking students to critically evaluate each study and propose what the next experiments might be. It is effective with undergraduate students [19], shifts students’ attitudes about science dissemination, and builds professional self-confidence [20], but it takes several weeks of class time. Other less time-intensive techniques focus on using single, seminal articles [1,21]. Within this context, the classroom journal club gives students a taste of the academic publishing process and a breadth of exposure to different biomechanical research topics with minimal disruption to an existing course structure.

The results presented here are limited by the modest sample size and single-university demographics. The survey addressed student perceptions, but did not objectively assess student learning or content mastery. However, it is expected that the principles of introducing students to primary sources is a lifelong learning skill [15,22] that may be universally beneficial to similar student populations. Additional extensions of this work may include surveys of course alumni to assess the relevance of the skills developed in the classroom journal club to their careers and lives.

In summary, the classroom journal club discussions are an effective way to engage students in biomechanics. Students are introduced to scientific literature and the research process, and learn customized content in an introductory course. Students generally enjoyed the activity: as one student wrote: “…journal club broke things up and was a lot of fun....”

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References
