

AC 2010-1117: INTEGRATION OF JOURNAL CLUB IDEOLOGY INTO A NANOTECHNOLOGY COURSE

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Integration of Journal Club Ideology into a Nanotechnology Course

Nanotechnology is bound to dramatically impact how we use materials in all aspects of engineering. As a result it is in our best interest to educate undergraduate engineers about the basics and its potential. However, being a nascent interdisciplinary field with constantly evolving applications, nanotechnology typically poses a challenge for educators to keep the course current while providing enough exposure to the various research areas. An integration of journal club ideology to a traditional lecture-based course offers a powerful alternative, simultaneously focusing on nanoscience fundamentals and methods. Among its multitude of benefits, journal club integration offers students a unique responsibility to exercise their higher level learning skills, namely, analysis, synthesis and evaluation of knowledge. This paper discusses how the journal club ideology was incorporated into an *Introduction to Nanotechnology* course for senior undergraduate and graduate students. Key details of the journal club model adoption are included to prompt such an implementation for courses dealing with similar emerging fields. The integration resulted in a more engaging senior-level engineering course that was student-driven and enforced independent learning.

Introduction

A journal club consists of a group of students and faculty meeting to share and discuss relevant scientific journal articles based on a selected topic. In its simplest form, students select, summarize and present journal articles to prompt further discussions. In the process, students develop the necessary skills to critically review literature and at the same time remain current with the developments in the field.¹ This approach is particularly suitable for emerging fields that are being actively researched.² Traditional courses that offer insight into these fields are often challenging for instructors due to the inherent nature of the content. The textbooks and content developed for a course focusing on these frontier fields become quickly outdated. Applying the journal club ideology to these courses can dramatically enhance the course content and lead to an engaging experience for the students. One such field is the research of nanomaterials for mechanical, electrical, chemical, thermal and optical applications.

The current progress in nanotechnology indicates its tremendous potential to transform material science.^{3,4} In order to expose undergraduates to the fast growing field of nanotechnology, a new course was developed as an elective for seniors and graduate students at Rowan University. There have been numerous similar courses developed to address this topic in a multitude of ways, therefore this effort is in no way a novel endeavor. There are nanotechnology courses that involve students writing research summaries⁵ and courses that incorporate various hands-on activities^{6,7}, among others.⁸⁻¹¹ This course in particular was designed with two goals in mind; one was to expose students to nanotechnology and the other to familiarize them to literature reviewing skills. Therefore, the primary learning objective of the course was to enable students to read nanotechnology related journal articles and provide critical feedback on methods, results and impact.

The course content was divided into three parts:

- (1) Fundamentals
- (2) Tools (for both synthesis and characterization)
- (3) Nanomaterial applications.

To familiarize the students with the field and establish some basic understanding towards the science at the nanoscale, the instructor covered parts (1) and (2) which involved the discussion of definitions, classifications, material properties and various tools along with their limitations. Students, on the other hand, were responsible for part (3) of the course content in the form of a course project. To discuss nanomaterial applications, the students employed the knowledge they acquired from the instructor to supplement literature review to present, share and propose new avenues to explore. This unusual course format (from students' perspective) presented unique opportunities for the students.

Core engineering courses typically struggle to function beyond the lower order thinking level; focusing often only on knowledge, comprehension and application. The incorporation of journal club methods elevated the *Introduction to Nanotechnology* course to function primarily at the higher order thinking levels, based on Bloom's Taxonomy.¹² As a result the performance of a student was essentially based upon their ability to analyze, synthesize and evaluate the information with which they were presented. This forced the course content to be molded by the students themselves, providing them a sense of entitlement for the learning.

This paper discusses the gradual introduction of journal research using simple activities along with developing a course project based purely on literature review. In addition to training students with the critical skill of reviewing research articles, the students were forced to independently learn and share their expertise with others. The paper also presents results of a survey that was conducted to assess the effectiveness of this approach.

Course Organization

Introduction to Nanotechnology was a 16 week long course which was divided into two halves.¹³ The first half involved instructor lectures primarily utilizing presentation slides while the second half was dedicated to the student presentations ('AppTalks'). The course content for the first half was developed using several excellent textbooks that are currently available on the general topic of nanotechnology.^{3,4,14} At the end of each half, a knowledge test composed of factual multiple choice and true/false questions was administered to test their basic knowledge on the content covered. Figure 1 provides a timeline depicting the weekly organization by content. The journal club activities discussed in the following section were mostly distributed within the first half of the course while the second half was dedicated to the course project.

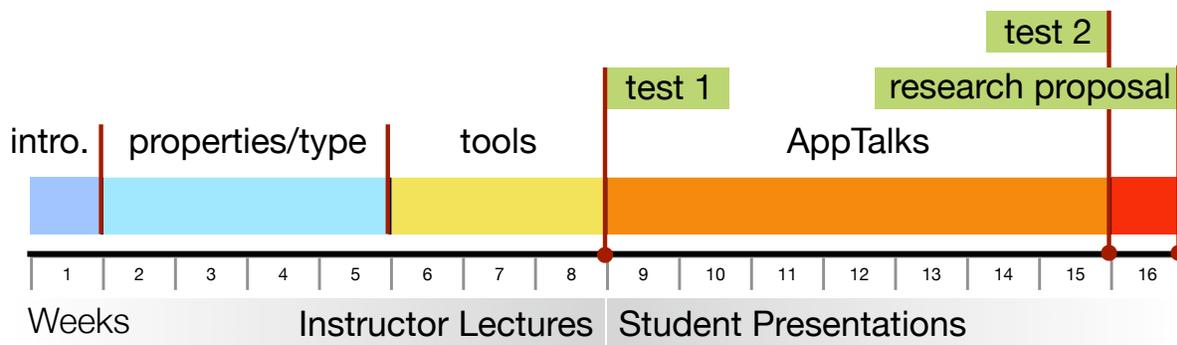


Figure 1: Timeline representing *Introduction to Nanotechnology* course content organization.

Journal Club Activities

Undergraduate students typically have very few opportunities to explore scientific literature. Since over a third of the course content relied on the course project, which in turn depended on scientific literature, it was necessary to train the students on reviewing journal articles before assigning the project. Table 1 lists the journal club activities along with the objectives and the resulting outcomes. The table lists the activities in a chronological order beginning with the mini assignments and ending with the course project.

Table 1: A chronological order of journal club activities used for the *Introduction to Nanotechnology* course. The final three activities constituted the course project.

Activity	Objective	Result
Major Journals	Identify major scientific journals that deal with research and innovations in the field of nanoscience and nanotechnology.	Prompted a discussion on the quality of journals and the reviewing process. Example topics: Peer review, impact factors, indexing services and gaining access via library services.
Journal Exploration	Select an article in the general field of nanoscience or nanotechnology from the narrowed list of journals identified earlier. Introduce the article to the class in two or three sentences.	Students experienced accessing the journal articles from the previously identified resources. The brief summary allowed the instructor to demonstrate the relevance of the topics being discussed in the course.
Bring a Topic Article	The course project topics are introduced and students are assigned a random topic to bring a relevant article, from the previously narrowed list of major journals.	Students were forced to think about the topic and use relevant terms to search for articles related to their assigned topic.
Topic Selection	List and rank three course project topics based on articles submitted by the students.	Students reviewed the peer submitted topic articles and shared their choices for the course project. Course project topics were selected early to begin refining their research efforts.

Activity	Objective	Result
Dude, where's my abstract?	A recent scientific journal article dealing with nanomaterial research is provided lacking a title and an abstract. The students are responsible for submitting a 150-word abstract along with suggesting a title.	All identifying information was removed and therefore students were forced to understand the paper and write an appropriate abstract. This also allowed students to recognize the importance of an abstract when reviewing articles.
Briefs from the Labs	Prepare a 'From the Labs' summary for an article relevant to one's topic and present within 3 minutes using a single powerpoint slide to the class.	'From the Labs' is a feature of MIT's Technology Review ¹⁵ magazine which briefly discusses 1. Results 2. Why it matters 3. Methods 4. Next Steps for particular scientific papers. This way students were able to efficiently summarize and draw critical information from scientific papers.
AppTalk	Prepare a 30 minute (50 min for graduate students) presentation that provides introduction, background, synthesis/ characterization methods and various applications for the nanomaterial within the assigned topic area.	Students reviewed multiple articles relevant to their assigned topic and shared their expertise with the class. The presentations were evaluated based on their content and the delivery. On average, students reviewed 5-6 journal papers.
One More Thing	At the end of each AppTalk another student is responsible for sharing a relevant article on the topic presented.	This provided further discussion on the topic by asking questions or presenting a different finding/perspective. The activity was an attempt to avoid students passively listening to the presentation.
Research Proposal	Identify a sub-topic within the assigned course project topic that needs further exploration and suggest a methodology for investigation and the rationale.	Students designed a scientific experiment to explore an idea they developed reviewing the journals within their topic. This assignment required the application of all the literature researching skills they had acquired and suggest a creative solution.

Key aspects of literature review were explored using several mini assignments. The first two assignments ('Major Journals' and 'Journal Exploration') were used to gradually familiarize the students, for instance, to the available resources/data bases, evaluating the quality of the resources and how to access them on or off campus. The next two activities ('Bring a Topic Article' and 'Topic Selection') focussed on introducing the students to the course project topics using journal articles. 'Dude, where's my abstract?' was an important exercise in recognizing the key elements of an abstract and its importance in reviewing journals. This assignment also prepared students to begin thoroughly reviewing journal articles to identify useful information for a general reader. This ability was further refined by the assignment that followed.

For the 'Briefs from the Labs' activity the students selected a single paper within their assigned topic to summarize in the specified format and present it for 3 minutes. The presenter was required to identify a single figure from the paper to discuss the key findings. Figure 2 provides

an example of a slide that the students were asked to prepare and present their ‘Briefs from the labs’. As indicated the students were required to identify 1. Results, 2. Why it matters, 3. Methods and 4. Next steps among other things, in essence summarizing the article in a concise and precise manner¹⁵. This activity proved to be particularly useful considering several students used the same format to present papers within their ‘AppTalks’. In addition, the students were forced to prepare and practice for the presentation considering the short three minute time allocated to present the material.

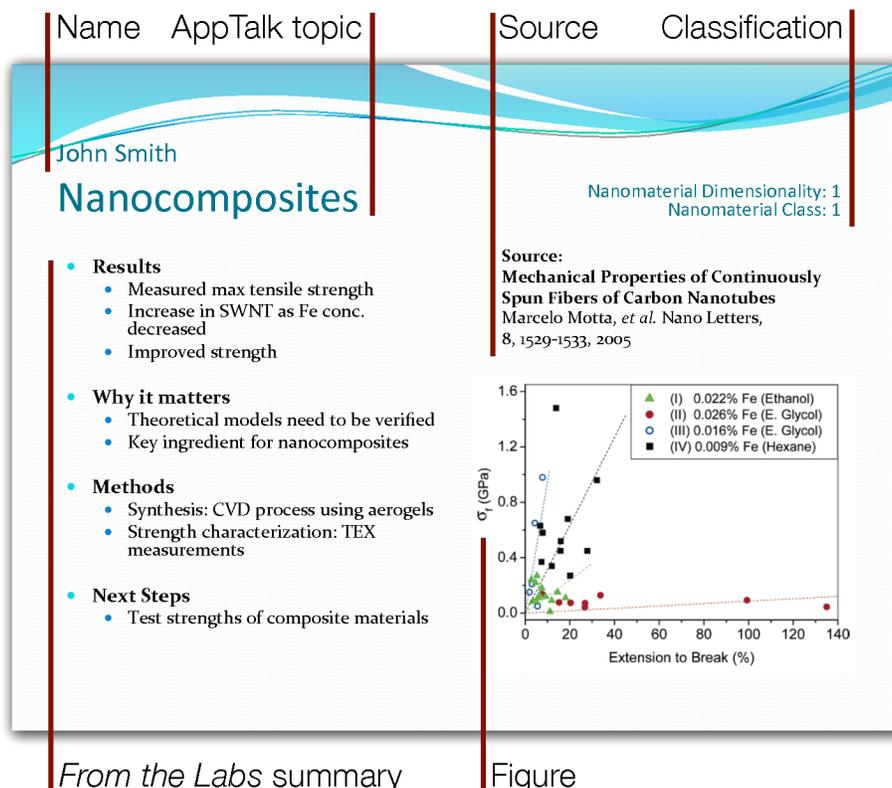


Figure 2: A sample slide showing the ‘Briefs from the Labs’ activity formatting requirement. The students were asked to present a single paper under the assigned course project topic within 3 minutes.

Course Project

The course project constituted a significant portion of their final grade (over 50%). The project was composed primarily of two large assignments, ‘AppTalk’ and ‘Research Proposal,’ and included a smaller assignment, ‘One More Thing’. Each activity was an individual assignment that required instructor’s pre-approval for the presentation outline and proposal title along with the abstract for the ‘AppTalk’ and the ‘Research Proposal’, respectively. The pre-approval process allowed immediate feedback on their efforts and yielded improved quality of assignments.

For the ‘AppTalks’ the students prepared a 30 min presentation to discuss a particular topic within nanotechnology. The topics were also gradually introduced to them via mini assignments which they eventually selected for the course project. For the presentations, the students were required to introduce the topic, discuss background, synthesis and characterization methods followed by a survey of applications they encountered while researching the nanotechnology journals. The students were evaluated on their content as well as their delivery and presentation layout. Performance was evaluated based on the instructor’s and peer’s assessment of the presentation.

The ‘Research Proposal’ assignment required the students to identify a sub-topic and propose an investigation using the background and tools they explored within the ‘AppTalk’ presentation. This was a particularly challenging assignment since the students were asked to identify a problem or a void in the field and propose a creative solution. Once identified, they were required to submit a five page proposal that included the following: 1. Abstract 2. Statement of the Problem 3. Background 4. Objectives 5. Methodology and 6. Potential Outcomes. The students were asked to reference at least 10 scientific references in order to support their thesis. Clearly, this assignment was designed to promote higher level learning skills.

‘One More Thing’ was tailored to prompt further discussion during the Q&A session immediately following an ‘AppTalk’. For this activity a student was assigned to share a topic article immediately following an ‘AppTalk’. The topic was directly relevant to the presentation preceding the activity. ‘One More Thing’ often yielded a useful discussion for the students or generated more involved questions for the presenter. The activity was intended to avoid the passive atmosphere for the audience by assisting students to engage.

Based on the activities described above, scientific journal articles were a primary resource for these assignments. Therefore success in these assignments was heavily dependent on the students’ ability to read journal articles and synthesize the information for a meaningful discussion and investigation. This was evident in the gradual improvement seen as the term progressed.

Instructor’s Evaluation of Student Performance

At the beginning of the course there was a noticeable discomfort felt from the students to research or read journal articles. For example, the students indicated they were frustrated with being unable to obtain journal articles that they discovered via Google or the extremely weak performance on the ‘Dude, where’s my abstract?’ assignment. Majority of the students failed to identify the key quantitative results within the abstracts. This was followed by a marked improvement in the quality of journal articles and the material beyond the initial assignments as the key library resources were identified and effective summarization methods were covered in assignments such as ‘Journal Exploration’ and ‘From the Labs’, respectively. The ‘AppTalks’ saw a dramatic enhancement in terms of selecting appropriate journal papers and discussing the key contents of the papers. Considering there were no required textbooks associated with the

course, the majority of the students solely relied on journal papers to research the background material and the associated tools for nanomaterial synthesis and characterization. The application articles themselves required supplementary resources to fully grasp the concepts. Students' journal researching skills were evident from the depth of their knowledge, the breadth of the application and the familiarity with the articles being presented.

As a pre-requisite for submitting a research proposal the students were asked to write a 200-word abstract for approval, within a week following their 'AppTalks'. This allowed students to draw from their 'AppTalk' material and identify a sub-topic they preferred to focus on. This pre-proposal discussed the general idea of the proposal and the methodology to be employed for the investigation. Majority of the students recognized the general elements necessary for an abstract from previous assignment. The lack of experimental specifics was identified as an area for weakness in their writing and presentation, nevertheless, the feedback was crucial to communicate the expectations for the final assignment.

In evaluating the research proposal there was a clear evidence for students' improved comfort towards the use of journal articles. A large number of students were able to adequately identify a necessary problem to address within a particular research study or a sub-topic. The solutions provided a reasonable methodology using tools discussed in the course. Though, at times their approach lacked the level of detail required for a research proposal, the methodology was often supported with justification that was backed by other references. Considering this was their first experience writing a research proposal, the overall performance on the research proposal was a strong indication of the success of journal club approach.

Student Survey

A survey was conducted to evaluate the effectiveness of using the above mentioned activities to explore the field of nanotechnology from students' perspective. Since this was an *Introduction to Nanotechnology* course, the survey focused on whether the students received relevant exposure to the field and was the level of exposure a result of the journal club activities. Therefore half of the survey probed their comfort with the field and the relevant tools and applications, while the other half examined the effectiveness the journal club activities. Table 2 provides a summary of the course survey results. Twenty three scaled-response questions were included in the survey with the twenty-fourth question requesting their comments. The students were asked to rate their comfort between the scales of 1 for 'Not at all' and 5 for 'Very or Highly' for the questions asked, unless otherwise noted. The anonymous survey yielded 16 responses out of the 17 total enrolled students (13 undergraduate and 4 graduate students).

Table 2: Summary of results of the scaled-response questions included in the course survey. The horizontal bars are included as a visual guide to the relative response rating for each question.

	Rating Scale: 1 for Not at all to 5 for Very/Highly	Average Score	
1	How comfortable are you at describing to someone what nanotechnology entails and its significance?	4.3	
2	How comfortable are you at identifying physical or chemical aspects important at the nanoscale?	3.9	
3	Do you feel comfortable to (a) classify (b) suggest a possible synthesis route and (c) recommend a characterization technique for a given nanomaterial?	3.4	
4	Do you feel comfortable to discuss various research areas (such as sensors, energy harvesting, hydrogen storage, medicine) emerging from nanotechnology, including their importance and progress?	3.7	
5	How effective were the lecture slides towards understanding the material?	3.7	
6	How would you rate your preference towards absence of a course text book?	4.2	
7	Were the assignments effective towards helping you understand the material?	3.8	
8	Was the instructor accessible to help you with the material or assignments?	4.5	
9	Did the course project (AppTalk & Research Proposal) help you get more familiar with nanotechnology?	4.1	
10	Did the combination of instructor lectures and student presentations provide a broad overview of nanotechnology field?	4.3	
11	How would you rate your knowledge in the general field of nanotechnology?	4.0	
12	What portion of your learning was directly a result of your instructor? (1 for Minimal and 5 for Almost all)	3.1	
13	What portion of your learning was a result of your own research? (1 for Minimal and 5 for Almost all)	3.8	
14	What portion of your learning was from other presenters during AppTalks? (1 for Minimal and 5 for Almost all)	2.7	
15	How did this course affect your comfort for researching a topic via scientific journals? (1 for Very negatively and 5 for Very positively)	4.0	
16	How would you have rated your ability to research a topic via scientific journals BEFORE this course? (1 for Very low and 5 for Very high)	3.1	
17	How would you rate your ability to research any topic via scientific journals AFTER this course? (1 for Very low and 5 for Very high)	4.1	

18	How applicable do you think the skill of researching via scientific journals is?	4.5	
19	How comfortable are you at reading nanotechnology-related journal papers?	3.7	
20	How were your expectations (that you shared at the beginning of the term) addressed by this course? (1 for Not addressed and 5 for Completely addressed)	3.6	
21	How comfortable are you at reading, summarizing and critiquing journal papers?	3.6	
22	How many scientific journal papers did you read for this course? (1 for 1-5, 2 for 5-10, 3 for 10-15, 4 for 15-25 and 5 for >25)	3.9	
23	Do you feel current with the progress in the field of nanoscience and nanotechnology?	4.4	
24	Would you recommend this course to a fellow student?	3.4	

Note: standard deviation on each response was on average ± 0.8

The survey summary highlighted four key points from students' perspective. These are discussed in detail below.

1. The students developed high level of comfort towards the field of nanotechnology.

The first four questions in the survey were directly related to the course learning objectives, while questions 10, 11 and 23 asked about the field in general. The high overall rating (3.4-4.4) for these questions lead to the above conclusion. This was substantiated by their class performance. Question 23, which asked whether they 'feel current with the progress in the field of nanoscience and nanotechnology' received the rating of 4.4. It is believed the high rating is a reflection of the journal assignments that fostered students to explore the latest research papers and therefore the current efforts in nanotechnology.

2. The course assignments played an important role in their learning and the students learnt majority of the content independently.

This is an expected outcome since assignments were heavily dependent on independent research, a skill that had to be gradually taught as the term went along via minor assignments. Based on the series of questions (12-14), the students felt they gained the least from their peers during presentation while learning most from their own research compared to the instructor. This is an important distinction from traditional engineering courses where a majority of the learning happens directly as a result of the lectures. Due to the unique format of the course, the instructor served the role of a supplementary resource for the students while they relied a great deal on their own resourcefulness with literature research. The responses here are another indication for the course functioning at higher order of thinking level, with respect to the assignments.

3. The students recognize the importance of literature research and the course had a positive influence on their researching skills.

Though the focus of the course was on nanotechnology the students perceived a substantial improvement in their researching skills directly as a result of the course, according to their responses to questions 16-17. Question 21 received similarly favorable response when asked independently for their comfort towards ‘reading, summarizing and critiquing journal papers.’ In other words, besides learning about nanotechnology the students were empowered with critical reviewing skills that would be beneficial beyond the course. The students themselves recognized the benefit based on their response to question 18 where they were asked how applicable is the skill of researching via scientific journals. This question garnered the highest average rating for the survey.

4. The students had an appreciable experience with literature research.

Question 22, provided a quantitative measure of their extensive experience with journals. On average students read 15-25 journal papers during the course. This response is especially encouraging since such opportunities are rare for undergraduate students. It is also important to note that the survey was conducted before the finals week, at the end of which the students were required to submit their research proposal with 10 mandatory references. In other words, the average would have been higher if the survey was administered later. Nevertheless, this considerable experience with journal articles is bound to impact their researching skills within academic or industrial realms.

Question 24, which is not listed in Table 2, requested responses from the students to the following question: ‘Besides learning about nanotechnology, what were some other things that you think you gained from this course?’ This was especially surveyed to solicit responses without pre-conceived ideas on the effectiveness of particular activities in this course. Out of the students that responded (12 out of 16), six students specifically stated they gained journal researching skills while four students (five if one accepts the sarcasm!) commented on their improved ability and comfort to deliver good presentations. The following are five selected comments that span the spectrum of responses:

Student 1 “Confident I can put on a long presentation that engages the audience”

Student 2 “Good presentation and preparation skills; Good searching and researching skills”

Student 3 “Presentation skills; Ability to set-up experiment (research proposal); General interest in nano; Understanding what nano actually means; Better idea for future career path; Journal reading experience”

Student 4 “An understanding, appreciate, outlook as to where graduate level research is headed. However, my interest in nano is very weak and main reason I took this course was positive previous experiences with the instructor. I wish there were more "baby-step" assignments to get me ready for AppTalk/Research Proposal. Maybe three "from the labs" presentations.”

Student 5 The ability to screw up an entire presentation

Overall the comments were strongly positive considering the demanding course content and assignments, especially for the undergraduate students. There were two (Students 4 and 5 above) whose responses were less than satisfactory. That said, their responses do indicate room for improvement in the form of providing more guidance in terms of literature reviewing and presentation skills. A number of students pointed out the benefit of this course towards a graduate career. Similarly, the graduate students expressed to the instructor how taking this course would help them with their research efforts for their master’s degree in engineering.

Conclusions

Journal club activities are tremendously beneficial tools for teaching emerging science fields such as nanotechnology, biotechnology, microfluidics, micro-electro-mechanical systems (MEMs), advanced alternative energy systems, etc. They allow the courses to remain current and foster student-driven content leading to a more engaging environment for the students. With the correct format and assignments, the broad content can be covered along with teaching other key tools for their career success. This approach imparts the invaluable skill of reviewing scientific literature to improve their ability to analyze, synthesize and evaluate the information provided. In addition, giving students the opportunity to make effective presentations that are conducive to learning. Finally, writing a research proposal deliberately solicits creative aspects of their problem solving skills beyond the traditional methods. As a result of the positives responses, this course will be offered again in Fall 2010 where further refinement in the activities will be made to provide more extensive experience with journal research.

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