Effectiveness of pre-learning online modules in the first year medical school curriculum

Carr, Jessica Raye

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EFFECTIVENESS OF PRE-LEARNING ONLINE MODULES IN THE FIRST YEAR MEDICAL SCHOOL CURRICULUM

by

JESSICA CARR

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Approved by

First Reader

Gwynneth Offner, Ph.D.
Director of Masters in Medical Sciences
Associate Professor of Medicine

Second Reader

Karen Symes, Ph.D.
Assistant Dean of Student Affairs
Associate Professor of Biochemistry
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JESSICA CARR

ABSTRACT

Introduction: Healthcare practices are rapidly evolving, shifting to multidisciplinary initiatives, and prompting a reevaluation of the current structure in the preparation of medical students. The response of medical schools is to adopt newly modeled curricula that use a flipped classroom structure to implement an integrated curriculum encouraging the practice of multidisciplinary inquiry within the basic sciences to develop physicians capable of thoughtful clinical reasoning skills. This pedagogical shift in medical education and the prevailing reaction of medical schools to fundamentally reform curriculum has lead to the emergence of a demand for innovative educational technology capable of effective distribution of pre-class material.

Objective: Assess student experience of SoftChalk online biochemistry modules as a pre-class learning tool to determine effectiveness in fostering student learning and engagement. In evaluating perceptions on improvement, future modules can be knowledgeably revised to maximize educational gains and elucidate effective/ineffective implementation practices. Data was stratified by previous biochemistry experience to determine if students who have taken the same traditionally instructed graduate biochemistry course (BI751) would have differing thematic opinions of the flipped model’s pre-learning environment.
Methods: Participants were Boston University’s first year medical school students (n=165) class of 2019 in an integrated curriculum containing basic science modules. After completion of the modules a mixed-methods anonymous survey with a thematic approach to assess experience and improvement of SoftChalk biochemistry modules were emailed, with reminders. The survey contained demographic data, qualitative free response questions, and likert scale assessment questions with no incentive for completion. The data was analyzed independently by researchers to assess common themes and stratified by previous biochemistry experience.

Results: Three main themes emerged in assessment of data: SoftChalk as a quality learning tool, lack of integration/consistency, and formatting concerns with an overall positive perception of the pre-learning tool. Respondents commented on quality of SoftChalk as a pre-learning tool; the majority deeming it helpful, interactive, and having beneficial activities. Integration and consistency concerns surfaced in both experience, with commentary on pre-class modules being too dense, and improvement by consolidating information into one resource. The major formatting concern was the ability to maintain module value in paper form. Themes were furthered by the quantitative data with students perceiving SoftChalk as effective, providing a foundation for material in-class, and questions having the correct difficulty. When data was stratified BI751 disagreed that SoftChalk helped students stay on track with course material despite the class on average agreeing.

Conclusions: While SoftChalk is an effective pre-class learning tool, the challenge is in reversing students’ perceptions that basic material should be instructed and that a
comprehensive syllabus is necessary. Future SoftChalk modules can enhance success if pre-class modules are condensed, have a stronger transition from pre-class information to in-class activities and maintain consistency among instructor expectations.
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LIST OF ABBREVIATIONS

BI751........Boston University Graduate Medical Sciences Biochemistry and Cell Biology
BU ........................................................................ Boston University
BUSM ...................................................................... Boston University School of Medicine
DNA ........................................................................... Deoxyribonucleic Acid
EMSSP ................................................................. Early Medical School Selection Program
MAMS ..................................................................... Masters of Science in Medical Sciences
MMEDIC .............................................................. Modular Medical Integrated Curriculum
PBL ........................................................................ Problem Based Learning
PrISM ................................................................. Principles Integrating Science and Medicine
RNA ......................................................................... Ribonucleic Acid
SMED ............................................................... Seven-Year Liberal Arts Medical Education Program
INTRODUCTION

Medical School Curricula Reform

Healthcare practices are rapidly evolving accompanying the trend in exponential expansion of literature across scientific disciplines prompting a shift to multidisciplinary initiatives to emphasize critical inquiry as an approach to effective patient care. This advancement within the evolving healthcare field demands a reevaluation of the current structure in the preparation of medical students and the effectiveness of the traditional instructional model through addressing its shortcomings.

The response of medical schools in adapting to the changing healthcare structure is through adopting newly modeled curricula. The most current model in progressive curricula on the broadest scale use an integrated approach and flipped classroom model to encourage the practice of multidisciplinary inquiry within the basic sciences to develop physicians capable of thoughtful clinical reasoning skills applicable to successful medical practices. The second Flexner report was produced to guide the chief objectives in medical education reform including: standardization of learning goals with emphasis of student centered learning process, acquisition of skills set necessary for critical inquiry and investigation, integration of basic and clinical sciences with practical experience, and development of professional identity (Mehta et al., 2013). This pedagogical shift in medical education and the prevailing reaction of medical schools to fundamentally reform curriculum has lead to the emergence of an abundance of diverse integrated curricula and a demand for innovative educational technology capable of effective distribution of pre-class material.
Boston University First Year Medical School Curriculum and its Counterparts

The arduous process of curricular reform within medical education is gradual and continuous. Its focus is on maintenance of key capacities and skill sets while developing an innovative approach to knowledge founded in learning frameworks and research. It is a common practice among medical schools to model their approach on other successfully implemented curriculum with similarly coveted objectives, resources, and design styles. One common style amongst first year medical school curriculum was adopted by Keck School of Medicine, Geisel School of Medicine, and Albert Einstein College of Medicine and contains integrated basic sciences supplemented with clinical and other health related courses. Each school’s curriculum, while having unique capacities, has components of: basic science knowledge embedded with problem-based and clinical case related coursework, clinical development including interviewing and patient skills, and behavior and population medicine to broaden the scope of content to emphasize healthcare in a social context (“M.D. Program Years 1 & 2,” n.d., “The MD Program Courses,” n.d., “Year I–II Continuum,” n.d.).

Boston University School of Medicine implemented a newly structured curriculum with the entering class of 2019’ that has a similar model focusing on the core competencies of: medical knowledge, interpersonal skills, communications skills, patient care, professionalism, and practice and systems based learning (“BUSM Curriculum,” n.d.). BUSM curriculum design addresses these foundations of education through course integration that contain overlapping competencies. In their first year of medical school students take: Principles Integrating Science and Medicine (PrISM) provides students
with a foundation in basic science knowledge with embedded clinical cases for practice in situational, ‘experiential’, and ‘active’ engagement with content; Integrated Problems furthers these approaches with small group sessions where problem-solving skills are bolstered by further ‘dissection’ of cases with the collaboration of peers; Introduction to Clinical Medicine allows students to use these newly gained skills in interviews with patients, and strengthen their skill set with interactive shadowing of a physician; Human Behavior in Medicine and Essentials of Public Health increase breadth of knowledge with regards to patient context, elaborating on the realities of the healthcare field and preparing students to have the exposure necessary for the utmost effective patient care (“Curriculum,” n.d.). Effective active learning strategies embedded in real world clinical scenarios are widely practiced within medical education with the potential for immense and long-standing learning gains.

*Problem Based Learning and Its Role*

One commonly accepted instructional method widely implemented across reform initiatives of medical school curricula is problem-based learning (PBL). Problem Based Learning, within the context of medical education, is the technique in which authentic clinical problems are used to prompt active, self-directed learning to improve critical thinking skills and mastery of learning objectives (Preeti et al., 2013). Instead of conventional didactic based lectures that present content in an instructional forum with distribution of factual information, PBL is implemented in a small group setting in which students are assigned a case and challenged to apply coherent integration of material to solve a problem. In order to solve problems students must employ thorough reasoning of
ideas, objectives, and hypotheses, as well as discard irrelevant ones, incorporating individual and collaborative efforts to acquire a contextual foundation of knowledge and solutions (Hung et al., 2008). This simultaneous embedding of the learning process in critical reasoning has invaluable practical and long-term implications within future classwork and in practicing medicine.

This scientific instructional model was implemented in the first medical school in the 1950s and has been rigorously studied since, with the majority of the literature in agreement with its effectiveness (Hung et al., 2008; Kilgour et al., 2016). Within the model, students work to gain a fundamental and applicable understanding of the material, recognizing the significance of learning objectives and outcomes while instilling a sense of responsibility to their learning process. The facilitators’ role is to provide support, model successful reasoning structures, and to actively engage with students to probe for a higher order of thinking (Kilgour et al., 2016). Their responsibility to guide contextual application of material as opposed to disperse information, allows professionals to use their time, skills, and resources to encourage students to gain a deeper understanding of content and utilize their abilities and experience to the utmost value. Kilhour et al. (2016) noted that high satisfaction among student perceptions is key to the success of implementing PBL still while retaining educational quality.

PBL maintains within its structure an abundance of educational goals including: increasing student responsibility and motivation to the learning process, developing individual techniques for self study, and organizing a structure of knowledge that promotes critical reasoning skills that can be applied to clinical contexts (Preeti et al.,
2013). More significantly, the objective of PBL is to develop physicians capable of utilizing their medical school education to thoughtfully apply interdisciplinary knowledge and to maintain a self-directed and lifelong responsibility in continuing their education. However independent implementation of a curriculum based on the principles of PBL is an incomplete solution within a medical school curriculum due to the extensive and foundational basic and clinical sciences that require student mastery. Implementation of PBL necessitates the aid of a structure that supports students’ interactive engagement with and understanding of material before class in order to devote class time to problem based techniques (Kilgour et al., 2016). This demand was embedded in learning research to develop evolution to the flipped classroom.

*Flipped Classroom as a Model For Curricula Reform*

While the definition of a flipped classroom varies across literature, it most nearly represents a pedagogical instructional technique that dedicates in class time to interactive individual and collaborative learning activities and applied inquiry, allocating the majority of content to be acquired through computer based interactive methods outside the classroom. It is a solution to the method in which academia is developed and delivered endeavoring to amend the issue of information transmission within the traditional model of lecturing and its ineffectiveness at providing material in a contextual manner useful to students for application purposes (Mazur, 2009).

Curriculum committees’ employment of this approach devises to fulfill educational reform objectives in their entirety through: engaging students in an environment centered on individual learning processes, in-class activities and case studies
developed to increase exposure to critical and problem oriented thinking skills, and integrating contextual clinical sciences with basic sciences to understand the foundation of their knowledge within the framework for practicing medicine. These objectives transform knowledge to maintain real world application with regards to professional and social contexts through practice of interdisciplinary investigation.

**Scientific Framework for Flipped Classroom Pedagogy**

The flipped classroom model is embedded in a rich scientific framework that justifies its popularity in implementation throughout education reform. It is grounded in the theories of constructivism and social learning through incorporating active learning into a social construct (Hung et al., 2008; Khanova et al., 2015; McLean et al., 2016; Moraros et al., 2015; Shimamoto, 2012). This structure of acquiring knowledge encourages students to challenge their understanding of the material and concepts by observation and direct interaction with peers.

Constructivist thought, originally encompassing many of Piaget’s cognitive theories, is based on the idea that when cognitive conflict is created by an interaction between experience and ideas, that knowledge is generated through this application of concepts (Savery & Duffy, 1996). In terms of the flipped classroom the student centered, problem based and active learning approach draws upon constructivism by dedicating in class time to application of material ensuring that students have the vital educational opportunity to organize and reinforce knowledge necessary for mastery of material.

While constructivism is more of a philosophical framework for the flipped approach, a foundational psychological theory is Bloom’s taxonomy, which constructs a
hierarchy of learning objectives with regards to difficulty in mastery with multiple domains including cognitive, affective, and psychomotor (Krathwohl, 2002). This taxonomy is used in the flipped model approach by dedicating independent pre-class time to mastery of the skills defined by the lowest difficulty level learning objectives including memorization (cognitive), receiving and responding (affective), and perceiving (psychosensory). In-class time, under the guidance of attentive instructors, is focused on mastering higher learning objectives that require analysis and an organized application of knowledge to specific and relevant problems (Krathwohl, 2002). This approach attributes an increased value to the instructors’ knowledge and experience and aims to satisfy both the instructors and students through efficient use of time and for a greater advancement in educational goals.

The flipped classroom pedagogy is also interrelated with a multitude of social learning theories. One of these theories, Lewin and Deutsch’s’ social interdependence theory, describes the goal-oriented responsibility and accountability one cultivates when associated with a group (Bishop & Verleger, 2013; Smith & MacGregor, 1992). This association motivates the perception that individual actions and interactions have an effect on the common goal or outcome (Bishop & Verleger, 2013; Smith & MacGregor, 1992). Foot and Howe (1998) elaborate on the benefits of group learning with peer-assisted learning. Peer-assisted learning encompasses within its psychoeducational philosophy the complexity of knowledge structures and their interrelationship to interactions with peers. Peers provide a multitude of enrichment opportunities: providing a consistent source of feedback to assess individually owning of the material, challenging
predispositions to malformed conclusions to strengthen foundational knowledge, sharing resources, and through interactive discussion to increase capacity for engagement and motivation to assimilate material (Foot & Howe, 1998). The flipped classroom embraces the benefits of and access to peers to support a social structuring of knowledge to enhance deeper interaction with conceptual content and application while contributing to the personal and professional advantages of developing interpersonal skills.

Vygotsky’s social interactionist theory also has basis in the flipped classroom model, in its combining of constructivist and social learning theories. Vygotsky emphasizes ordering of interactions as crucial to the development of knowledge since it must first be constructed socially to allow for incorporation on an individual level (Bishop & Verleger, 2013; Crews & Butterfield, 2014). Topping and Ehly (1998) later expanded Piaget’s and Vygotskys’ theories in terms of a new theory called cognitive co-constructionism.

Cognitive co-constructionism is derived from Piaget’s ideas on cognitive conflict and Vygotsky’s interaction schema comprising a learning pedagogy that prioritizes continuous reciprocal interactions, such as questioning then explaining. This approach allows students to identify individual holes within the organization of their knowledge through thorough interplay in association with important concepts to encourage consistent deviation from original ideals and to reinforce deliberate conclusions (Topping & Ehly, 1998). The flipped classroom design has the inherent capacity for allocation of in-class time to appropriate activities that contribute to these reciprocal interactions with instructors and peers. This is particularly important within medical school curricula due
to the breadth and depth of knowledge contained within coursework; content overload can be addressed and assessed with interactive computer based techniques while understanding and application is maximized through peer and instructor collaboration.

Background on the Flipped Classroom Approach

Despite widespread implementation within medical school programs, upon review of the literature, resultant research is relatively narrow in effective evidence of its implementation and subsequent conclusions. Articles on flipped classroom models are restricted to: instructional guides (Mehta et al., 2013; Prober & Khan, 2013; Sharma et al., 2015), proposals (Prober & Heath, 2012), lessons learned (Nematollahi et al., 2015), a case study of first year medical students in France designed to confront increased student enrollment and its role in limiting class space and instructor time and resources (Gillois et al., 2015) and a case study with partial flipped classroom characteristics addressing student perceptions of small group and independent learning styles in medical anatomy education (Whelan et al., 2016). Despite the limitations of available research paralleling our study on the flipped classroom within the medical school context, sufficient applicable research within similar demographics and especially within the realm of higher education can be analyzed for comparable salient themes.

Implementation of a new approach that shifts content learning to pre-class and requires instructor guidance of activities in-class is fundamentally new to educational approaches, requiring a labor-intensive reworking of material to fit this innovative structure cohesively. Accordingly, there is an abundance of literature dedicated to the time and staffing required for successful implementation.
Although the restructuring to a flipped classroom model has the potential for decreased instructor time commitment post-implementation (McLaughlin et al., 2014), the majority of literature acknowledges the “upfront investment” (Davies et al., 2013) in time, resources, and support staff required for implementation of the flipped classroom (Ferreri & O’Connor, 2013; Hoffman, 2014; Prober & Khan, 2013; Schlairet et al., 2014) with potential requirement of unforeseen assistance such as an IT specialist for coordination of pre-class material (Schlairet et al., 2014). The extensive resources and time committed to revamping a newly modeled and relevant curriculum are a reality to construct a successful flipped classroom. Instructors’ challenges in curriculum development include fostering an in-class experience that smoothly transitions from pre-class work to genuine, interactive, and collaborative activities that engage students in real world application of material. With regards to pre-class material, previously instructed content must be reshaped to stand alone without the need for explanation or excessive questioning in order to allow students to independently engage with content supported by the capability to assess depth of understanding. Gillois et al. (2015) demonstrates the appreciation among students for content checks in the form of multiple-choice questions to evaluate the effectiveness of study techniques prior to examination. A significant challenge with the pre-class workload is in its density and time commitment, with many student reports of frustration with regards to unreasonable pre-class expectations of instructors (Khanova et al., 2015; Mason et al., 2013; Prober & Khan, 2013; Simpson & Richards, 2015; Yeung & O’Malley, 2014).
Instructors must be mindful of the capacities and concerns of students adapting to this new and necessary out of class preparatory work to avoid wasting in class time with students who are misinformed or poorly prepared. One study by Khanova et al. (2015) compiled qualitative responses from ten courses suggesting pre-class modules maintain a desirable 20-30 minute interval and the most conducive modules to productive student learning are “edited, concise, simple, and engaging... containing very good information”. An important aspect of generating new curricula is to carefully devise a strategic and informed structure of material to prevent a need for a massive reworking. While the time and resource demands for adaptation to a flipped curriculum are considerable, studies have shown a successful alternative through implementation of a semi-flipped model in order to decrease time demands considerably with maintenance of similar learning gains (Gorres-Martens et al., 2016; Hung et al., 2008).

The rudimentary nature of the flipped concept as a learning model can induce feelings of apprehension, similarly for both instructor and student, because of an uncomfortable transition away from the deep-seated conventional lecture. For the instructor, their new role as a facilitator of a student centered learning process can be far removed from their previous presentation role. An important key to success in their new role is through acknowledging the inherent value in the flipped approach and augmenting its educational competencies through capable and enthusiastic facilitation of implementation (Khanova et al., 2015a). To evaluate ‘educator readiness,’ workshops in which instructors can gain confidence and have access to demonstration of successful techniques can be instrumental to success (Khanova et al., 2015a).
Prior to the venture of revising curricula, student expectations, attitudes, and learning styles can be gauged to consider realistic goals regarding outcomes and success. One study demonstrated a pre-study survey assessment as an accurate model for prediction of an unsuccessful flipped outcome with regards to satisfaction and perceived learning gains of a 171 student pharmacotherapy class in a PharmD program (Khanova et al., 2015b). This study noted conclusions from a pre-study assessment including: 72% of the students prefer the traditional model to the flipped class and that students held the opinion that reading text was not an agreeable forum to enhance learning. Considering this study used predominantly textual based modules as a pre-class approach to preparation, these conclusions coincide with student struggles in course format (Khanova et al., 2015b). This study’s conclusions were uncommon amongst the literature due to the failure to demonstrate learning gains associated with the flipped classroom.

Despite the collective of positive conclusions, the majority of studies address an array of concerns regarding implementation primarily differing based on student population and modality of structuring. To knowledgably structure and implement a flipped curriculum tailored to the specific needs of each unique student demographic, instructors can incorporate assessment to further course redesign as it is likely that refinements and multiple revisions will be necessary (Khanova et al., 2015b). Instructor and course flexibility to address these concerns including adaptation and adjustment are to be expected (Khanova, et al., 2015a). The collective research with reference to the flipped classroom contains evidence of numerous challenges in implementation outlined
below; nonetheless the model is supported as a successful approach that is overall positively received.

As with any change in fundamental processes, students’ preference of a familiar instructional model prompts student hesitation towards the shift to an unaccustomed flipped model in which expectations are unclear (Mason et al., 2013). These ambiguous expectations with regard to class structuring have basis in students’ inability to recognize crucial information and lack of understanding regarding the value of pre-class completion of quizzes as an assessment and reinforcement tool (Simpson & Richards, 2015). In one study of a graduate physiology course, students had a general sense of “low enthusiasm” regarding the flipped model despite significant quantitative learning gains (Tune et al., 2013). However, student resilience was demonstrated in adaption to the new learning style (Mason et al., 2013) through adjustment in approach to the content and by fostering successful learning habits (McLean et al., 2016). Despite the initial apprehension in implementation many advantages of the model were studied including increased quantitative learning gains.

Quantitative measurements of learning gains for the flipped course model generally compare exams of a historical control instructional lecture course to the same currently implemented flipped course. In comparison to the control instructional model of a past year, several studies reported an increase in examination score (Galway et al., 2014; Mason et al., 2013; McLaughlin et al., 2014; Pierce & Fox, 2012) with one notable study reporting an increase in all three exams scores (two reported as having statistical significance) (Albert & Beatty, 2014). A uniquely designed study, also measuring exam
scores for quantitative comparison, compared two concurrent classes of comparable graduate students evaluating their performance on cardiovascular, respiratory, and renal physiology (Tune et al., 2013). Tune et al. (2013) identified within their study a considerable weighted cumulative increase of 12 percentage points. Another study, in the redesigning of a second year pharmacy course, measured an increase in course grades, as opposed to exam scores (Ferreri & O’Connor, 2013). While research is limited with regards to an increase in quantitative learning gains attributed to the flipped approach, it is encouraging that the model across literature consistently maintains equal performance as lecture courses, as reported in unchanged exam scores (Baepler et al., 2014; Ojennus, 2016; Prober & Khan, 2013; Whillier & Lystad, 2015). This suggests that the flipped model has the potential to maintain or increase previous learning performance while also having the benefit of contributing to a multitude of higher order cognitive goals and an increase in student satisfaction of the learning experience.

Student satisfaction of flipped classroom courses was assessed through likert scale data and qualitative free responses with comparison to its traditionally lectured counterpart. In comparison to the traditional instructional model, the totality of literature reports increased student satisfaction (Critz & Wright, 2013; Davies et al., 2013; Gillois et al., 2015; Mason et al., 2013) and instructor satisfaction (Critz & Wright, 2013) with the flipped approach. In fact one study, conducted by Moraros et al. (2015), of 67 masters graduate students in an epidemiology course concluded that 80% of participants found the flipped approach to be somewhat to very effective. Convincingly, a study by Gilboy et al. (2015) reported 62% of participants in a nutrition flipped classroom preferred the
flipped model. Pierce and Fox (2012) published data that revealed 80% of students, within their study, believed the flipped course “assisted with their learning”. In a survey assessment involving Stanford medical students 82% of the 141 respondents favored the flipped approach as opposed to traditional lecture (Prober & Khan, 2013). In a study of medical staff in the emergency department 98% of respondents preferred the flipped approach to learning emergency medicine (Tan et al., 2015).

To bolster the encouraging conclusions of this wealth of research, another study by Gorres-Martens et al. (2016) suggested that the positive perception and outcomes reported have the potential to increase overtime. Gorres’ study reported an increase in all areas of student satisfaction during the second flipped class, with the most notable 32% increase of students perceiving an enhanced retention of information from the original 56% in the first flipped class (Gorres-Martens et al., 2016). One study did not assess satisfaction directly but suggested that the flipped classroom was positively received by students and residents (Young et al., 2014). Despite the majority of positive literature a study conducted on chiropractic students in undergraduate neuroanatomy reported no change in satisfaction among students attributing their results to poor planning of the flipped course and shortened course time despite extensive content (Whillier & Lystad, 2015). Missildine et al. (2013) conducted a study on a group of undergraduate nursing students in their first and second year and concluded that despite the decrease in percentage of student failing the course there was an overall decrease in satisfaction. However, increased satisfaction in a flipped course model can also be seen in reference to a paralleled increase in attendance. When a flipped course was implemented into the
Stanford medical school biochemistry curriculum, attendance by students of a core biochemistry class increased from 30% to 80% (Prober & Khan, 2013).

Many challenges and successes were reported qualitatively with regards to in-class active and collaborative learning activities. The perception of students concerning flipped model successes were a noticeable increase in practical skills including communication and collaboration in group work through effective engagement with peers (Ferreri & O’Connor, 2013; Ojennus, 2016; Whelan et al., 2016). Accompanying teamwork skills was the notion that collaboration tended to increase skills for innovation (Davies et al., 2013; Pierce & Fox, 2012; Strayer, 2012; Young et al., 2014). The flipped course also increased opportunities for application of information, furthering a thorough understanding of content and increasing one’s individual capability to incorporate “logical approaches” into real world issues (Khanova et al., 2015a; McLean et al., 2016; Simpson & Richards, 2015). There were mixed conclusions as to the most effective in-class activities, multiple studies regard the application value inherent within case scenarios and discussions as the most effective (Khanova et al., 2015a; Tan et al., 2015) while another study perceived solving questions in class as the most beneficial aspect to learning (Moraros et al., 2015). Considering an increase in instructor emphasis on engagement with comparison to the traditional structure (McLaughlin et al., 2014), consequentially students perceived and increase in active participation conducive to spending more quality time engaging with material (Khanova et al., 2015a).

Several salient themes surfaced with regards to in-class implementation of the flipped model. Students demonstrated a preference for reinforcement of pre-class
material embedded in in-class activities requiring a sensible transition from basic knowledge to case scenarios with attentive awareness to prevent providing too much new information that would essentially function as a “double lecture” (Khanova et al., 2015a). Despite a preference for reinforcing the material the study by Khanova, Roth, et al. (2015) also cited redundancy as a draw back of the flipped model. Also noted was the increased responsibility of the instructor in flipped course implementation. Students perceive new instructor roles to encompass: facilitation and elaboration of important material, addressing questions within the coursework, and having the essential role in continuous evaluation of student mastery of knowledge (Khanova et al., 2015a). In a contradicting study by Yeung et al. (2014) students felt that instructor responsibility was decreased excessively, with disproportionate individual responsibility for learning, compounded with the inability to ask questions while completing coursework led to unreasonable expectations of students. A study by Wilson (2013) elaborated on this finding, that when personal expectation of the learning process was excessive students’ attitudes toward content shifted to ‘boredom and disengagement’. With regards to multiple instructors, Khanova, Roth, et al. (2015) demonstrated that coursework that is taught in a team has the positive aspects of a “change of pace” and a chance at hearing “different viewpoints”. However, with multiple instructors, varying expectation with regards to coursework, can emphasize a lack of smooth transitions and inconsistencies in assessment (Khanova et al., 2015a).

Despite in class concerns, pre-class content offloading into independently studied modules has potential benefits including increasing the sense of autonomy a student has
in their learning process. This autonomy materializes as the ability to control the pace of content acquisition, increased time associated with processing and pausing of lectures, and in organization (Critz & Wright, 2013; Khanovaet al., 2015a; McLean et al., 2016; Ojennus, 2016) and flexibility of coursework (Simpson & Richards, 2015; Yeung & O’Malley, 2014). A common theme among complaints of poor implementation was unsatisfactory quality of video and online modules perceiving characteristics of the worst modules as “monotonous, boring, full of errors and having confusing language” (Conner et al., 2014; Enfield, 2013; Khanovaet al., 2015a; Young et al., 2014). Although instructors had misgiving with regards to student motivation to complete preparatory work before class (Herreid & Schiller, 2013), studies reported that pre-work was consistently completed prior to class (although the capability of re-watching lectures was rarely utilized) (McLaughlin et al., 2014; Tune et al., 2013). Tune et al (2013) and McLaughlin et al. (2014) also assessed student perceptions, concluding that students aligned with the belief of responsibility in preparation, understanding its crucial role in the individual learning process and its necessity for in-class success.

Despite the many goals identified in pursuing implementation of a flipped classroom model, the overall benefits are numerous. Studies cite student benefits including: an increase in the learners experience (Baepler et al., 2014; McLaughlin et al., 2014; Prober & Khan, 2013), the ability to cover an increased content load (Mason et al., 2013) and the fostering of independent learning skills while increasing student confidence (Ferreri & O’Connor, 2013). In the realm of higher order thinking, the flipped classroom produced instructor and student perceived positive results, including
strengthened critical thinking (Critz & Wright, 2013; Gorres-Martens et al., 2016), increased retention (Gorres-Martens et al., 2016), a heightened sense of comfort with complex topics and better use of in-class time (Ojennus, 2016). A study by Davies et al. (2013) claimed that the larger emphasis on learning and motivation, attributed to the flipped class, accompanied an increase in time spent on homework. Khanova, Roth, et al. (2015) cites that students felt that an advantage of the flipped classroom was in encouraging current pace with the material to prevented cramming. Mclean et al. (2016) reports a decrease in “multitasking behavior,” which was interpreted as an interruption of knowledge, suggesting that students are adapting their behavior to align with deep and active learning habits. One unique study of medical school students in France proposed that the flipped class model has a direct positive affect on the low socio-economic class students by decreasing the inequality of opportunity to perform well in the course (Gillois et al., 2015). Another study by Baepler et al. (2014) offered that an advantage of the flipped classroom is in reduction of instructor contact by two-thirds while producing the same results. Students in Prober and Khans’ (2015) study perceived an increase in empowerment, development, and engagement. Considering the vast educational advances inherent within the flipped model, it is encouraging that students would recommend the flipped course to others (Davies et al., 2013) and “wished more instructors used the model” (Gorres-Martens et al., 2016).

The flipped classroom is integrated into medical school curricula with the use of educational technology as a forum for guided independent study where content is administered in the form of print, audio and video lectures, often with interspersed with
practice problems to check content understanding. This structure creates a learner-centered approach where students can engage with the content on their own time and pace. In class time focuses on a series of activities including: problem based learning, team based learning, case based scenarios, expert led discussion, and presentations, to foster an active and collaborative learning environment that applies higher order and critical thinking skills to bridge analysis and application in basic and clinical science.

Instructors have a shift in role from delivery of content to challenging students to develop their personal and professional skill set, encourage reflection, and cultivate attitudes critical to innovation. The flipped classroom also has a unique goal for medical education in that it supports student responsibility and accountability to their own education allowing them to engage deeper into material within their particular interests coinciding with their specialization.

Effectiveness of Online Education Modules

The flipped model is largely dependent on pre-class mastery of material to shift in-class time to interactive and genuine application of content. This structure relies upon the successes within online modules as a pre-learning environment and requires superior competency with online software as an interactive platform. The majority of healthcare related research demonstrates the effectiveness of online modules to teach continuing medical education (Masud et al., 2016; VanNieuwenborg et al., 2016; Williams, 2014) or in gaining a specialized review of a topic to enhance patient care (Kerfoot et al., 2007; Lockey et al., 2015; Phillips et al., 2014). The most cited educational module advantages were increased flexibility to learn material at own pace (Lockey et al., 2015) and its
ability to increased the depth of knowledge regarding the topic (Kerfoot et al., 2007; Phillips et al., 2014). In a study by Kerfoot et al. (2007), of 693 residents and medical school students, it was demonstrated that online modules could enhance learning gains across multiple competencies as measured by pre and post test assessments and are a valuable asset to the healthcare field (Kerfoot et al., 2007).

There is very limited research with regards to online modules being used in medical school curricula. The majority of studies that exist reside in different countries and were designed for a very specific competency or content. One study at The University of Nebraska Medical Center in the pediatrics unit showed improved confidence of medical school students with online module integration despite lack of increased test performance. These conclusions were also found within a study in Indonesia with a module in gross motor screening, finding this approach “effective, efficient, and acceptable” (Pusponegoro et al., 2015). Conversely, a study by Abdelhai et al. (2012) in Egypt claimed an increase in results on score in a reproductive health module that accompanied an enhanced learning experience and eagerness to access modules. Studies regarding increased task performance were: a study by Deghan et al. (2006) that demonstrated medical students more accurately administer drugs post-module and in a study by Ronn et al. (2012) found that 88.9% of respondents agreed that the modules prepare them for pelvic examinations.

The online software platform SoftChalk can be used to design curricula into individual online modules with embedded questions and activities. While there were no studies on medical school students and the use of SoftChalk, one continuing medical
education study by Williams et al. (2014) with emergency medical physicians concluded that the modules increased learning gains significantly and participants enjoyed use of the modules. The only other study with regards to SoftChalk use, involved embedding prerequisite information into online modules (Alsharif & Henriksen, 2009). The study concluded that SoftChalk was positively received but it was not extensively studied (Alsharif & Henriksen, 2009). Thorough appraisal of online programs can be used to assess future success with integration. Curriculum needs should be addressed prior to software acquisition in order to construct modules that fit all needs specific to the design.

*Specific Aims and Objective*

The objective of this study was to determine if SoftChalk is an effective pre-learning environment within flipped medical school biochemistry modules. Students were surveyed to gain insights into their learning experience in the hopes of strategically and knowledgably improving future module content and implementation. These revisions are crucial in advancing an intelligently designed curriculum embedded in learning research aimed to enrich the student learning process and in successful educational outcomes.

Upon review of the literature there is a notable lack of research regarding the flipped approach within the context of medical school curricula. There is a demand for studies of flipped classrooms specific to medical education due to the unique requirement of medical educational objectives to address an extensive mastery of both basic and clinical sciences, not necessarily generalizable from other higher education research. To this end, there is a clear need for research that assesses pre-learning tools within flipped class medical education to construct a successful solution to content overload through effective
dispersion of basic science information. Within the collective of flipped classroom research there are no studies that have a control comparing students that have taken both the flipped and traditional course. This study aims to address student experience with SoftChalk as a pre-class learning tool in medical school biochemistry modules to improve upon implementation of a flipped class within medical school curricula while having the exceptional benefit of a control that uses a subset of students that have taken both the traditional and flipped course. Comparing these students to those with other biochemistry experience, will allow a more thorough understanding of the inherent preferences of medical school students to be determined. This insight will empower development of a successfully structured medical school curriculum to meet the unique demands of medical students while maximizing the value within their rigorous education and constructing an associated learning tool that is of the utmost effective.
METHODS

Course Design

The Boston University School of Medicine curriculum is outlined in Figure 1. It is composed of PrISM (basic science courses with integrated clinical content including: Gross Anatomy, Biochemistry, Cell Biology, Histology, Neurosciences, Physiology, Immunology and Genetics modules), Introduction to Clinical Medicine Integrated problems and Public Health in Medicine (“a course designed to teach the social, ethical, political and economic context of health care” (“BU School of Medicine (BUSM) Required Courses,” n.d.).

Figure 1. Boston University First Year Medical School Curriculum Structure.

A newly designed first year medical curriculum was implemented beginning with
the class of 2019’ in August 2015. Within the curriculum of PrISM, modules containing Biochemistry material (Molecules to Cells and Cells to Tissues) were implemented with a flipped classroom design in which pre-class information was disseminated through the SoftChalk interactive online learning platform, and where class time was focused on interactive activities such as cases, discussions, and clicker questions, with a reduction in lecture material. Online modules were assigned for completion prior to class and graded (5%) for participation.

*Module Design*

The modules were designed in SoftChalk 9 Lesson Builder (SoftChalk LLC, www.softchalk.com) and were composed of 16 different sections including: protein structure and function, protein folding, enzymes, introduction to DNA, DNA replication, DNA modification and repair, RNA structure and synthesis, RNA processing and gene splicing, protein synthesis and trafficking 1, control of gene expression, techniques in molecular medicine, protein synthesis and trafficking 2, control of gene expression at the translational level, principles of membranes, protein synthesis and trafficking 3 and connective tissue proteins. These modules contained mostly text-based content with additional learning objectives, figures, rollover definitions and quiz questions throughout (Figure 2-4). The number of quiz questions varied with each section but were composed of mostly content check questions with a lesser amount of conceptual questions. The quiz questions were of different forms including short answer, multiple choice, true/false, and also included matching, labeling, and ordering exercises (Figure 5). SoftChalk was accessed by students through their student online portal (blackboard).
Protein Structure and Function

Learning Objectives
At the end of this session the students will be able to:

1. Recognize the basic structure of an amino acid
2. Classify the 20 amino acids according to the side chains and explain where in a folded protein each class of amino acid might occur
3. Explain the forces that govern protein structure
4. Define the four levels of protein structure
5. Describe weak acid/base behavior for single amino acids

References
Biochemistry with Clinical Correlations, Devlin 7th edition
Chapter 3: Proteins: Composition and Structure, pp 75-102, 112-138.

Lecture Guide
Prior to class, students should complete this exercise, which covers the fundamentals of protein structure and function. Come to class prepared to answer clicker questions based on this material. In-class material relevant to all Learning Objectives will be highlighted in the context of disease.

Figure 2. Introduction Page of Protein Structure and Function Module To Demonstrate Structure of SoftChalk Content.

Amino Acids and Protein Structure

Overview
Proteins mediate virtually all cellular processes, many of which will be discussed in this course, and include structural proteins, enzymes, plasma membrane proteins, messengers, molecular machines, and oxygen carriers.

Amino Acids
Twenty "common" amino acids provide the basic building blocks of proteins, and are joined in linear chains via covalent bonds called peptide bonds (Figure 1 and 2). A water molecule is lost in the process.

Proteins may also contain derived amino acids that are modifications of the common amino acids that occur after they have been incorporated into the polypeptide chain.

Figure 1. Formation of the Peptide Bond. There is no rotation around the C-N bond (gray box)

Figure 3. Example of Embedded Figures and Rollover Definitions.
Figure 4. Example of Quiz Question Assessment at End of Module.

Figure 5. Example of Activity Integrated into SoftChalk to Assess Understanding.
Participants

Participants of this study were all students enrolled in Boston University School of Medicine class of 2019’ (n=165). A percentage of the first year medical school class comes from pathway programs at Boston University in which some students were exposed to the same material in a traditional course format (BI751 Biochemistry and Cell Biology). The pathway programs include MS in Medical Sciences (MAMS, a special program designed for students interested in pursuing a career in medicine), Seven-Year Liberal Arts Medical Education Program (SMED, an accelerated medicine program that allows students to receive a bachelors degree and Doctor of Medicine degree in 7 years), Modular Medical Integrated Curriculum (MMEDIC, a program that allows undergraduate students at Boston University to take first year medical school classes to enhance understanding of medical sciences), and Early Medical School Selection Program (EMSSP, an early medical school selection program that aims to increase diversity in the physician workforce by selecting candidates from Historically Black Colleges and Universities). These pathway programs provide a unique opportunity to compare traditional and flipped courses for the biochemistry modules to better address the effectiveness of SoftChalk at disseminating pre-class information and the goals of curriculum reform on a whole. Participation was voluntary and the study was reviewed by the BU Institutional Review Board and designated “Exempt”

Study Design

The study was designed with a mixed-method anonymous survey, shown in Figure 2, to explore experience with SoftChalk online sections by students in the newly designed
flipped biochemistry course modules. Surveys were created on survey monkey and were sent out via email after completion of all first semester modules. An email reminder was sent out 3 times. The survey was composed of a total of 10 questions. The first question was a select from above question regarding previous biochemistry experience including: BI751, graduate course at other institution, undergraduate course, or no previous biochemistry experience. The next two questions were open-ended free response questions including a neutrally posed question regarding experience with biochemistry online SoftChalk modules and how the assignments could be improved upon. The next question outlined all 16 modules and asked approximate time to complete each module. The final six questions were likert scale responses asking specifically about the effectiveness of SoftChalk as a pre-learning tool, its ability to provide a foundation for material in class, its ability to guide students with staying on track with material, the questions’ ability to assess understanding and assessment of perceptions regarding difficulty of the questions. The survey was optional as there was no incentive for completion.
We are inviting you to participate in a short survey to assess online education as part of the medical curriculum. The survey will be conducted anonymously. Only aggregate data will be collected and individual responses will not be examined. Each survey should take approximately 5 minutes to complete. While it is appreciated if all questions are answered, this is not required and you can opt out of any question. Participation in the survey is voluntary and will not affect your grade in the course. This survey is completely anonymous. None of your answers can be linked back to you. Additionally your choice to participate or not participate in this survey will have no affect on your grade. This is not a required assignment. Answers from this survey will be used to improve online education, and analysis of survey answers may be published. Once again, this survey will be anonymous and will have no bearing on your grade in this course or any other course.

If you have any questions please contact Karen Symes (course director) at symes@bu.edu or at 617-638-4077. If you have questions about your rights as a research subject please contact BUMC IRB at 617-638-7207 or medinfo@bu.edu.

1. Which of the following best describes your previous experience studying biochemistry?
   - [ ] I have never taken a biochemistry course
   - [ ] I have taken (an) undergraduate course(s) in biochemistry before
   - [ ] I have taken the graduate biochemistry course, BI751 Biochemistry and Cell Biology (course director: Dr. Otter), at BUSM
   - [ ] I have taken graduate course(s) in biochemistry at another institution other than BUSM

2. How would you describe your experience with the online (soft chalk) biochemistry assignments?

   [ ]

3. How could the assignments be improved?

   [ ]

4. How long did it take you to complete the biochemistry assignments (including both reading and assessment)?

<table>
<thead>
<tr>
<th>Less than 30 minutes</th>
<th>30 minutes</th>
<th>1 hour</th>
<th>1 hour 30 minutes</th>
<th>2 hours</th>
<th>More than 2 hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein Structure and Function</td>
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<tr>
<td>Protein Folding</td>
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<td>Enzymes</td>
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<tr>
<td>Introduction to DNA</td>
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<td>DNA Replication</td>
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<td>DNA Modification and Repair</td>
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<tr>
<td>RNA Structure and Synthesis</td>
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<tr>
<td>RNA Processing and Gene Splicing</td>
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<tr>
<td>Protein Synthesis and Trafficking 1</td>
<td>[ ]</td>
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<td>[ ]</td>
</tr>
<tr>
<td>Control of Gene Expression</td>
<td>[ ]</td>
<td>[ ]</td>
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</tr>
<tr>
<td>Techniques in Molecular Medicine</td>
<td>[ ]</td>
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</tr>
<tr>
<td>Protein Synthesis and Trafficking 2</td>
<td>[ ]</td>
<td>[ ]</td>
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<td>[ ]</td>
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</tr>
<tr>
<td>Control of Gene Expression at the Translational Level</td>
<td>[ ]</td>
<td>[ ]</td>
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<tr>
<td>Principles of Membranes</td>
<td>[ ]</td>
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<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>Protein Synthesis and Trafficking 3</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>CTT: Connective Tissue Proteins</td>
<td>[ ]</td>
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<tr>
<td>Other (please specify)</td>
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</tbody>
</table>

30
Figure 6. Boston University School of Medicine Curriculum Assessment Survey.

**Data Collection and Analysis**

Data was collected through survey monkey and exported to an excel sheet where all responses were compiled for analysis. Qualitative data was analyzed independently by three analysts for common themes and their coinciding frequencies. Salient themes were refined through multiple meetings. Likert scale data were analyzed to determine frequency of responses and stratified by previous biochemistry experience to determine if the control group with experience in the same traditional lecture would have differing conclusions than the class average.
RESULTS

A total of 165 students in Boston University medical school class of 2019 were surveyed with a compilation of qualitative free text responses and quantitative likert scale questions. The likert scale responses had the options of strongly agree, agree, neutral, disagree, and strongly disagree. The survey response rate was 27-35%, with 96 qualitative free response and 345 quantitative likert scale responses. Specifics of response rate and individual questions are outlined in Table 1. Of the respondents, quantitative data was stratified by previous biochemistry experience including BI751 (66%), undergraduate biochemistry course (24%), graduate course at other institution (5%), and no biochemistry experience (5%). Qualitative data was not stratified by biochemistry experience due to the assessment that free text themes maintained similarity throughout.

In assessment of qualitative and quantitative data sets, three major themes emerged: SoftChalk as a quality learning tool, lack of integration and consistency in implementation and formatting concerns with an overall positive perception of the pre-learning tool.
Table 1. Number of respondents and biochemistry background data.

<table>
<thead>
<tr>
<th>Qualitative respondents</th>
<th>n (%)</th>
<th>n (%)</th>
<th>BI751 Biochemistry</th>
<th>n (%) Undergrad Biochemistry</th>
<th>n (%) No Biochemistry</th>
<th>n (%) Grad Biochemistry at other institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1: How would you describe your experience with the online (soft chalk) biochemistry assignments?</td>
<td>51 (31)</td>
<td>35 (69)</td>
<td>10 (20)</td>
<td>3 (5.5)</td>
<td>3 (5.5)</td>
<td></td>
</tr>
<tr>
<td>Q2: How could the assignments be improved?</td>
<td>45 (27)</td>
<td>33 (73)</td>
<td>6 (13)</td>
<td>3 (7)</td>
<td>3 (7)</td>
<td></td>
</tr>
<tr>
<td>Quantitative respondents</td>
<td>58 (31)</td>
<td>38 (66)</td>
<td>14 (24)</td>
<td>3 (5)</td>
<td>3 (5)</td>
<td></td>
</tr>
<tr>
<td>S1: The online modules were effective at teaching me about different aspects of biochemistry.</td>
<td>58 (31)</td>
<td>38 (66)</td>
<td>14 (24)</td>
<td>3 (5)</td>
<td>3 (5)</td>
<td></td>
</tr>
<tr>
<td>S2: The online modules provided the foundation for the material discussed in class.</td>
<td>57 (31)</td>
<td>38 (67)</td>
<td>13 (23)</td>
<td>3 (5)</td>
<td>3 (5)</td>
<td></td>
</tr>
<tr>
<td>S3: I felt that the online modules helped me to stay on track with my studying of the course material.</td>
<td>58 (31)</td>
<td>38 (66)</td>
<td>14 (24)</td>
<td>3 (5)</td>
<td>3 (5)</td>
<td></td>
</tr>
<tr>
<td>S4: I felt the questions assessed my understanding of the material.</td>
<td>57 (31)</td>
<td>37 (65)</td>
<td>14 (25)</td>
<td>3 (5)</td>
<td>3 (5)</td>
<td></td>
</tr>
<tr>
<td>S5: The questions were too easy.</td>
<td>57 (31)</td>
<td>37 (65)</td>
<td>14 (25)</td>
<td>3 (5)</td>
<td>3 (5)</td>
<td></td>
</tr>
<tr>
<td>S6: The questions were too hard.</td>
<td>57 (31)</td>
<td>37 (65)</td>
<td>14 (25)</td>
<td>3 (5)</td>
<td>3 (5)</td>
<td></td>
</tr>
</tbody>
</table>

n=165
BI751: Graduate Biochemistry at BUSM

**SoftChalk as a Quality Learning Tool**

Students’ experience with SoftChalk was explored to assess the effectiveness of online modules as a pre-learning tool for content dispersion and to identify the main advantages and weaknesses of its integration into the structure of the curriculum. Students responded with free text feedback to neutrally framed questions regarding experience and improvement of online SoftChalk biochemistry modules. Fifty-three percent of respondents (n=51) commented on SoftChalk as a helpful (13) pre-class learning tool:
“I thought (it) was an extremely helpful early exposure to the material.”

“The most useful part of the course, from my perspective.”

Within the context of SoftChalk as a learning tool several notable subthemes surfaced with multiple iterations (Table 2). The most commented on subtheme was with respect to the activities within online modules (13) including: an appreciation of quiz questions throughout content to function in assessment of accurate understanding of material (7), and augmentation of textual content through quality figures (4) to improve visual learning. Another common subtheme was the usefulness of the platform to engage students in interactive exercises as early exposure to the material that was furthered in in-class activities (6). Students expressed appreciation for the platform’s productive qualities:

“I enjoyed the interactive portions that helped me test my knowledge.”

“They were very educational, streamlined/concise and to the point … I found them very helpful in preparing for interactive lectures.”

The qualitative data also suggests (n=45) that the assessment functionality of SoftChalk can be improved through the addition of more questions per section (3) and in shifting the focus of question to have basis in challenging concepts (2). Many students also commented on SoftChalk as an informative resource (5) that was ‘helpful’ to their studies.
Table 2. Student perspective regarding experience with SoftChalk online biochemistry assignments.

<table>
<thead>
<tr>
<th></th>
<th>Number of Comments n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SoftChalk as a quality learning tool</strong></td>
<td></td>
</tr>
<tr>
<td>Activities as a helpful tool (quizzes, figures)</td>
<td>13</td>
</tr>
<tr>
<td>Interactive/early exposure to material</td>
<td>6</td>
</tr>
<tr>
<td>Informative resource</td>
<td>5</td>
</tr>
<tr>
<td>Helped with reinforcement/clarification of material</td>
<td>2</td>
</tr>
<tr>
<td>Helpful study/review tool</td>
<td>2</td>
</tr>
<tr>
<td>Comprehensive</td>
<td>1</td>
</tr>
<tr>
<td><strong>Integration and consistency concerns</strong></td>
<td>23 (45)</td>
</tr>
<tr>
<td>Too dense/time consuming (shorter is better)</td>
<td>11</td>
</tr>
<tr>
<td>Preference for comprehensive syllabus</td>
<td>8</td>
</tr>
<tr>
<td>Redundant/irrelevant information</td>
<td>3</td>
</tr>
<tr>
<td>Lack of addressing material in class</td>
<td>3</td>
</tr>
<tr>
<td>Needs more autonomy/too rigid expectation of use</td>
<td>2</td>
</tr>
<tr>
<td>Inconsistency among instructor expectations</td>
<td>1</td>
</tr>
<tr>
<td><strong>Formatting issues</strong></td>
<td>4 (8)</td>
</tr>
<tr>
<td>Incomplete transfer from electronic to pdf</td>
<td>4</td>
</tr>
<tr>
<td>Difficult to navigate</td>
<td>1</td>
</tr>
</tbody>
</table>

n=51

The value of SoftChalk as a productive learning tool is reinforced by quantitative data results. In assessing student perceptions on the ‘effectiveness of online modules at teaching different aspects of biochemistry’ a definitive evaluation of success can be calculated. Figure 7 demonstrates that on average 64% of the class agreed/strongly agreed that SoftChalk was effective, 16% were neutral, and 20% disagreed/strongly disagreed. When stratified by biochemistry experience, the trend demonstrated consistency across all students with prior exposure to biochemistry. Student responses among the cohort with no biochemistry experience had an even distribution in agreement,
disagreement and neutrality.

Figure 7. Student perceptions of effectiveness of online modules at teaching biochemistry stratified by previous biochemistry experience.

The quantitative data also provides elaboration on the utility and quality of quiz questions within SoftChalk modules. On average 64% of respondents agreed/strongly agreed that the questions assessed their understanding of the material (Figure 8). Students with no experience in biochemistry and those with a background in undergraduate coursework agreed more with this statement whereas students with a background in BI751 or other graduate biochemistry course were more neutral on the subject. All groups
maintained minimal agreement with the statement. Figure 9 demonstrates the perceptions of quiz questions in the negatively posed statement that ‘SoftChalk questions were too easy’. The majority of respondents 53% disagreed/strongly disagreed with the statement with a lesser 36% being neutral. The students with no biochemistry background agreed with this statement 100% of the time, where as those with an undergraduate background disagreed with a lesser 57%. Students with BI751 or graduate course experience disagreed even less with 43% and 33% respectively. In Figure 10 regarding the negatively posed question if quiz ‘questions were too difficult’ 42.5% of the class disagreed/strongly disagreed and 47% were neutral. Students with no biochemistry experience disagreed 100% with this statement followed by 64% in BI751, 33% graduate course and 30% undergraduate experience. There was minimal agree/strongly agree responses regarding questions being too difficult with only 10.5% responding in this manner. Both qualitative and quantitative data demonstrates SoftChalk as a quality pre-learning tool by assisting in application through an interactive platform to assess understanding of material. However success may also be attributed to the sophistication of questions written.
Figure 8. Student perceptions on the questions assessing understanding of the material stratified by previous biochemistry experience.
Figure 9. Student perceptions on the SoftChalk questions being too easy stratified by previous biochemistry experience.
Figure 10. Student perceptions on the SoftChalk questions being too difficult stratified by previous biochemistry experience.

Lack of Integration and Consistency

Although students acknowledged that online biochemistry modules had inherent value within effectiveness and assessment, students recognized the distinction in flawed integration with regards to expectations and consistency. Commentary surfaced with respect to inconsistencies within modules and instructor expectations in both experience (n=51) and improvement (n=45) qualitative data sets. Regarding student experience with SoftChalk 45% of students mentioned issues with implementation within the course load. The most prominent criticisms the students held were that the pre-class modules were too dense and time consuming (11) and that one comprehensive source of all information was preferable (8). Student criticisms ranged often accompanied an appreciation of value of

n=57
BI751: Graduate Biochemistry at BUSM
the online modules while others simply mentioned its inadequacies:

“The soft chalks that I found most useful were on the shorter side and were more of a preview of the lecture than supplemental to the lectures. In general, the SoftChalks that were designed as the primary source of learning material were very dense, which made it challenging to go back and find information for review.”

“I felt the softchalks were far too dense. I feel online material should supplement the textbook or in this case the syllabus.”

Within the quantitative data student alignment with their experience with SoftChalk was mixed despite their impression that the online modules fulfilled their purpose of providing a foundation for class activities. Students were asked if SoftChalk provided a foundation of material for topics discussed in class, 73% of the class agreed/strongly agreed and 17% disagreed/strongly disagreed (Figure 11). There were consistent trends across biochemistry experience suggesting the success of the online modules in guided distribution of content. In Figure 12, with respect to SoftChalk online modules, the majority of students (51%) perceived their use in staying on track with studying course material while 31% of the class disagreed/strongly disagreed. Students with a background in graduate biochemistry and undergraduate biochemistry agreed more than average 67% and 56% respectively. While those that had never taken biochemistry were even distributed with 1 student agreeing, 1 being neutral and 1 disagreeing. Students with BI751 experience however disagreed/strongly disagree (54%) with only 30% agreeing with this statement. This disagreement was a significant deviation from the class
on average suggesting the control experience with the traditional lecture affected the perception of the online modules.

![Bar chart showing student perceptions of SoftChalk modules.](chart)

- Average: 73% Agree/Strongly Agree, 10% Neutral, 17% Disagree/Strongly Disagree
- Graduate Course Biochemistry (not BI751): 100% Agree/Strongly Agree
- BI751: 64% Agree/Strongly Agree, 21% Neutral, 15% Disagree/Strongly Disagree
- Undergraduate Biochemistry: 74% Agree/Strongly Agree, 18% Neutral, 8% Disagree/Strongly Disagree
- Never Taken Biochemistry: 67% Agree/Strongly Agree, 33% Neutral

n=58
BI751: Graduate Biochemistry at BUSM

Figure 11. Student perceptions of SoftChalk modules providing a foundation for material discussed in class stratified by previous biochemistry experience.
Figure 12. Student perceptions of online modules helping students stay on track with studying course material stratified by previous biochemistry experience.

Since students viewed lack of integration and consistency of SoftChalk as a major concern in implementation it is not surprising that many students addressed solution for improvement. Table 3 outlines the major suggestions of students with frequency of responses. The most cited improvement was that efforts be made to consolidate all information into one resource (13):

“I wasted most of my time not being confused by the material but rather how the material was presented and trying to integrate all the resources.”

n=57
BI751: Graduate Biochemistry at BUSM
While students expressed the value of SoftChalk they also highlighted the need for autonomy within their education (7), including the freedom to study modules at leisure as opposed to a pre-class tool. Since 5% of student grades depended upon answering questions within modules prior to class this was perceived disadvantage. Other more direct survey responses were to make the modules more concise (5), cutting out all redundant or irrelevant information (5). Another critical improvement area was consistency among instructors’ expectation of the purpose and role of SoftChalk (4), students citing:

“Each instructor had very different expectations regarding preparation for class.”

“Having more continuity between instructors. Each instructor had very different expectations regarding preparation for class, making it so that different material had to be studied in different ways.”

Future revisions of SoftChalk online biochemistry modules can use these implementation frustrations and suggestions to maximize use of all competencies and worth inherent within this educational tool.
Table 3. Student perspective regarding how to improve SoftChalk online biochemistry assignments.

<table>
<thead>
<tr>
<th>Category</th>
<th>Number of Comments n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Integration and consistency concerns</strong></td>
<td>32 (71)</td>
</tr>
<tr>
<td>Consolidate resources into one place (syllabus)</td>
<td>13</td>
</tr>
<tr>
<td>Use of soft chalk as post versus pre class exercise</td>
<td>7</td>
</tr>
<tr>
<td>Make modules more concise</td>
<td>5</td>
</tr>
<tr>
<td>Remove redundant/irrelevant information</td>
<td>5</td>
</tr>
<tr>
<td>Maintain a consistency in instructor expectations</td>
<td>4</td>
</tr>
<tr>
<td>Devote more time to explaining material in class</td>
<td>1</td>
</tr>
<tr>
<td>Visual learning more help than textual explanation</td>
<td>1</td>
</tr>
<tr>
<td><strong>Enhance softchalk as a quality learning tool</strong></td>
<td>8 (18)</td>
</tr>
<tr>
<td>Increase number of questions per module</td>
<td>3</td>
</tr>
<tr>
<td>Make questions more challenging/conceptual</td>
<td>2</td>
</tr>
<tr>
<td>Increase depth of explanations to questions</td>
<td>2</td>
</tr>
<tr>
<td>Add more helpful videos/links</td>
<td>2</td>
</tr>
<tr>
<td><strong>Formatting issues</strong></td>
<td>4 (9)</td>
</tr>
<tr>
<td>Paper/better printing option</td>
<td>2</td>
</tr>
<tr>
<td>Address compatibility with mobile device</td>
<td>1</td>
</tr>
</tbody>
</table>

n=45

*Formatting Concerns*

Another common theme among the qualitative data was formatting within SoftChalk regardless of prompt. The major frustration regarding formatting with experience and improvement was the inability to contain all SoftChalk capabilities within a PDF format so it could be printed (4,4) or used to take notes.

“The formatting of soft chalk and the fact that it was a website rather than a pdf made it difficult for me to study from it.”

“The hover on definitions do not show up when the SoftChalks are printed.”
Other minor concerns were difficulty navigating online modules (1) and incompatibility with mobile devices (1).

Confounding Data: Other Non-Biochemistry Modules

In analysis of the data set there is a noticeable amount of confounding responses, however the confounding data appeared to be easily identified and omitted from considerations. The largest distinction in confounding data is with reference to other non-biochemistry modules with histology in particular emerging with more frequency. Within the improvement prompt other course modules was referenced 16% of the time (n=45), with 71% of the responses referencing histology. Numerous comments cited histology directly:

“They were OK for the 1st module. The histology SoftChalks, however, were brutally long and contained far too much extraneous information that did not enhance my understanding of the material.”

“When they were kept to the length of the BC SoftChalks (as opposed to the histology ones), I thought the were a good intro to the material.”

While others made indirect reference to specific modules or module components:

“I did not like when substantial amounts of material were covered in SoftChalk but not in lecture (Intro to Bone).”

“The soft chalk with all the videos of the cells was very helpful and informative.”

Other comments were less straightforward as to origin but lack characteristics of the biochemistry modules:
“More detailed explanations to answers. If question was answered incorrectly just says incorrect.”

Interestingly one student recognized the fact that it was a biochemistry survey mid-free texting but felt the need to emphasize improvement of other course SoftChalk modules outlining the deficiencies in each. The overwhelming theme common to histology references was the density of modules and the unreasonable expectations of students. It is possible that these concerns within our data set were confounded by responses to other course non-biochemistry modules.

Overall both quantitative and qualitative data have similar conclusions, regarding their experience with SoftChalk as positive. SoftChalk’s ability to construct an interactive platform with basic pre-class material with integration of activities for checking understanding of the material is a superior functionality. The online modules served as an informative resource for the foundation of content discussed in class. The results point to online modules as a valuable educational resource and SoftChalk characteristics having considerable quality as a pre-learning environment. Future challenges will be in reversing students’ perceptions that basic material should be instructed and that a comprehensive syllabus is necessary. Future SoftChalk modules can enhance success if pre-class modules are condensed, have a stronger transition from pre-class information to in-class activities and are consistent among instructor expectations. Future surveys should attempt to highlight the exact modules or topic being address to prevent future confounding data.
DISCUSSION

This study is the first of its kind to explore the pre-learning tool SoftChalk within a medical school program with the unique benefit of including students exposed to the material in a traditional course format. The findings of this study support previous research that SoftChalk is an ideal and effective tool for pre-class delivery of information and is an intuitively easy to use resource (Williams, 2014). Despite the low response rate of the survey, upon assessment of all data and the significant percentage of student agreement among surfacing themes, data saturation among responses suggest the qualitative evidence is of high quality. Limitations within quantitative data include a small sample size within the subset of students that have never taken a biochemistry course and those that have taken a graduate level course at another institution, each comprised of only 5% of the respondents (3). Considering that an accurate analysis within this small of a sample is not probable, conclusions with regards to these two subsets of students will not be addressed.

The findings elaborate on the usefulness of SoftChalk as a tool to disseminate content to students for pre-class preparation. To maximize its value within a flipped class medical school curriculum, student impressions on use and implementation were studied within the context of first year medical education. This study contributes to and builds upon the collective flipped class research through novel conclusions regarding module design and instructor implementation in order to bolster learning gains, target and revise concerns to enhance worth in future revisions and provide a model for success in implementation within a medical school curriculum.
Conclusions regarding SoftChalk as an effective pre-class learning environment are among the first given the general lack of research on integration of SoftChalk into a flipped classroom approach, especially with regards to medical school education. Of the literature associated with SoftChalk, one study on emergency physicians in a continuing medical education course had similar conclusions regarding the platform’s use as an effective and helpful resource (Williams, 2014). A less pertinent study characterized SoftChalk as an effective platform for dispersion of prerequisite material (Alsharif & Henriksen, 2009).

In the current study SoftChalk emerged as an effective pre-learning tool through both quantitative and qualitative data sets. Quantitatively, respondents agreed that the modules were ‘effective at teaching different aspects of biochemistry.’ The trend withstood all levels of biochemistry experience (undergraduate and BI751), suggesting that the large inherent benefit of SoftChalk is in its ability to successfully fulfill the invaluable role of distribution of basic pre-class biochemical information while promoting assimilation of knowledge. Qualitative conclusions further the utility of pre-class module assets. The collective perception of students regarded SoftChalk as an informative and comprehensive review and study tool. Dissemination of information through this interactive platform pre-exposed students to the dense material discussed in class and functioned to increase student engagement with content.

Despite marginal disagreement with the effectiveness of SoftChalk, a study by Mason et al. (2013) corroborates that initial student unease is common within the flipped class approach. This apprehension is potentially due to the shift in responsibility from
instructor to student regarding pre-class content acquisition. This conclusion is indirectly supported in the current study embedded in student responses such as, “It is difficult to teach yourself by reading.” Encouragingly Gorres-Marten et al. (2016) demonstrated that the educational benefits of the flipped model, from that standpoint of the students, have the potential to increase with multiple terms. Other studies attributed an increase in satisfaction over the course period to the flexibility of students to adapt to the new approach (Mason et al., 2013; McLean et al., 2016). Evidence of similar conclusions within our data set includes feedback along the lines of, “Initially, I disliked them (SoftChalk modules), but I eventually realized that they were very comprehensive and I used them as a resource for my review.”

A considerable advantage of the incorporation of SoftChalk into the curriculum is maintained within its interactive platform. Numerous responses mentioned the useful activities contained within the modules, suggesting they were highly regarded amongst students in our study. With respect to the quizzes, quantitative data suggests successful execution of question writing, with appropriate level of difficulty. SoftChalk questions were also successful at assessing understanding of course material, with the most agreement among students with previous undergraduate biochemistry experience. A proposal for this higher agreement is that students new to higher education course material, in transitioning, may rely on questions to assess their understanding of concepts more heavily than those with graduate course experience. The BI751 students answered more neutrally to this questions, one suggestion for this phenomenon is that these students possibly established other text sources as question banks or had less of a need to
assess understanding of material due to previous exposure. Despite neutrality within the BI751 cohort, one study claimed that regardless of question content embedded quizzes retain value with regards to providing incentive for student preparation for class (Kim et al., 2014).

Suggestions for improvement of activities related mostly to quizzes including increasing the number of questions per modules, revising the questions to focus less on content checks and more on a conceptual material, and increasing the depth of explanations to questions. One student suggested that, “There could be more interactive assignments/questions on the SoftChalk because I got a lot out of actually actively answering questions.” To address improvement concerns of question content a study by Gillois et al. (2015) claimed that students had the most appreciation for multiple-choice questions that were of similar format to the exam in order to assess effective study techniques early on in the course. Overall the findings of this study are in agreement with a study by Williams (2014) concluding that SoftChalk’s module format with interspersed questions is a superior format for examination of material.

Although there is limited research on SoftChalk as a pre-learning tool, direct and indirect evidence involved in implementation of a flipped classroom model corroborates the present findings. One of the biggest challenges regarding implementation of the flipped course is in structuring pre-class materials to be conducive to students’ workload and in having reasonable expectations of their capabilities. Within the entirety of flipped research the most consistently noted grievance is associated with time management (Prober & Khan, 2013). Students in this study, and in numerous other studies, aligned
with the perceptions that pre-class material was often too dense and time consuming for reasonable management (Khanova et al., 2015a; Mason et al., 2013; Prober & Khan, 2013; Simpson & Richards, 2015; Yeung & O’Malley, 2014). To remedy this complaint students recommended creating concise modules by reducing irrelevant and redundant information (Khanova et al., 2015a; Nematollahi et al., 2015). These same studies quoting redundancy as a draw back to the flipped classroom found that modules with time estimates of 20-30 minutes in pre-classwork were desirable although this may be less feasible across medical school curriculum (Khanova, Roth, et al., 2015; Nematollahi et al., 2015). It is important to note that within the current study, comments regarding density of modules may have been confounded by references to other non-biochemistry modules. Careful attention to survey framing should be addressed to prevent further confounding of data.

Another solution, while a minor point in this study, was noted consistently throughout flipped classroom literature was the preference that students had for visual over textual material (Ferreri & O’Connor, 2013; Khanova et al., 2015b). Considering Khanova, Mclaughlin et al. (2015) attributes the negative perception of students to the flipped model largely to difficulty with text based pre-class content, suggesting that structuring modules to have more video and visual elements could potentially further increase the satisfaction of students in our study. Student commentary within our study, calling for more videos within modules bolsters this conclusion.

A concern regarding reinforcement of pre-class content within class time surfaced within the qualitative data set and is further substantiated in a study by Khanova et al.
(2015); this study suggests constructing attentive transitions to avoid gaps in information that could prevent students from making appropriate connections from pre-class to in-class material. It also emphasizes the importance of the increased role of the instructor in the flipped classroom to maintain emphasis on facilitation and adaptation within material to adequately address concerns of students to make the most of in-class time.

Another role of the instructor that was addressed within this study and throughout flipped classroom literature was the demand for collaboration and teamwork amongst instructors (Khanova, et al., 2015a). While positive aspects of instructor collaboration were identified in Khanova’s study such as providing a fresh perspective and deviance to routine, lack of consistency among instructor expectations were regarded as needing improvement. This was also noted in the present study. This concept is crucial to the success of the pre-class learning tool, and the flipped model, through providing an intuitive resource that supports student responsibility to their education. As one student explained, “Making the lengths of the (modules) and the purpose of them uniform throughout the block would allow students to develop a consistent routine.”

An interesting feature of the control group in this study (those having taken the traditionally instructed BI751) was that they were provided with a comprehensive syllabus (lecture notes) whereas the current medical students were not. This magnified concerns with respect to what one “needed to know” to be successful and in struggling to adapt to the change in course structure, especially when considering their previous success in the traditional style. The two main benefits cited with reference to a syllabus were wasted time with consolidation of resources and unclear expectations in what was to
be tested. Interestingly, this concept surfaced in the quantitative data, specific to students that previously took BI751. While the majority of the class was in agreement that SoftChalk helped them ‘stay on track with course material’. Of those that have previously taken BI751, the majority disagreed with this notion. Based on indirect qualitative evidence a potential conclusion to this isolated disagreement by the BI751 students, points to their preference for a comprehensive syllabus as an assistive guide for their reference to the material. Within improvement responses were mentions of the syllabus, one student commented that, “Having multiple sources (soft chalk/lecture/syllabus) of information and learning objectives is confusing. The class feels disorganized and redundant. It is very unclear what we are expected to know.” While these concerns have basis in structuring of the curriculum, aspects of these concerns are a reality in shifting of educational goals away from test-oriented learning styles and in encouraging real world application skills such as consolidation of information from multiple resources. While acquisition of these skills may be uncomfortable the will have beneficial life-long consequences.

Another concern not widely addressed in the literature but noted in this study, was students’ perception of SoftChalk as lacking a defined and reasonable role. SoftChalk was viewed by numerous students as an assignment placed in the incorrect timing of the course (pre-class as opposed to post-class) as opposed to a content preparation tool designed for the flipped course structure. One study had a similar conflict regarding implementation, claiming that students struggled to understand the inherent value of pre-class assessment (Simpson & Richards, 2015). While it is apparent that within our study
students had a similar difficulty in comprehending the value of in-depth preparation of knowledge prior to class, it is possible that students did not understand the worth inherent to the flipped classroom approach or that adaptation to a new structure was not as compelling as maintaining deep-seated study techniques.

This concern can be amended with two solutions, the first being that the role of the instructor needs to be extended to involve explanation of the importance of SoftChalk as a pre-learning tool to define its purpose within curriculum (although its use as a study/review tool should also be encouraged). The second solution is implementation of a consistent flipped classroom model across the entire curriculum to promote standard expectations and to allow students to create and maintain a successful routine.

Despite implementation concerns, students perceived SoftChalk as providing a foundation for the material discussed in class, with the majority of students agreeing despite different biochemistry backgrounds. One student elaborated on the foundational aspect of SoftChalk as, “Educational, stream-lined/concise and to the point (very manageable), I found them very helpful in preparing for interactive lectures, [and] had almost all the info we needed to know.” While implementation issues must be addressed to maintain all the competencies and potential learning gains SoftChalk has to offer, it is encouraging to demonstrate that student perceptions of module construction ultimately align with its purpose as an interactive pre-learning environment.

The formatting limitations of SoftChalk were a consistent concern throughout the qualitative data. In transitioning to paperless curricula and learning tools, in order to maximize cohesive integration and student satisfaction, software with an inherent
printing or pdf function that maintains all functionality of modules is an important requirement. The quality of online materials has been addressed across a multitude of literature and is seen as central to the satisfaction of students in the switch to flipped classroom (Khanova et al., 2014; Enfield, 2013; Maher et al., 2013).

Conclusions and Future Directions

While SoftChalk maintains significant value as a pre-class learning tool and within a flipped class medical school curriculum, revision in implementation must be addressed to maximize its effectiveness. Considering the flipped classroom approach is new to both instructors and students, acknowledging a learning curve is crucial to increasing instructor capacity to perform roles and maintain consistent expectation as well as to evolving student attitudes in maintaining a sense of responsibility for their learning process. This study contributes to research elucidating successful and unsuccessful styles of flipped classroom implementation and allows for the opportunity to revise future models to better fit the needs of students. Since the extent of medical school coursework is unique, with magnified emphasis on content overload, there is a significant lack of studies that address the flipped approach within the context of medical education. Studies that assess adaptation to the flipped model in subsequent medical school terms after students have adapted to the pressures and coarse load required in medical school would vastly improve the body of literature to increase implementation success. Studies on module content comparing video lectures to text based pre-class preparation would also be of value.
APPENDIX

We are inviting you to participate in a short survey to assess online education as a part of the medical curriculum. The survey will be conducted anonymously. Only aggregate data will be collected and individual responses will not be examined. Each survey should take approximately 5 minutes to complete. While it is appreciated if all questions are answered, this is not required and you can opt out of any question. Participation in the survey is voluntary and will not affect your grade in the course. This survey is completely anonymous. None of your answers can be linked back to you. Additionally, your choice to participate or not participate in this survey will have no effect on your grade. This is not a required assignment. Answers from this survey will be used to improve online education, and analysis of survey answers may be published. Once again, this survey will be anonymous and will have no bearing on your grade in this course or any other course.

If you have any questions please contact Karen Symes (course director) at simes@bu.edu or at 617-638-4077. If you have questions about your rights as a research subject please contact BUMC IRB at 617-638-7207 or medirb@bu.edu.

1. Which of the following best describes your previous experience studying biochemistry?
   - [ ] I have never taken a biochemistry course
   - [ ] I have taken (an) undergraduate course(s) in biochemistry before
   - [ ] I have taken the graduate biochemistry course, BI751 Biochemistry and Cell Biology (course director: Dr. Offner), at BUSM
   - [ ] I have taken graduate course(s) in biochemistry at another institution other than BUSM

2. How would you describe your experience with the online (soft chalk) biochemistry assignments?

3. How could the assignments be improved?

4. How long did it take you to complete the biochemistry assignments (including both reading and assessment)?

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<thead>
<tr>
<th>Protein Structure and Function</th>
<th>Less than 30 minutes</th>
<th>30 minutes</th>
<th>1 hour</th>
<th>1 hour 30 minutes</th>
<th>2 hours</th>
<th>More than 2 hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein Folding</td>
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<td>Enzymes</td>
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<td>Introduction to DNA</td>
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<td>DNA Replication</td>
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<td>DNA Modification and Repair</td>
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<td>RNA Structure and Synthesis</td>
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<td>RNA Processing and Gene Splicing</td>
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<td>Protein Synthesis and Trafficking 2</td>
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<tr>
<td>Control of Gene Expression</td>
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<td>Techniques in Molecular Medicine</td>
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<td>Protein Synthesis and Trafficking 1</td>
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<tr>
<td>Control of Gene Expression at the Translational Level</td>
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<td>Principles of Membranes</td>
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<tr>
<td>Protein Synthesis and Trafficking 3</td>
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<tr>
<td>CTT: Connective Tissue Proteins</td>
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<td>Other (please specify)</td>
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57
5. Please choose from the following statements:

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<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
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</thead>
<tbody>
<tr>
<td>The online modules were effective at teaching me about different aspects of biochemistry</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>The online modules provided the foundation for the material discussed in class</td>
<td>☐</td>
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<tr>
<td>I felt that the online modules helped me to stay on track with my studying of the course material</td>
<td>☐</td>
<td>☐</td>
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<tr>
<td>I felt the questions assessed my understanding of the material</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
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<tr>
<td>The questions were too easy</td>
<td>☐</td>
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<td>The questions were too difficult</td>
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CURRICULUM VITAE

Jessica R. Carr

703 Massachusetts Ave #11, Boston, MA 02118 • 951.963.4331 • jrcarr@bu.edu • 1993

1432 Roadrunner Drive, Corona, CA 92881 • JessicaRCarr@sbcglobal.net

Skills
- High level of organizational skills, strict attention to detail, quick learner, work independently, self-starter, highly motivated, complete tasks minimal supervision, meet deadlines, excellent verbal and written communication skills, ability to maintain confidentiality, punctual, reliable, positive, energetic, and works well on teams.

Education and Honors
- 2014-Present: Boston University School of Medicine
  - Major: Medical Sciences
  - Masters of Medical Sciences
- 2011-2014: University of San Diego, La Jolla
  - Major: Biochemistry/Pre-med
  - Provost Honors (6 quarters)

Applicable Experience
- Scribe- BMC Pulmonary Hypertension Clinic
  August 2015 to Present
  Scribing for Dr. Farber in the Pulmonary Hypertension clinic at BMC has provided me with the opportunity for development of professional skills including charting in EPIC software, preparing letters, taking an accurate patient history and in knowledge regarding vocabulary, physiology, and medication. This experience has provided me with skills in effective and sensitive engagement in situations regarding patients. Working in a fast-paced environment will strengthen my adaptability in encountering patients.

- Tutor/Teaching Assistant- Boston University School of Medicine MAMS program
  September 2015 to December 2015
  The role of a teaching assistant in biochemistry was to stay up to date on material to answer questions in class and on an online platform, proctor examinations and to run question and answer sessions. Tutoring biochemistry and dental physiology gave me an opportunity to explain and strengthen the knowledge of others and myself through consistent questions in course material. This was a valuable opportunity to engage with vibrant faculty and peers to strengthen knowledge in the basic science while assisting fellow classmates and faculty.

- Rosie’s Place- Teacher of English as a Second Language
  February 2015 to Present
  Teach English as a second language to a group of under-privileged women in order to afford them the same opportunities available to native language speakers. I am learning about the sensitivities of those living in gross scarcity and daily lack of basic needs being met, in a community full of excess and the impact is has on them and their families. I learn
how to be a more efficient communicator, practice conflict resolution and how to best meet the needs of those who have been underserved and learn how to most effectively address those with social, emotional and mental conflict.

**Scripps Volunteer Surgery Nursing Floors**
July 2013 to Present
Answer call lights, page appropriate people, check on patients, bring patients anything they need, admit and discharge patients, shred discharge paperwork, make photocopies, Make admission packets, answer telephone, escort and orient new patients.

**Biochemistry Department UCSD- Research Assistant**
September 2012 to April 2013
Assist with experiments involving the control and manipulation of protein self-assembly. The goal of this project is to use the strength and directionality of metal coordination to create new, protein assemblies and functional biomaterials and to rationally engineer protein crystals.

**Jet Propulsion Laboratory – SMAP Testbed Assistant**
June 2012 to Sept 2012
Run flight software procedures, create testbed wiki on trac, diagram SMAP interfaces, reassemble MSL’s XTB testbed, execute procedures to make sure testbed still runs properly, rebuild the JCI system that was used to stress test the rover compute elements, exposure to the electrical and software interfaces used to test the rover computer, use a digital multimeter for measuring circuit resistance, use an oscilloscope for capturing and visualizing discrete events, use an oscilloscope for viewing waveforms, write and execute Python scripts, use a UNIX, Linux, sqlite computer and associated file systems.

**UCSD HR/Administrative Office Assistant – Careers Services Center**
August 2011 to June 2012
Assist with computer spreadsheets, data entry, filing, Xeroxing, typing, sorting mail, logging, invoicing, deposits/income, reconciling ledgers, payments/recharges, email confirmations, reports, forms processing, ordering and supplies replenishing, payroll related duties and special projects.

**Publication**
Brodin, J.D., Smith, S.J., Carr, J.R., & Tezcan
**Designed, helical protein nanotubes with variable diameters from a single building block**

Jeffery D. Brodin, Jessica R. Carr, Pamela A. Sontz, and F. Akif Tezcan
**Exceptionally stable, redox-active supramolecular protein assemblies with emergent properties**

**Certifications**-
- American Heart Association- Basic Life Support for Health Care Providers