SHORT COMMUNICATION

Innovation in Medical Education: Teaching Medical Devices via Curricular Co-Creation

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Background: Teaching medical devices presents the pinnacle of interdisciplinary educational efforts. To thoroughly cover this complex topic in a single course, it is required to encompass the principles of science, engineering, biology, medicine, pharmacy, economy, politics and humanities, all under one hat. Challenges faced by educators in the attempt to accomplish this naturally call for the exploration of innovative pedagogic strategies to be implemented in teaching this extremely broad subject.

Method: Here I share with the readers a new instructional method I devised after a decade of coping with these challenges. The method is based on collective in-class presentations and discussions centered around the hierarchy of Bloom's learning taxonomy and the students' individual choices of medical devices for elaboration and analysis.

Results: The method was overwhelmingly well accepted by the students, who have expressed a statistically significant preference for it over the traditional didactic method involving the instructor's own choice of the material. Specifically, their mean (SD) satisfaction with teaching on the scale of 1.00 – 5.00 increased from 3.89 (0.78) for the instructor-centered didactics to 4.55 (0.82), 4.88 (0.34) and 4.91 (0.30) for this new pedagogic model implemented in the semesters of Fall 2021, Fall 2022 and Fall 2023, respectively.

Conclusion: The method shared here is particularly well suited for audacious instructors who feel comfortable improvising the topics and those who are broadly educated and well versed in a variety of subjects.

Keywords: Biomedical Materials, Bloom's Taxonomy, Engineering, Medical Devices, Medicine, Pharmacy

الابتكار في التعليم الطبي: تدريس الأجهزة الطبية من خلال إنشاء المناهج الدراسية المشتركة

الخلفية: يمثل تدريس الأجهزة الطبية قمة الجهود التعليمية متعددة التخصصات. لتغطية هذا الموضوع المعقد بشكل شامل في دورة واحدة، يجب أن تشمل مبادئ العلوم والهندسة والأحياء والطب والصيدلة والاقتصاد والسياسة والعلوم الإنسانية، وكلها تحت قبعة واحدة. إن التحديات التي يواجهها المعلمون في محاولة تحقيق ذلك تتطلب بطبيعة الحال استكشاف استراتيجيات تربوية مبتكرة ليتم تنفيذها في تدريس هذا الموضوع الواسع للغاية.

الطريقة: أشارك هنا مع القراء طريقة تعليمية جديدة ابتكرتها بعد عقد من التعامل مع هذه التحديات. تعتمد الطريقة على العروض التقديمية والمناقشات الجماعية داخل الفصل والتي تتمحور حول التسلسل الهرمي لتصنيف بلوم للتعلم والاختيارات الفردية للطلاب للأجهزة الطبية للتوضيح والتحليل.

النتائج: لاقت هذه الطريقة قبولاً جيدًا من قبل الطلاب، الذين عبروا عن تفضيل ذي دلالة إحصائية لها على الطريقة التعليمية التقليدية التي تنطوي على اختيار المعلم للمادة. على وجه التحديد، ارتفع متوسط رضا الطلاب عن التدريس على مقياس من ١,٠٠ إلى ٥,٠٠ من ٣,٨٩ (٠,٧٨) لوسائل التعليم التي تركز على المعلم إلى ٤,٥٥ (٠,٨٢)، و ٤,٨٨ (٠,٣٤) و٤,٩١ (٠,٣٠) لهذا النموذج التربوي الجديد. سيتم تنفيذها في فصول خريف ٢٠٢١ وخريف ٢٠٢٢ وخريف ٢٠٢٣ على التوالي.

الخلاصة: الطريقة التي تمت مشاركتها هنا مناسبة بشكل خاص للمدرسين الجريئين الذين يشعرون بالراحة في ارتجال المواضيع وأولئك الذين حصلوا على تعليم واسع وعلى دراية جيدة بمجموعة متنوعة من المواضيع.

الكلمات المفتاحية: المواد الطبية الحيوية، تصنيف بلوم، الهندسة، الأجهزة الطبية، الطب، الصيدلة

طبی تعلیم میں جدت: نصابی تعاون کے ذریعے طبی آلات کی تعلیم

پس منظر: طبی آلات کی تعلیم بین الضابطہ تعلیمی کوششوں کا عروج ہے۔ اس پیچیدہ موضوع کو ایک ہی کورس میں پوری طرح سے احاطہ کرنے کے لیے، سائنس، انجینئرنگ، حیاتیات، طب، فارمیسی، معیشت، سیاست اور انسانیت کے اصولوں کو ایک بیٹ میں شامل کرنا ضروری ہے۔ اس کو پورا کرنے کی کوشش میں ماہرین تعلیم کو درپیش چیلنجز فطری طور پر اس انتہائی وسیع مضمون کو پڑھانے کے لیے جدید تدریسی حکمت عملیوں کی تلاش کا مطالبہ کرتے ہیں۔

طریقہ: یہاں میں قارئین کے ساتھ ایک نیا تدریسی طریقہ بتا رہا ہوں جو میں نے ان چیلنجوں سے نمٹنے کے ایک دہائی کے بعد وضع کیا تھا۔ یہ طریقہ کلاس میں اجتماعی پریزنٹیشنز اور مباحثوں پر مبنی ہے جو بلوم کے سیکھنے کی درجہ بندی کے درجہ بندی اور وضاحت اور تجزیہ کے لیے طبی آلات کے طلباء کے انفرادی انتخاب کے گرد مرکوز ہے۔

نتائج: اس طریقہ کو طلباء کی طرف سے زبردست طور پر قبول کیا گیا، جنہوں نے اس کے لیے اعدادوشمار کے لحاظ سے اہم ترجیحات کا اظہار کیا ہے جس میں انسٹرکٹر کا مواد کا اپنا انتخاب شامل ہے۔ خاص طور پر، ۱٫۰۰ - ۵٫۰۰ کے پیمانے پر پڑھانے سے طلباء کا اوسط (SD) اطمینان اس نئے ماڈل کے لیے ۳٫۸۹ (۰٫۷۸) سے بڑھ کر ۴٫۵۵ (۰٫۸۲)، ۴٫۸۸ (۰٫۳۳) اور ۴٫۹۱ (۰٫۳۰) ہو گیا۔ بالترتیب موسم خزاں ۲۰۲۱، خزاں ۲۰۲۲ اور خزاں ۲۰۲۳ کے سمسٹرز میں لاگو کیا گیا۔

نتیجہ: یہاں شیئر کیا گیا طریقہ خاص طور پر ان بہادر اساتذہ کے لیے موزوں ہے جو موضوعات کو بہتر بنانے میں آسانی محسوس کرتے ہیں اور جو وسیع پیمانے پر تعلیم یافتہ ہیں اور مختلف مضامین میں مہارت رکھتے ہیں۔

مطلوبہ الفاظ: بایومیڈیکل مواد، بلوم کی درجہ بندی، انجینئرنگ، طبی آلات، دوا، فارمیسی

نوآوری در آموزش پزشکی: آموزش دستگاه های پزشکی از طریق ایجاد برنامه درسی مشارکتی

زمینه و هدف: آموزش دستگاه های پزشکی، اوج تلاش های آموزشی بین رشته ای را ارائه می دهد. برای پوشش کامل این مبحث پیچیده در یک دوره واحد، لازم است که اصول علوم، مهندسی، زیست شناسی، پزشکی، داروسازی، اقتصاد، سیاست و علوم انسانی، همه در زیر یک چتر گنجانده شود. چالش‌هایی که مدرسان در تلاش برای انجام این امر با آن مواجه هستند، طبیعتاً نیاز به کاوش در راهبردهای آموزشی نوآورانه برای اجرای آموزش این موضوع بسیار گسترده دارد.

روش: در اینجا روش آموزشی جدیدی را که پس از یک دهه رویارویی با این چالش ها ابداع کردم، با خوانندگان به اشتراک می گذارم. این روش مبتنی بر ارائه‌ها و بحث‌های جمعی در کلاس است که حول سلسله مراتب طبقه‌بندی یادگیری بلوم و انتخاب‌های فردی دانشجویان از دستگاه های پزشکی برای توضیح و تجزیه و تحلیل ارائه می شود. این روش آموزشی به ترتیب در ترم های پاییز ۲۰۲۱، پاییز ۲۰۲۲ و پاییز ۲۰۲۳ اجرا شد.

یافته‌ها: این روش آموزشی به خوبی توسط دانشجویان پذیرفته شد. دانشجویان ترجیح آماری معنی‌داری برای این مدل آموزشی نسبت به روش آموزشی سنتی که شامل انتخاب خود مدرس از مواد است، ابراز کردند. میانگین رضایت (SD) دانشجویان از تدریس در مقیاس ۱,۰۰ – ۵,۰۰ از ۳,۸۹ (۰,۷۸) برای آموزش مدرس‌محور به ۴,۵۵ (۰,۸۲)، ۴,۸۸ (۰,۳۴) و ۴,۹۱ (۰,۳۴) افزایش یافت.

نتیجه‌گیری: روشی که در اینجا به اشتراک گذاشته می‌شود، مخصوصاً برای مدرسان جسور که در بداهه‌پردازی موضوعات، احساس راحتی می‌کنند و کسانی که به طور گسترده در موضوعات مختلف تحصیل کرده و به خوبی آشنا هستند، مناسب است.

واژه های کلیدی: مواد زیست پزشکی، تاکسونومی بلوم، مهندسی، تجهیزات پزشکی، پزشکی، داروسازی

INTRODUCTION

Medical devices exist at the intersection of numerous disciplines and no course in any natural sciences curriculum can compare in its breadth to that on medical devices. To elaborate on the operational principles, biological effects and regulation of all medical devices requires a combination of knowledge from the fields of medicine, engineering, biology, physics, chemistry, pharmacology, sociology, political economy and numerous other subjects and disciplines. Because of this distinct interdisciplinary nature of medical devices, students attending courses on them come with a variety of expectations: students in engineering are most interested in acquisition of hard science and practical, know-how concepts implementable in the design of devices; basic science students would like to learn about how fundamental physical and chemical principles can be implemented in materials and devices that help save lives; medical students wish to learn about the types and modes of applying medical devices in clinical and other point-of-care practices; pharmacy students tend to find knowledge on devices for drug administration and delivery most useful; programmers wish to learn how and where to apply their computational knowledge for medical ends; social scientists want to know more about regulation and socioeconomic repercussions of the healthcare industry centered around medical devices; and so on. To live up to the expectations of each and every student requires a colossal instructional effort; it also calls for the introduction of innovative methods of instruction.

METHODS

After over a decade of teaching medical devices, first at a public R1 university, then at a private school of pharmacy and currently at a California state university, I devised a method of teaching medical devices that engages students in co-creation of the curriculum. Accordingly, each student selects up to three medical devices of their choice and elaborates on them in three different presentations. This triad of presentations is structured so that their contents gradually ascend along the hierarchy of Bloom's learning taxonomy (1), as formulated by Anderson and Krathwohl (1,1) (Figure 1). Correspondingly, students initially present on medical devices of their choice, describing their medical purpose, modes of operation, history and socioeconomic aspects of their use. Each student presentation is accompanied by meditations on problems associated with the respective devices aided by literature search, which introduces the students to the second set of presentations. For those, they select individual research papers of choice to learn how other researchers have solved challenges in medical devices through innovation. Finally, for the third set of presentations, the students select a problem in a medical device and propose their own research approach on how to solve it. This provides students with a training in innovative, creative thinking, complementing the emphases on foundational knowledge and critical thinking from the preceding two sets of presentations.

RESULTS

Student response – how was the method received?

The analysis of student feedback surveys distributed at the end of the semester showed that the student satisfaction after attending a graduate course on medical devices implementing the co-creational model of instruction was higher than after attending a graduate course on the same subject centered around the instructor's choice of the material. As it can be seen from Figure 2, the mean (SD) student satisfaction with overall teaching increased from 3.89 (0.78) for the instructor-centered model to 4.55 (0.82), 4.88 (0.34) and 4.91 (0.30) for the democratic, co-creational model of instruction implemented in the semesters of Fall 2021, Fall 2022 and Fall 2023, respectively. Simultaneously, the difference in student satisfaction between the two pedagogic models increased from the borderline statistical significance of $p = 0.1094$ (> 0.05) in year 2021 to conventionally exceptional levels of statistical significance of $p = 0.0003$ (< 0.05) and 0.0011 (< 0.05) in years 2022 and 2023, respectively. This increase in student satisfaction attests to the propensity of the proposed instructional model for steady and spontaneous improvements during its repeated implementation. Contrary to traditional didactic

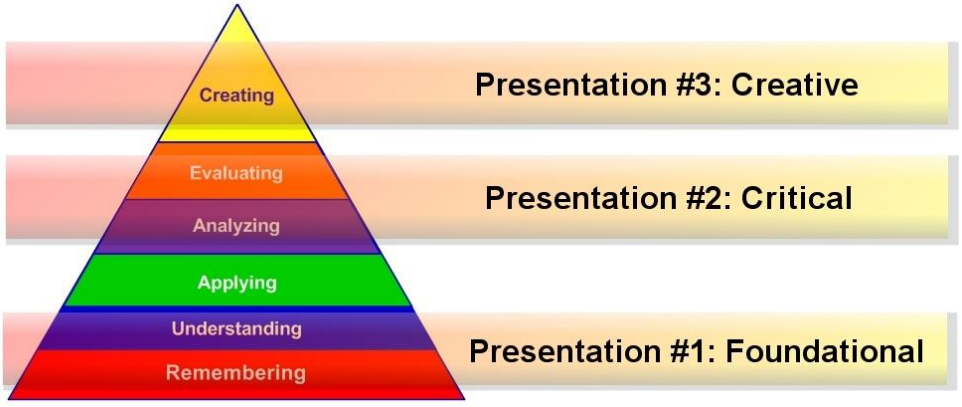

Figure 1. Schematic representation of the correspondence between the hierarchy of Bloom's taxonomy of learning and the instructional model based on a triad of student presentations made successively during this innovative course on medical devices.

models, which can tire the instructor through the repetition of the same or highly similar material in the same manner year after year, thus lessening the enthusiasm and the spark in the classroom, the improvisatory nature of the model proposed and elaborated here ensures that teaching becomes like wine: the tastier, the more seasoned it gets.

Assessment – what can the student grades tell us?

Student satisfaction is intimately related to the assessment strategies and lenient grading often leads to positive student responses. In the course implementing the innovative instructional method reported here for three years in a row, the mean (SD) student grades on the scale of 1 to 4, however, dropped from 3.866 (0.352) in 2021 to 3.848 (0.306) in 2022 to 3.776 (0.230) in 2023. The fact that this drop was accompanied by an increase in the student satisfaction serves as an evidence that the characteristics of the instructional method, not the assessment, had the decisive effect on producing the positive response amongst the students. As for the concrete assessment strategy implemented, it adopted the same improvisatory attitude that is generally required during the instruction, given the unpredictability of the content evolution. It was based on 100 % participation, which included attendance, activity during discussions, the quality of presentations and the innovativeness of the final idea, requiring unsatisfactory performance with respect to two or more of these criteria before it was reflected in grade reduction. This improvisational nature of the course, making it uncertain for everyone which content will be exposed from one moment to the next, is something that requires the adjustment of the students' frames of mind and expectations. Any of them who are accustomed to exceedingly structured classes must leave this rule-ridden zone behind and find comfort in open-endedness and stochastics that accompany intellectual freedoms disseminated by a course like this at its every level. Besides, to lose the ground under one's feet can be unsettling, but this is what flying is all about.

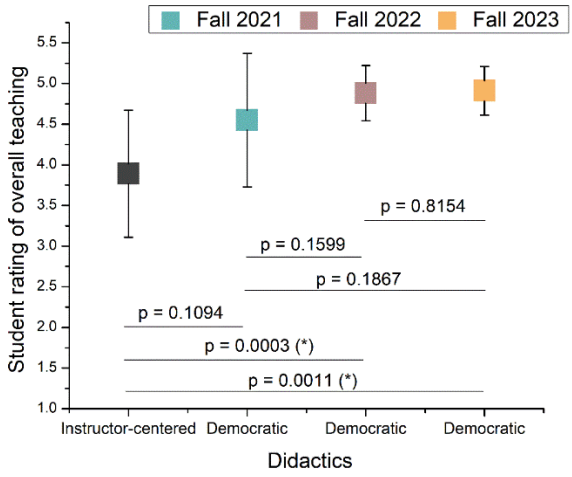

Figure 2. Overall student satisfaction rated on the scale of 1 to 5 for the graduate course on medical devices delivered by the author using a didactic method predominantly based on instructor-centered choice of the material and lecturing versus the same course delivered in three different semesters using the democratic didactics elaborated here, involving the student choice of the material and three sets of presentations relating to the hierarchy of Bloom's learning taxonomy.

The instructor, i.e., the author, and the general subject of the course were the same for each sample group, while different cohorts of students at different universities were compared and topics addressed within each course were subject to change given the students' freedom to choose them. Individual bars for the instructor-centered and the democratic didactic model represent means obtained through 7, 11, 16 and 11 responders (left to right), while error bars represent standard deviations. Two-tailed p values obtained in an unpaired t test denote the level of statistical significance of the difference between the pairs of sample groups connected by the line. Asterisks next to the p values denote the surpassing of the conventional threshold for statistically significant difference ($p < 0.05$).

What lessons were learned ?

A new, co-creational method of instruction was devised and tested in a medical devices graduate class taught at San Diego State University between 2021 and 2023. The students have been overwhelmingly in favor of this democratic, co-creational model of instruction. Their satisfaction with instruction after attending a graduate course on medical devices implementing this new model of instruction was higher than after attending a graduate course on the same subject delivered by the same instructor and centered around the instructor's personal choice of the material for study. Specifically, their mean (SD) satisfaction with teaching on the scale of 1.00 – 5.00 increased from 3.89 (0.78) for the instructor-centered didactics to 4.55 (0.82), 4.88 (0.34) and 4.91 (0.30) for this new pedagogic model implemented in the semesters of Fall 2021, Fall 2022 and Fall 2023, respectively. Simultaneously, the mean (SD) student grades on the scale of 1.00 – 4.00 decreased from 3.87 (0.35) in 2021 to 3.85 (0.31) in 2022 to 3.78 (0.23) in 2023, indicating that the innovative pedagogic method implemented and not specific assessment strategies and criteria in place was responsible for producing the positive impression among students.

DISCUSSION

One prerequisite for the successful implementation of an inherently democratic teaching method like this is that everybody's opinion is accepted as equally relevant and influential. For this condition to be satisfied, anything that reinforces the superiority of the instructor and the inferiority of the students must be obliterated, starting with the power to judge and grade the student performance that is being handed to the instructors by the university. Among many other negative effects that it produces, grading misleads students into thinking that knowledge is quantifiable and prepares them for the careerist rat race awaiting them beyond the bounds of the university. In fact, had grading not been mandated, I would have never used it in my teaching endeavors. One major reason for my aversion to grading is that every assessment imparts artificial authority onto the instructor and deepens the gap of mistrust posed between him and the students. On the other hand, student satisfaction can never be a good indicator of the true quality of the instruction. If the truest pedagogic objective is to inspire the students to discover something extraordinarily beautiful in the subject and perhaps dedicate their lives to exploring it, then the quality of teaching will always remain a mystery to all.

It goes without saying that many instructors get their kicks from taking the stance of authority in the classroom by policing the environment and creating a system where the students are motivated to work not for the sake of their personal progress, but mainly to satisfy the expectations of the teacher. My goal has been humbler in some respects, but also grander and more difficult to achieve in other ways. The goal, namely, has been to inspire the students, to incite their wonder, to make them fall in love with the subject, to open up a whole new window to the world before them, but also to humanize their knowledge in lieu of transmitting the mere know-how. Rather than establishing an authority and then preserving it by all means, I have worked hard to topple it the best that I can, as every anarchist at heart ought to do. This has required the elevation of the students' confidence when they sink and want to be led like sheep, but also a constant striving to lower myself before them until the condition of equality is reached, like that idealized by Martin Buber in the form of a relationship between an I and a Thou (4). It requires a colossal effort to accomplish this and ensure that no formal expectations of the institution or other stale professional standards interfere with the human in us and that we continue to engage in a relationship with every other human, from a toddler to a professor emeritus, as our equal.

In all, I am convinced that there is a room for humanities, metaphysics and poetry in science classroom and have made sure all throughout my career as a teacher that this room remains bountiful and well-watered.

CONCLUSION

The students' active engagement in creating the curriculum notwithstanding, they still benefit from the instructor's ability to maintain a unified structure to the curriculum by connecting the diverse subjects of discussion into a coherent whole. One extraordinary feature of this pedagogic model is that it is a living one, changing perpetually from one lecture to the next and from one semester to the next, immersing the students and the instructor alike into a state of undying suspense. Through the exposure to this method of teaching, the attention of the students is being tuned to that of a constant receptiveness to surprises, which would prove to be of benefit for their extramural endeavors in later professional careers. The living, improvisatory nature of this method of teaching ensures that limitless variations to it can spin off from its further implementations in the classroom, as it was the case with the flipped classroom model elaborated earlier (5). This has been the primary motivation for sharing this method with the readers and the pedagogy peers on this occasion. In other words, fellow academicians are encouraged to implement this original method in their classrooms as well and create their own variations on it. If they decide to engage in this adventurous endeavor, they should never cease to improvise the content and the delivery style so as to remain true to the foundational features of the method at hand.

Ethical considerations

Ethical issues including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc. have been completely observed by the author.

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