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The UNSIN project: exploring the molecular physiology of sins

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Naji F, Salci L, Hoit G, Rangachari PK. The UNSIN project: exploring the molecular physiology of sins. Adv Physiol Educ 36: 13–19, 2012; doi:10.1152/advan.00087.2011.—Although active learning works, promoting it in large undergraduate science classes is difficult. Here, three students (F. Naji, L. Salci, and G. Hoit) join their teacher (P. K. Rangachari) in describing one such attempt. Two cohorts in a first-year undergraduate biology course explored the molecular underpinnings of human misbehavior. Students were divided into 18 groups and randomly allotted to deal with one of the four deadly sins: sloth, gluttony, lust, and wrath. Students were expected to read primary sources to devise molecular ways to counter these sins. Group progress was monitored over the 12-wk period by the preceptor (P. K. Rangachari) at scheduled intervals. A single randomly selected student was questioned about the work done, and future directions were provided by the preceptor. At the end of the term, randomly selected students defended their group’s approaches to the entire class. A final written report was graded. The following multiple target molecules were considered for each sin: gluttony (cholecystokinin, ghrelin, GABA, leptin, peptide YY, neuropeptide Y, and the melanocortin 4 receptor); sloth (dopamine, glutamate, GABA, and orexin); wrath (serotonin, GABA, glutamate, and corticotropin-releasing hormone receptor 2); and lust (prolactin, testosterone, oxytocin, dopamine, and estrogen). Students noted that the project provided a valuable learning experience, and the random selection approach gave students a greater sense of responsibility to their group. The project helped students hone their skills at searching, synthesizing, sharing, and presenting information, fostered group interactions, and provided a solid knowledge base for subsequent courses.

ACTIVE LEARNING WORKS. Evidence gleaned from a variety of disciplines (learning sciences, cognitive psychology, and educational psychology) has provided sufficient justification for promoting interactive learning in the classroom (4, 6, 7). Many different strategies have been proposed to engage students in their own learning. All are, in reality, variations of a theme proposed by Dewey under the rubric of inquiry (1, 2). He regarded the inquiry process as the “directed transformation of an indeterminate situation into one that is so determinate in its constituent distinctions and relations as to convert the elements of the original situation into a unified whole” (1). Thus, students, when presented with problems or situations about which they have partial or incomplete information, use these as starting points for exploration. They proceed to gather the information required to either solve the problem posed or learn more about the situation. They progress to a point where they can state with confidence that they have learned something. To capture the tentative nature of the enterprise, Dewey used the term “warranted assertibility.” All the diverse strategies mentioned in the educational literature are variations of the above basic theme (3, 5–7).

In practice, instituting such measures is not easy, particularly in a large class setting. Here, we describe an approach used in a freshman course in biology at McMaster University. The UNSIN project formed part of a full-year (two terms) course taken by students who were enrolled in the Bachelor of Health Sciences (Hons) programme at McMaster University. The course itself adopted a hybrid approach with a judicious blend of didactic and interactive sessions (9). In contrast to most first-year biology courses, this course was narrower in scope but discussed issues in depth. The focus was on cellular communication, since it was felt to be of particular significance to health science students, given its relevance to understanding disease processes. Students were told that cellular signaling involves the recognition and response of cells to a variety of signaling molecules. This has been a particularly fruitful area of modern biological study, and the discoveries made have been richly rewarded both in terms of Nobel Prizes as well as in translation into many facets of modern healthcare.

During the didactic sessions, students were given not only the “facts” but also some indication as to how those facts emerged. We emphasized throughout the course that modern science is a cooperative, cumulative venture and that the “facts” we take for granted are constructed and that advances in knowledge in cellular signaling were made possible by the development of powerful techniques (electrophysiology, subcellular fractionation, analytic microscopy, and molecular biological approaches). Although the didactic sessions focused on a limited set of messenger molecules (histamine, acetylcholine, norepinephrine, prostaglandins, corticosteroids, and nitric oxide), we emphasized to the students that the framework provided would equip them to explore many others. To emphasize the constructivist nature of modern scientific practice, we discussed the flow of scientific information from initial findings to peer-reviewed publications to textbooks and common knowledge. Sessions were held where students deconstructed specific research publications to recognize the distinct components.

The specific project described here was completed by students in the second term of the course and was described in the course outline as follows:

The objective of this exercise is to demonstrate your abilities to transfer your learning from Term 1 to novel situations. We want you to transgress boundaries. The health sciences stand midway between pure sciences and the humanities and we want you to explore that interface. Humanities are particularly concerned with appropriate behaviour. Literature (in many languages) is particularly concerned with human misbehaviour. After all, books based on decent, well-behaved people would be excruciatingly and painfully dull, like leading healthy,

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politically correct lives and promoting wellness. In the Christian world, various forms of misbehaviour have been labeled as sins. Seven of these [Accidia (Sloth), Luxuria (Lust, Lechery), Superbia (Pride), Ira (Wrath, Anger), Invidia (Envy), Avaritia (Greed, Avarice), and Gula (Gluttony)] are considered serious enough to be labeled “deadly”. Biologists who probe both animal and human behaviour have come to realize that there may be an underlying biological basis for some if not all of these sins. In this section of the course then, you will explore the Molecular Physiology of Sinning.

We created a simulation for this project in which an anonymous donor had left a considerable sum of money to fund ways and means to “treat” sins. A research institute had been set up with four divisions. Poor investments had led to disarray, and certain projects were to be axed. Groups were asked to provide reasons as to why their particular project should receive funding for further research.

This report describes this exercise from two perspectives. The teacher (P. K. Rangachari) set the stage, described the process and expectations from the faculty, and summarized the information gleaned from a questionnaire given to two cohorts of students. Three students (F. Naji, L. Salci, and G. Hoit), who formed part of the initial cohort that took this course, provided their personal experiences with the project. These students volunteered their services to help the teacher reframe and redesign the course. A number of sessions were held during the summer, and the possibility of writing a joint paper arose during one of those sessions.

METHODS

The Students

The project was completed by two cohorts. There were 184 students in the first cohort and 160 students in the second cohort. All of the students were enrolled in a 4-yr Bachelor of Health Sciences (Hons) undergraduate programme where admissions were based on high academic grades from high school as well as on supplementary applications.

The Process

Formation of the groups. The entire class was divided into groups of 7–11 students. Each group was randomly assigned to deal with one of the following sins in a specific division: anti-lust, anti-gluttony, anti-wrath, and anti-sloth; Table 1 shows the molecules targeted for intervention. The number of groups in each division was sometimes unequal. The formation of the groups themselves was not random. All of these students were also taking an inquiry course during the same period where they were in groups working with individual facilitators. We tried as much as possible to keep these inquiry groups intact. This made it logistically easier for each group to set their own meeting times and hopefully minimized internal conflicts. The logistical issue was a serious one, since the groups were relatively large.

Interim explorations (self-directed study). Each group was expected to explore their allotted sin. The students had already been primed about this project in the first term and in the first open session; the expectations were made clear to them.

Monitoring of the interim progress. Each group met the preceptor (P. K. Rangachari) at biweekly intervals according to a schedule. At each meeting, they were required to bring an interim progress report that included 1) a single page summarizing the information gathered, 2) avenues for further exploration, and 3) a list of annotated references. At these sessions, one student was selected at random to report on behalf of the group. The grade or mark received by that student was given to the entire group. Several such sessions were held.

<table>
<thead>
<tr>
<th>Table 1. Molecules targeted for intervention</th>
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<tbody>
<tr>
<td>Cohort 1</td>
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<td>----------------------</td>
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<tr>
<td>Glutony</td>
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<td>Cholecystokinin</td>
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<td>Ghrelin</td>
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<td>GABA</td>
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<td>Leptin</td>
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<td>Peptide YY</td>
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<td>Sloth</td>
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<td>Dopamine</td>
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<td>GABA</td>
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<td>Glutamate</td>
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<td>Orexin</td>
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<tr>
<td>Wrath</td>
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<tr>
<td>Corticotropin-releasing hormone receptor 2</td>
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<tr>
<td>Serotonin</td>
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<tr>
<td>Glutamate</td>
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<tr>
<td>GABA</td>
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<tr>
<td>Lust</td>
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<td>Prolactin</td>
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<tr>
<td>Testosterone</td>
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<tr>
<td>Oxytocin</td>
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<tr>
<td>Estrogen</td>
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Open discussion/debate. Toward the end of the project, an open discussion was held. This was called either the FUNSIN Fisticuffs or UNSIN Uppercuts (to foster the competitive spirit). This was deliberately set out to be fiercely competitive and a no-holds barred session. To foster heated exchange, this component was not evaluated.

The different groups in each division argued among themselves. The following rules of engagement were defined:

1. One student from each of the listed groups was drawn at random to act as the reporter.
2. All the reporters were to be seated in front of the class.
3. Each reporter had 3 min to present their accomplishment.
4. Only two slides were used as visual aids; the first slide listing the members of the group and the second slide stating the locus targeted for their intervention, the rationale for that choice, and the nature of the intervention.
5. Once all the presenters had finished, the reporters argued among themselves as to the relative merits of their position in a fashion policed by the moderator.
6. Once all the divisions had completed their arguments, the sessions were open to the entire class.

Final report. A final report was submitted by each group, for which clear instructions and parameters were provided. Each report had three sections:

1. Framing the problem (3 pages maximum). This section provided the background information, the potential loci for the development of an UNSIN approach, and a clear statement as to why a particular strategy was chosen. Each group was specifically told to begin with their definition of the particular sin being considered, framed in molecular, not moral, terms.
2. Accomplishments, future plans, and justify your presence (5 pages maximum). Here, students were expected to provide details about the work that had been accomplished. This work could have been done at any level: isolated cells, tissues, animals, or humans. They were to provide details of the methods and “results” obtained. They were told specifically that, since this was a simulation, none of this work had actually been done by them and, thus, they had to indicate where they had interpolated the simulated information into the existing data. In providing methodological details, they were to
give specific references in the body of the report but add more precise information in the annotations. They were told to write very clear legends to the figures and label axes as well as to provide sufficient details in tables. The final element in this section was termed “justify your presence” (JYP). Here, they had to explain clearly why they felt that their work was important and the larger implications for tackling sins in humans. They were told that they were not expected to solve all anticipated problems but give the readers a sense that they had considered them carefully.

3. Annotated references. A heavy emphasis was placed on this component. Students were expected to annotate their references carefully and provide methodological details. There was no prescribed page limit to this section.

Grading

This project was only ONE component of the entire course. Overall, it accounted for 20% of the overall grade. The interim reports were valued at 2.5%. The final report was assessed at 17.5%.

The Faculty Survey

At the end of the course, students were given a detailed questionnaire about the course as a whole. A series of statements was given to the students, and they were asked to indicate their agreement/disagreement with each statement on a 10-point scale (where 1 = strongly disagree and 10 = strongly agree). Students were also asked to add any comments if they had them. Table 2 shows the responses to statements that specifically related to the UNSIN project.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Cohort 1</th>
<th>Cohort 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>The UNSIN project provided a valuable learning experience.</td>
<td>8.9 ± 1.4</td>
<td>9.4 ± 0.82</td>
</tr>
<tr>
<td>The random choice of reporters for the UNSIN sessions facilitated group learning.</td>
<td>7.3 ± 2.53</td>
<td>8.22 ± 1.72</td>
</tr>
<tr>
<td>The possibility that I could be selected to report for the UNSIN sessions gave me a greater sense of responsibility to my group.</td>
<td>8.15 ± 2.35</td>
<td>9.04 ± 1.2</td>
</tr>
<tr>
<td>The project allowed me to appreciate the effort and commitment involved in carrying out modern scientific research.</td>
<td>8.87 ± 1.33</td>
<td>9.2 ± 1.1</td>
</tr>
<tr>
<td>The project gave me a sense of the excitement and fascination of modern scientific practice.</td>
<td>8.3 ± 1.57</td>
<td>8.75 ± 1.34</td>
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</table>

RESULTS AND DISCUSSION

The overall objectives of this project were 1) to provide an opportunity for students to work together to produce a document that demonstrated their abilities to apply knowledge gleaned from standard didactic classes to a novel situation and 2) to give students an opportunity to experience the excitement and fascination of modern scientific practice and appreciate the time and effort required.

The UNSIN project was completed by two cohorts of students. The approach used was essentially the same.

The Teacher’s Perspective

The teacher’s perspective is given below by the preceptor, P. K. Rangachari.

Formation of the groups. As mentioned briefly above, the groups for the UNSIN projects were the same as those in another inquiry course that was designed to foster group skills. From our perspective, this made logistics easier. One of the major hurdles in self-directed group learning is providing optimal opportunities for interactions between students. Since these students had common schedules and knew each other, these problems were minimized but not entirely eliminated.

Interim reports. All groups met with me periodically to report on their progress. At these sessions, I would draw one person at random. I had their pictures cut out from their class list in an envelope and would hand the envelope to the group to select their representative. The chosen person sat facing me and answered all questions. Once that interaction was over, I usually asked the other students to comment to ensure that their reporter had represented them accurately. This proved to be very contentious. Some students felt that this was manifestly unfair, whereas I insisted that it was about the only way I could ensure that they had shared information equitably. I felt quite strongly that the possibility that anyone could be selected would give them a stronger sense of responsibility. This was borne out by the results of a questionnaire (see later). There was clearly a difference between groups. Some were so breezily confident that they entered the room in a jocular mood and any reporter chosen was able to function effectively without turning to their peers for support. Others were rather tense. These were groups that appeared to have fairly dominant personalities, and it was quite evident that there really was little cohesion among them. Fortunately, the majority of the groups took this activity in stride. These interim sessions proved very useful to me as I could monitor the groups’ progress and provide avenues for exploration.

Open discussion/debates. These proved very lively. Although these was not evaluated, students approached them with a great deal of enthusiasm. There was often a fierce exchange where students grilled each other on the choice of targets and even the delivery options. This was even more impressive as these students had really done no formal courses in biochemistry, organic chemistry, or pharmacology. They had clearly plunged into the primary literature and had learned a good deal about different delivery options, ranging from nanoparticles to patches and nasal delivery.

Final reports. These were very well put together. The students had obviously spent a good deal of time and effort. The target molecules chosen varied widely (see Table 1). The possible interventions also varied. For instance, in the second cohort, three of the anti-sloth groups selected dopamine as their target molecule. However, their interventions were different. One group designed a $D_2$ receptor agonist that was adminis-
tered nasally, whereas another group synthesized a combined D$_2$ and D$_1$ receptor agonist that was administered with a transdermal patch. The third group designed a dopamine transport inhibitor, which served to increase the concentrations of the amine at selected sites. In most cases, the students had read the literature carefully, and their proposed interventions nicely incorporated published information. The JYP sections were extremely well written. My insistence on annotated references made students pay great attention to this component. An example of one such annotated reference is shown below:


This journal provides a simplified and standardized protocol for scintigraphy—the current most effective method of measuring gastric emptying. The article outlines an economical yet accurate procedure and an effective way of analyzing the data obtained. Through this information, we were able to perform a scintigraphy on four different groups (McD, McD + PP2A, SBWY, SBWY + PP2A) in order to prove that the reduced amount of food intake is due to the PP2A that resensitizes the CCK-A receptors which are known to decrease the rate of gastric emptying and promote satiety. In addition, we were able to produce a graph representation of our data—with percent gastric retention on y axis vs. time on x axis—based on their method of analysis (power exponential model). This article is a credible source as it was published in a well established journal, the *American Journal of Gastroenterology*, which is a part of the journal *Nature*. Furthermore, number of the authors such as Dr. Gervais Tougas, Ying Chen, Michel Boiving, and Geoffrey Coates have pursued the subject of gastroenterology and published other peer reviewed articles, validating their credibility.

As part of our general survey, we asked students to list the information sources that they had used for these projects. The data from both cohorts were as follows: PubMed (96.6%), research article (99.6%), review articles (95.8%), Google scholar (87.7%), Wikipedia (56%), and standard textbooks (46.9%). In addition, approximately half of the students had consulted faculty members (46%). I was quite thankful that Wikipedia was a distant fifth in that order. The time and effort we had spent in the first term discussing the relative merits of different publication formats had been worthwhile.

The Student’s Perspective

The student’s perspective is given below by three students: F. Naji, L. Salci, and G. Hoit.

Formation of groups. Having to work with a group of over 10 colleagues initially posed the greatest challenge of the UNSIN project. At first, there were difficulties in coordinating suitable group meeting times for all members. However, being assigned into the same groups as those in our other course (inquiry) made this task easier. Additionally, agreeing on how to carry out the next steps as a group was an obstacle in the early stages. There were many differing opinions regarding the direction that the group should take. Usually, each member would stand strongly alongside the research that they contributed to the group. For instance, while one student insisted on further exploring the signaling cascade of cholecystokinin receptors, another student was adamant about investigating the neurological aspect of hunger. This evidently led to numerous debates early on, although it was only a matter of time before we began developing more systematic methods of tackling such issues. Over time, we saw a significant improvement in our ability to work as a cohesive unit, as we began prioritizing and distributing tasks among one another and regularly meeting to compile the information and discuss future steps.

A major advantage of being in a group was that it enabled us to make the most of the open-ended nature of this project. Having numerous group members meant that we could explore various avenues of research and take many different approaches toward our goal of curing a sin. Although conceding a final cure eventually meant narrowing down in scope and choosing a single approach, tackling the research stage as a group enabled us to consider a multitude of approaches before making that decision. Since this was not always practical to do as one large group, we often found ourselves dividing into smaller subgroups, each investigating a specific aspect of our assigned topic. We then met at regular intervals as a whole group to compile our work. Being encouraged to explore topics with such freedom definitely served to broaden our knowledge of the biological and medical sciences and of scientific research in general. Figure 1 shows an example of the complex pathways considered by one group that sought to design an intervention to counter gluttony.

Interim reports. In the weeks leading up to our biweekly meeting with P. K. Rangachari, we would meet early in the week as a large group to discuss the information that we had found within our small groups in the previous week. The goal of this meeting was threefold: 1) to select the information we found to be important to our progress within the project, 2) to ensure that all members of the group understood the relevant research, and 3) to write the progress report. The writing took place as a large group, with different people taking the lead at different times to ensure that the report contained all essential information yet also had continuity. This task proved to be very difficult in the beginning, as initially members would have differing opinions when it came to particular word choice, etc. However, as the term progressed, we became far less focused on irrelevant details and were able to work quite efficiently in this stage. The next meeting would take place on the day of the biweekly interview. The primary focus of this meeting was to ensure that all members were ready to present the information, as the choice of presenter was random. Being picked at random to present at each meeting encouraged all of us to unify our group’s knowledge regularly throughout the semester. This format of presentation was unique to us as first-year students, emphasizing the importance of understanding the material rather than memorizing points, which is characteristic of a typical PowerPoint presentation. At times, students were nervous of presenting on behalf of the group, so some groups took measures to help reduce their fears of public speaking. For example, in one group, individuals who were strong presenters offered presenting tips for those who wanted to work on that skill. Overall, the experience of being randomly chosen was a beneficial one. It helped students step out of their comfort zone and learn they were capable of accomplishing in a safe environment, before being immersed in the workplace. In addition, having biweekly meetings and reports ensured that we kept on track with our work and did not fall behind in our progress.

Open discussion/debates. Although this component of the course was not evaluated, groups put a great amount of effort
in preparing for the debate. Many students were eager to participate, and discussions were very intense. Debates among the few individuals presenting their group’s findings to the class created triggers for discussion topics among all class members when given the opportunity to share their ideas.

The final symposium provided opportunities for students to go beyond their own group’s knowledge and become familiar with other groups’ research. We researched the pathways we did not choose, so as to point out potential problems with the other groups’ interventions. We critically examined our chosen pathway and intervention to determine shortcomings or potential problems to be prepared for questions we could have received from the other groups. From this, we generated a list of responses to cover any question that we thought we could potentially face. In addition, many details were discussed pertaining to the delivery of the drug, further allowing students to explore knowledge that was not covered in lectures. Collectively, we decided what information was necessary to include in the 2-min explanation, and every group member practiced delivering this speech to the others. We decided not to script this, to allow for spontaneity and individual spin, so each person’s prepared speech varied charismatically within the framework.

The format of randomly choosing presenters was beneficial for students not accustomed to public speaking as it provided an opportunity to go beyond their comfort zone. For many groups, those who had previous debate experience outlined a strategy for success. Before the debate, a slightly more formal debate workshop was hosted by an individual in the group who had previous debate experience to overview the strategies of debating, to ensure that all members of the group were ready.

Final reports. A large amount of work was conducted throughout the term; thus, compiling the entirety of it into a single report proved to be quite challenging. For example, if a group was assigned the sin of gluttony, they likely explored all of the possible avenues for gluttonous intervention throughout the term. Including this extensive exploration into a report was a trying task, as many explored pathways may not have been directly related to the final chosen intervention. The product of this process is shown in Fig. 1. The final report was also unlike any other paper assigned to us in freshman year, as it required us to present our findings in the form of a scientific research paper, using dense jargon and formatting styles. Each specialty subgroup presented their information, and, collectively, we determined what information was to be included in the report. As a whole group, we wrote the entire report using a projection screen so that everyone could see and provide input to the individual typing. By this time, most groups had learned to function efficiently, so the minimal debating that took place was constructive in nature. We had also determined when were the appropriate times to have breaks, ensuring that we kept on task throughout most of the allotted time. The actual writing of the material was done fairly quickly, as the research had all been completed before the debate. However, completing the
final touches, such as formatting the figures, editing any grammatical errors, and inserting the references, took a great deal of time. It should also be noted that because of the variety in the requirements of the project, no one single person was the leader within the group. Depending on the strengths of the group members, different people led at different points throughout the term. The range of individual strengths included researching, writing, presenting, and fostering smooth group dynamics. The alternation of leaders allowed all members to feel as though they contributed equally and helped incredibly with the dynamics of the group.

The Composite Picture

Both cohorts were surveyed at the end of the course. Since there were multiple components, only the responses pertinent to the UNSIN project are shown. The data are shown separately for both cohorts (Table 2). Both cohorts found that the project provided a valuable learning experience, and the simulation gave them insights into the effort and commitment required for practicing modern science as well a flavor of the excitement and fascination of science. There was general agreement that the possibility that anyone could be chosen required for practicing modern science as well a flavor of the ‘sciency’ courses I have enrolled in past years. My insatiable curiosity was truly rewarded in this course.

UNSIN made me think harder than I ever have before, but it was an AMAZING learning experience. Although a group of ten is slightly large, putting smart people together for a seemingly impossible project produce surprising results. I had a blast on this project!

Un-Sin was by far my favourite, for it was unique, fun, exciting, and brought a whole new perspective for me in terms of scientific research and the painstaking work that is done by medical professionals. It also allowed for creativity, which was extremely refreshing. Through overcoming obstacles and dealing with the many challenges, our group excelled and grew to function quite well as a unit, receiving input from all group members.

Oddly enough, my overall rating for teaching this course was reasonably high from both cohorts. On a scale of 1–10, for my effectiveness as an instructor for this course, the first cohort gave me a score of 8.37 ± 1.4 (mode 9) and the second cohort gave me a score of 9.2 ± 1.45 (mode 10).

Summing Up: Long-Term Impact

The information gathered at the end of the course suggested that the UNSIN project had met the set objectives. The students were able to transfer their learning to a novel simulated situation AND had obtained a sense of the excitement and fascination of modern scientific practice. However, the intentions behind this project design stretched much further than to simply teach the basic facts of cell signaling, and, as such, it is more important to gauge whether there were any effects in the long term. The fact that assessments drive learning is well known, yet one of the major problems in education is to gauge the long-term consequences of any assessment procedure. The term “consequential validity” has been used to describe the impact of assessment procedures on learning (5, 8).

The student's perspective. Continuing on from our first-year practices, this year we processed our group’s information in a way that allowed us to understand the core principles rather than memorizing the facts. We were able to discuss, in presentations, the information that we had learned as a group and answer questions on the spot. We were more confident in presenting in a format that did not rely heavily on reciting a PowerPoint presentation because of the UNSIN format. More importantly, we were already familiar with the task of taking on an open-ended research question and tackling it in a systematic, problem-solving manner. We significantly improved our skills in finding, reading, and analyzing academic articles and were more accustomed to the process of extracting and synthesizing information based on our findings. Less time is now spent trying to find ways to be successful in a group setting and more time can be put toward mastering content. We wanted to know if others in our class had a similar opinion. We sent out a brief questionnaire to our peers consisting of the following question: “How useful have you found the design of
the UNSIN project in preparing you for your second-year courses. Assess this on a scale of 1–10 ([where] 1 - least value; 10 - extremely valuable). The responses were generally favorable, with an average rating of 8.3 (95% confidence interval: 8.0–8.6, n = 102).

The teacher’s perspective. Active learning makes demands on both students and teachers in different ways. It drags both of them out of their comfort zones. Students have to take responsibility for their learning, whereas teachers must emerge from their information dispensaries into a world where they have to relinquish authority and learn to trust the students to fend for themselves. This issue of trust cuts both ways. Students have to trust their teachers to guide them properly so that they will not let them founder, whereas teachers have to take on a monitoring role and ensure that the students remain focused on the task at hand. This was a course aimed at freshman who had just entered university, and the temptation to be overly directive was difficult to resist. Although individual groups only came in for brief periods, I had to be present for the entire 3 h and be extremely attentive to ensure that I was giving useful comments. This was not easy! Even after each session, I had to spend considerable time reading the reports and checking the references. Any doubts that I had about their abilities quickly vanished when I saw the depth to which they had plunged into the project and the quality of the information they brought in. The annotated references were really reassuring. In the process, I learned a good deal, not only in terms of the factual material based on their reports but also an awareness of different approaches to the same problem. The consequences for me were enormous. I learned as much, perhaps more, than my students, since I was learning from 18 groups each year—an exhilarating, enriching experience. This in a sense captured what Dewey envisaged in his model of learning, where both teachers and students are inquirers into the problems they face. Certitude goes out the window (1).

DISCLOSURES
No conflicts of interest, financial or otherwise, are declared by the author(s).

AUTHOR CONTRIBUTIONS

REFERENCES