11

Pursuing problem-based learning as an alternative didactic option to the traditional teaching/fill-up-the-tanks method

Sayed Hossein Hashemi

Department of pharmaceutics and analytical chemistry, University of Copenhagen

Background

The traditional way of lecturing has for years followed the fill-up-the-tanks model that does not define what is to be learned. Therefore, the students tend to wonder at the relevance of what they are doing or at their motivation for doing it. Furthermore, declarative knowledge, which is the main output, may be insufficient for job market and thereby curriculum, teaching and assessment are not aligned.

In comparison problem-based learning (PBL) reflects the way people learn in real life; they simply get on solving the problems life puts before them. Professional practice requires functional knowledge that can be put to work on the spot. PBL is considered to equip the students with more such knowledge and aid introduction into real-life professional practice. Therefore, PBL is alignment itself (Biggs & Tang 2007).

I have been teaching in the master course Pharmaceutics and Drug Development (see Appendix A) since 2009 involving in lectures, instructing labs, supervising writing literature reviews and examination. My lectures in previous years followed the fill-up-the-tanks model discussing the text book in the class room with fewer opportunities for questions, discussions and elaborations. Although I experienced student learning by final assessment/examination I have an interest to pursue other didactic methods in benefit of the students and the course.

This year, I have pursued performing the lecture in PBL-style in benefit of student learning and in assessing this teaching a questionnaire was sent to the students a week before my lecture (see Appendix B).

Implementation and performance

Course description - overall context

Structure: Main weight on laboratory work and project assignment with a focus on formulation, production and biopharmaceutical characteristics which are supported by class lessons. Examination: Individual oral examination based on outcome (report) of the project assignment. Approval of all lab reports, ditto the report. Criteria are outlined for excellent, good and acceptable performance. Key words for excellence are to "elucidate" (and discuss), for good to "explain", "discuss", "relate", "categorize" and "sketch", and for acceptable to "know" and "mention".

The curriculum structure indicates that a PBL-approach or at least a problem-solving learning (PSL) approach would be relevant to consider as this would lead to generation of profession-related knowledge.

Teaching - preparations

My teaching this year is related to chapter 14 and 15 of the text book whereas that of the follow-up speaker (HG) chapter 17 and 18 providing together a cohesive subject in relation to microorganisms as a challenge in production of drugs. The title of my lecture was Action of Chemical and Physical Agents on Microorganisms and these lectures were provided coverage for the key topic "Quality requirements for drug products".

HG in a meeting with me, which was facilitated by the course director, learned before the lectures about the content of my lecture and I about his - that a couple of important key factors, e.g. D-value and Z-value (chapter 15 of the text book), would be addressed during my lecture. This meeting helped to avoid repetition and to make these more cohesive in benefit of teaching and learning activities (TLA).

A power-point presentation of 34 slides was prepared applying underlining, empty slides with only a subtitle precedes the fully elaborated slides and hand-pointing to the critical content as well as changing the tone and pace of the talk in support of TLA. Furthermore, pictures were used mainly to highlight the content without much discussing the details.

The title and headings of my lecture were designed to link to the intended learning objectives (ILOs) of the course, in particular with "Have acquired insight into the challenges of developing new drug products". These ILOs were implemented to provide insight into diversity of microbes and

the treatments affecting these whereas those of HG were focused rather on the evaluation of the treatments. Therefore, the content of my lecture was more of general nature providing an introduction to that of HG.

In this presentation all microbes as challenge in drug production were presented and highly specialized microbiology was skipped as they were treated similarly in the lectures by HG. However, there was a focus on bacteria as they comprise a major challenge in drug production.

To evaluate my teaching a questionnaire was provided to the student prior to the lecture that would contribute to discussion of PBL vs. fill-the-tank teaching methods. Another questionnaire based on Blooms and the SOLO Taxonomy was considered in harmonizing the ILOs and the TLA in line with constructive alignment (CA). However, this was not pursued as it could in combination with the questionnaire above cause confusion, inappropriate expectations and damage to constructive alignment (CA).

Teaching - implementation and performance

The sequence of PBL is typically as following; a problem from real-life become presented by teacher, learners become activated very quickly through for instance assignments, teacher facilitated building of a knowledge base, application of knowledge to the problem, problem is reviewed and learners develop monitoring skills.

Pursuing PBL I have prepared and performed the lecture highlighting an important subject by a question; tools assessing microbial contamination (D- and Z-values) that are important for understanding the follow-up lectures by HG.

The second question elaborated an insight into modern drug production; that the pharmaceutical industry is relying more and more on “biological drugs” than small molecule drugs. Furthermore, this direction is also relevant for the scientific topic of the final report that is crucial in final assessment/student examination in this course. Therefore, although this question was not related a problem in professional practice it was aligned with the course content.

There were 44 participating students filling up the long classroom. Before starting the lecture I welcomed everybody to this lecture and checked if people in the end of the classroom if they heard me well. The slide-show started with the main title followed by a reminder about a questionnaire for assessing my teaching by the present students.

After declaration of the content and showing a funny cartoon to capture the attention of the students the two questions were presented. They were shown asking the students to find answer during this lecture and to provide the answers in the end of the lecture. The jargons used as part of the question like D_{130} were touched briefly and the students were asked to be patient until the end to find enough clues for the questions.

After reviewing some of the key points of the text book using 24 slides the students were asked to answer and elaborate the questions. I moved away from the blackboard toward the students asking the first question "How does treatment of microorganisms work, biologically?".

A few students in front responded and elaborated the answer that triggered other students to do the same. The discussion highlighted cell and molecular structure of living cells and brought the attention to details which were underlined in slides.

After 10 minutes of discussions on a variety of cellular and molecular levels, which had been directly or indirectly touched during the lecture, I asked the second question "What is the Z-value if D_{130} and D_{140} are 25 and 2.5 minutes, respectively?" in connecting quality with quantity. It is noteworthy that pointing fingers to individual students was avoided as in my experience it causes dislike related to the subject and inhibits long-life learning.

Some of the students answered to the second question and some others showed that they grasped some fundamental knowledge of cell and molecular biology beyond the subject of the lecture. I noted though that the majority stayed silence.

The slide-show took 30 minutes time the discussions roughly 15 minutes – totally 45 minutes for the whole lecture.

Results and discussion

Teaching - student assessment

Besides sending the questionnaire (see Appendix B) in advance it was also reviewed quickly in the start of the targeted teaching/lecture (see Appendix D) and sent again to the students after the lecture together with a PDF of the lecture as a reminder. However, only 6 out of 44 students responded to this and thereby drawing any solid conclusion is not possible. Nevertheless, the following points are considerable.

- By the majority of these students (see student responses, Appendix C) there was an agreement about this point; that the ILOs clearly state what students were supposed to achieve, the students learned what these ILOs stated and that the elements of the teaching prioritized in a purposeful way in light of these ILOs.
- The students found the lecture different from regular lecture and that structuring the content in relation to ILOs and a problem was somehow appreciated.
- There was one student that did not find the lecture different, interesting or strong enough for this course. The other critics were related to number of used pictures/slides (the more, the better!), too fast slide show, not interactive enough, and applying not specified enough ILOs.

I think it is important to focus on the critics as that could be the reason behind too few responses. Alternatively, some students may have time issue or in general not interested in these kinds of processes.

Application of more specified ILO could contribute to student learning. The challenge is to balance these with those of the course and in this case more specification of the ILOs could damage CA with regard to the course content.

I think structuring the teaching based on ILOs was useful. I experienced more interaction with students and more activity in the classroom as result of application of these and the questions. Students were more alert in comparison with those in my previous lectures/years in which I mainly talked and the students listened (fill-in-the-tank model).

I have experienced planning, implementing and performing this teaching in light of KNUD ("Course in University Science Teaching and Learning" in Danish) highly useful not just for teaching this subject but also for teaching in general as well as project management. Therefore, this experience is encouraging to continue with PBL-based teaching and to explore more student and learning-centred approaches.

Teaching - future direction

Making more fruitful interactions in the classroom requires more fruitful interactions before classroom!

More frequent interactions with course director can contribute to fine-tuning of teaching in terms of understanding ambitions of the course, organizing teachers for a specific theme, and choice of didactics methods.

These discussions may contribute to application of common ILOs toward more cohesive teaching. In this line the focus on what the students should be able to know and do after these lectures as well as what they have to do to achieve these goals is likely to promote more stimulating lectures/provocative content and generation of functional knowledge.

It would be also useful to apply Blooms and the SOLO Taxonomy to improve levels toward application, analysis, synthesis etc. Certainly, this process also benefits from development of the course curriculum with more clarification on skills and competences. However, this would be a challenge as students of this course have highly heterogeneous background; most of the enrolled ones have achieved B.Sc. degrees in other countries than Denmark. Therefore, stratifying the prerequisites for student enrolment may be considered to improve more student-cantered learning.

Another challenge in organizing the teaching is the affiliation and employment terms of the involved teachers. For instance, teaching load of externally funded researchers/teachers is normally different from internally funded ones. It would be certainly useful to create a dialogue in this regard to harmonize ambitions of the university with reality of research funding in benefit of teacher and the students.

Defining these challenges is of importance in identification of solutions in pursuing CA, a process that can benefit from discussions with course director, program director or dean.

Grouping students in relation to problem-solving may involve more students in the classroom including those sitting far from the blackboard. Perhaps, moving away from the blackboard toward could be useful to get more students involved however the trade-off is to give up the momentum of brain-storming in front. A fewer slides can generate more time for discussion in the end but that would require reorganizing the content of the lecture.

Well-balanced pace in teaching can give more time for student reflections in benefit of TLA. Furthermore, including more time in the end for showing more slides/writing on blackboard in relation to institutionalization and summarizing can help student learning. Timing of teaching is likely to be promoted by more teaching practice and experience.

Finally, participating in seminars covering university pedagogy and, observing experienced teachers who are excellent in different kinds of didactics methods also help in developing teaching skills. In particular, it is of interest to learn more about PSL and PBL as not so infrequently teachers

at university have difficulties in differentiation between these two (Savin-Baden 2000).

A Course description

Course: Pharmaceutics and Drug Development (7.5 ECTS), MSc in Pharmaceutical Sciences - compulsory, MSc in Medicinal Chemistry – elective-FLVKA0331U
Text book: Aulton's Pharmaceutics, The Design and Manufacture of Medicines, M.E. Aulton Ed. 3rd Edition 2007, Churchhill Livingstone
Purpose: broad, solid knowledge of (types of) drugs, special focus on drug formulation, production and quality assurance (Ph.Eur.).
Prerequisites: least 15 ECTS in chemistry (10 of which in organic chemistry).
Intended course outcome:

- Describe what the term medicine comprises
- Have knowledge of absorption, fate of drug substances in vivo related to bioavailability
- Have acquired knowledge in different dosage forms
- Have acquired insight into the challenges of developing new drug products
- Be able to clarify the critical characteristics of various dosage forms for drug substances and rational design of dosage forms for specific drug substance in question
- Have acquired knowledge of producing various dosage forms of drug substances
- Have acquired knowledge of quality assurance and quality control for drug products
- Have acquired knowledge of The Danish Medicine Agency's requirements for drug approval
- Have acquired knowledge about The European Pharmacopoeia (Ph.Eur.) and Danish drug standards (DLS)
- Be able to choose suitable methods to characterise the biopharmaceutic and physicochemical properties of drug substances and characterize drug products
- Have an insight into the difference in drug development of small molecules and biologics.

Content:

- Introduction to biopharmaceutical principles of drug delivery, scientific principles of dosage form design, pharmaceutical manufacturing technologies and different types of dosage forms.

- Impact of physiochemical and biopharmacological characteristics of drug substances on dosage form design.
- Practical opportunities in the lab to work on producing granulates and tablets, in which it is possible to present a number of unit operations and evaluation of the final drugs products.
- Review of these key topics
  - Requirements for drug substances including solubility, impurities and stability
  - Quality requirements for drug products
  - Quality assessment of drug substances, excipients and drug products
  - Formulation and composition of drug products with relation to technical production requirements as well as bioavailability
  - Selecting excipients
  - Production techniques including the special regulations for sterile drug products
  - Alternative administrative routes
  - Drug product specifications and Pharmacopoeia requirements
  - Quantitative and analytical techniques for drug substances and characterization techniques for physical characteristics of intermediate drug product and final drug products
  - Process control and finished-goods control
  - Durability and stability studies
  - Quality by Design (QbD) in Drug Development.

B Letter

APPENDIX II

To students enrolled in the current Pharmaceutics and Drug Development course (FLVKA0331U)

Teachers at the university are obligated to complete a program in pedagogy improving teaching quality. In this regard we are currently pursuing a project that requires feedback from the students.

The traditional way of lecturing has for years followed the fill-up-the-tanks model whereas problem-based learning (PBL) intends to equip the students with more functional knowledge (Teaching for Quality Learning at University, 3rd edition, Biggs and Tang).

The lecture scheduled for 9-10AM, November 29 will be performed in PBL-style. In this regard you are kindly asked to answer to the questionnaire below, of course after this lecture.

We are very grateful for your comments and answers that will be used only for improving teaching quality at the university. Please, forward your response to amha@farma.ku.dk no later than December 6, 2011.

Sincerely yours

The team of FLVKA0331U

- Did the intended learning outcomes (ILOs), which is first provided in the lecture, clearly state what you were supposed to achieve?
- Did you learn what the ILOs stated?
- Did the ILOs guide the teaching?
- Were the elements of the teaching prioritized in a purposeful way in light of the ILOs?
- Do you experience that structuring the content in relation to a problem has made a difference compared to an ordinary lecture?
- What did you like about this lecture in particular?
- Please, state a suggestion for improvement!

C Student answers

- Did the intended learning outcomes (ILOs), which is first provided in the lecture, clearly state what you were supposed to achieve?

Student1: Yes. Maybe more than I expected.
Student2: Yes the ILO was fine.
Student3: Yes, the lecturer stated ILOs
Student4: Yes, they did.
Student4: Yes
Student5: Yes
Student6: Except the first one. The first ILO was not specific.

- Did you learn what the ILOs stated?

Student1: Yes. All the ILOs are mentioned during the lecture.
Student2: Yes, but the first part about microorganism went wery fast, so it did only cover a bit of the information about microorganisms in the text book.
Student3: Yes.
Student4: Yes, I did (hopefully!)
Student5: well, superficially I quess yes.. At least for the two first ILOs.
Student6: Yes

- Did the ILOs guide the teaching?

Student1: I think so. The ILOs make the teaching more coherent and logic.
Student2: Yes, the lecture was organized and defined from the ILO.
Student3: Yes, the slides and lecture is in accordance with ILOs
Student4: Yes they did.
Student5: Yes
Student6: Yes the teaching was guided by ILOs.

- Were the elements of the teaching prioritized in a purposeful way in light of the ILOs?

Student1: Yes.
Student2: Yes, the lecture was organized and defined from the ILO.
Student3: Yes, in this lecture it has 3 ILOs and the lecturer presented them according to sequence.
Student4: Yes the teaching followed the ILOs sequence and logic, as stated at the very beginning of the lesson.
Student5: If you mean in the order of the three ILOs - then yes.
Student6: Yes it was in accordance with the ILOs.

- Do you experience that structuring the content in relation to a problem has made a difference compared to an ordinary lecture?

Student1: I think it is different from the ordinary one. It makes the lecture more understandable for me.
Student2: No normally you will also organize a lecture.
Student3: Yes, the ILOs will guide the lecturer as well as student to be more focus.
Student4: Yes, I think that this kind of teaching help us to stay more focused waiting to achieve (through the teaching way) the tools and skills that could help us solve the problem
Student5: In general I didn´t find this lecture and the structural contents of it, different form any other ordinary lecture. There were no new thing in it, in relartion to making an agenda and follow it,

and then summarise it at the end. For me, that is a general structure of a presentation, which many of our teachers also follows.
Student6: It did make the difference.

- What did you like about this lecture in particular?

Student1: The professor was trying to inspire student throughout the lecture which made me more intend to thinking instead of just listening.
Student2: The question /discussion part was good.
Student3: I like that the lecturer stated ILOs in the beginning of lecture as well as the questions in the end.
Student4: That it helped us experience a purposeful learning (knowing in advance what we wanted to achieve at the end of the lesson and feel we were achieving it while listening the professor)
Student5: I actually didn´t like much of the lecture. It was uninspiring and I could not really relate to the topic. There was lack of overall message and meaning with the different sub-topics presentet, and thus it was several times unclear to me why theese were chosen for the presentation - I mean, they probably were justified topics, but it was not communicated out that it was especially important.
Maybe it also has something to do with the topic, but the guy Holger made the same topic much more interesting AND made a much better structured presentation. Check him out maybe?!
Student6: I liked the way the contents of lecture was structured in accordance to the problem that was presented in the beginning.

- Please, state a suggestion for improvement!

Student1: If more pictures in the slide will be better. Sometimes it's hard for me to imagine and react what the professor is actually talking about.
Student2: It went very fast, and it seems like you were lecturing in a chapter that we shold not read. So it was difficult to fall along because it went so fast.
Student3: It is good to have interactive lecture, but I hope that lecturer will give answers or feedback after listening to some answers from student. Then proceed with the lecture or another questions.
Student4: NO ANSWER PROVIDED BY THE STUDENT!
Student5: For example explain why we are talking about ionizing radiation before describing what it does... And all the different headlines: "Treatment with.." leave them out or let them in - not only in one slide!! Write numbers on the slides. ... Always explain math with graphic illustration, if possible. In this case it was accually possible! (D - and Z values).
Student6: I think the intended learning goals should be more specific, like instead of specifying only microorganisms, it could be something that states what aspects of micro-organisms are we supposed to know in relation to pharmaceutical field. Though ILOs didn't specifically demonstrated what we are supposed to know about microorganism the content about it was really good.

instead of using questions as problem it would have been more interesting if some real world problem related to the topic could have been stated. By that way we can learn how to apply the gained knowledge in practical problems. The second question though was more related to real world problem.

D PowerPoint from lecture

Action of chemical and physical agents on microorganisms

Amir Hashemi

Faculty of Pharmaceutical Sciences
University of Copenhagen

Teaching project

Problem-based learning

Your comments complete this project (deadline, December 6).

Ex.

- Did the intended learning outcomes, which was first provided in the lecture, clearly state what you were supposed to achieve?
- Were the elements of this teaching prioritized in a meaningful way?

Before end of this lecture.....

You will be asked to address:

- How does treatment of microorganisms work, biologically?
- What is the Z-value if D_{130} and D_{140} are 25 and 2.5 minutes, respectively?

Content

- Microorganisms
- Treatments with
  - Chemical agents
  - Gases
  - Dry and moist heat
  - Ionizing radiation
- Measuring antimicrobial effects

Intended Learning Outcomes

To learn about

- Microorganisms
- Treatments affecting microorganisms
- Measurements evaluating treatments

Microorganisms

- Cause human diseases
- Spoil prepared medicines

***Sterility** is defined as "freedom from all viable life forms.".*

Microorganisms

1) Viruses

- 0.020um - 0.300um in size.
- 0,2um filters, not good enough for sterilizing liquids!

Tobacco mosaic virus

Microorganisms

2) Bacteria

- 0,75-5um in size.
- Growing in strings (streptococcus), irregular clusters (staphylococcus), etc.

Microorganisms

2) Bacteria

- Capsules- protective against disinfectants.
- Cell Wall- Gram positive (retain methylviolet) and Gram negative.
- Cytoplasmic membrane- Osmotic barrier

Microorganisms

2) Bacteria

- Endospores- extremely resistant to a number of harsh environments, including: heat, desiccation, radiation, chemicals, acids, and drying.
- Endotoxin- inflammatory response when released from cell wall upon bacterial death.

▲ Sterile not good enough!

Microorganisms

3) The others

- Viroids= small circular single-stranded RNA.
- Prions= small self-replicating proteins, no nucleic acid, highly resistant to inactivation by sterilization.
- Fungi

Treatments with .....

How does treatment of microorganisms work, biologically?

Treatments with Chemical agents .....

Chemical agents

1) Ethyl alcohol

- Example= Ethanol
- Rapidly lethal to bacteria and fungi.
- no effect on bacterial endospores.
- little effect on viruses.
- Act by disrupting the bacterial cytoplasmic membrane and can impact enzymatic activity.

Chemical agents

2) Phenolics

- Example= Cresols and xylenols.
- Used as bactericide and antiseptic in hospitals.
- Cause cell lysis.

Bactericide: anti-bacterial chemical
Antiseptic: chemical used in cleansing of wounds, burns, etc.

Chemical agents

3) Quaternary ammonium compounds

- Antiseptics.
- Mainly affecting gram-positive bacteria by interfering with cell permeability that leads to leakage of cell content.

Chemical agents

4) Halogens

- Example= Chlorine.
- lethal to bacteria, fungi, and viruses and to some extent spores.
- denatures proteins and enzymes by its powerful oxidative effects

Treatments with
Gases....

Gases
1) Ethylene oxide (EO):
Inactivates the complete spectrum of microorganisms including endospores and viruses- no microorganism of high resistance has been found.
more potent antimicrobial agent at 50-60°C.

Gases
2) Propylene oxide
The antimicrobial effects are similar to those of EO.
The effect is conveyed by modification of proteins; e.g. esterification of carbonyl, hydroxyl, amino and sulphydryl.

Gases
3) Formaldehyde
A more potent antimicrobial agent than EO and a very effective sterilization medium even at low temperature.
The antimicrobial effects are because of intramolecular crosslinks between proteins and interactions with RNA and DNA (mutagenic effect).

Treatments with
Dry and moist heat ....

Dry and moist heat
In autoclave dry saturated steam (100% water vapour with no liquid water present) is used at 121-135°C that rapidly kills microorganisms.
Induce antimicrobial effect by hydrolysis of proteins and nucleic acids.

Treatment with radiations ....

Ionizing radiations

- α- and β- particles are resulted from disintegration of radioactive elements.
- γ- rays are emitted from the nucleus upon emission of α- and β- particles.

Ionizing radiations

- α -particles has very little penetrating power- not considered for sterilization.
- Whereas β- particles can be stopped by a thin sheet of aluminum whereas γ- rays penetrate lead.

Ionizing radiations

- The primer target of ionizing radiations in living cells is DNA.
- The generated hydroperoxyl radicals lead to increased sensitivity.
- The lethality is associated with microorganism's ability to repair the damaged DNA.

Measurements evaluating treatments ....

Determine Z-value If D_{130} and D_{140} are 25 and 2.5 minutes, respectively!

Measuring antimicrobial effects

D-value

- The time period required for a 90% reduction in microorganism count.
- Expressed in minutes and temperature at which the antimicrobial action was studied.
- If D_{130} of Staphylococcus aureus is 25 minutes= After 25 minutes only 10% of the bacteria survive if temperature is at 130°C.

Measuring antimicrobial effects

Z-value

- The number of degrees of temperature change required to achieve a 10-fold change in D-value.
- Expressed in centigrade.

The questions

- How does treatment of microorganisms work, biologically?
- What is the Z-value If D_{130} and D_{140} are 25 and 2.5 minutes, respectively?

Grateful for your comments.....

- Did the intended learning outcomes (ILOs), which is first provided in the lecture, clearly state what you were supposed to achieve?
- Did you learn what the ILOs stated?
- Did the ILOs guide the teaching?
- Were the elements of the teaching prioritized in a purposeful way in light of the ILOs?
- Do you experience that structuring the content in relation to a problem has made a difference compared to an ordinary lecture?
- What did you like about this lecture in particular?
- Please, state a suggestion for improvement!

Grateful for your comments.....

By
December 6

All contributions to this volume can be found at:

http://www.ind.ku.dk/publikationer/up_projekter/2013-6/

The bibliography can be found at:

http://www.ind.ku.dk/publikationer/up_projekter/kapitler/2013_vol6_bibliography.pdf/