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Design, conduct, and evaluation of a course in which the students become the researchers!

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The background

Upon my arrival at the University of Copenhagen, I was tasked with being course responsible for "Experimental Nutrition Physiology" (MSc Programme in Human Nutrition). The general idea of the course was to teach students about the various techniques and methodologies used in nutrition research, including aspects of study design (cross-sectional, paired, crossover, etc.), ethical and responsible conduct of research, methods to assess dietary intake, appetite, energy expenditure, but also laboratory methods to measure metabolites in blood and urine samples.

The design

I decided to put together a less lecture-based, and more hands-on-based course. Something like research-oriented teaching but instead of simply bringing research paradigms into lecturing, having the students learn by conducting the actual research themselves.
I put together the following Intended Learning Outcomes:

1. Knowledge:
    - To understand the principles behind study design and different scientific methods used in nutritional research.
    - To understand the role of different factors that influence the validity of an experiment and the parameters that describes the quality of analyses.

- To understand the basic principles of Good Clinical Practice and data management in a research project.
- To understand the principles behind the methods used in research to assess energy requirements and energy expenditure, and discuss their pros and cons.
- To understand the principles behind the methods used in research to assess dietary food intake, and discuss their pros and cons.
- To understand the principles behind the methods used in research for anthropometric measurements, and discuss their pros and cons.
- To understand the role of biological and laboratory factors in assessment of micronutrient status and reflect on the use of appropriate biological materials, as well as discuss the pros and cons of different biomarkers as methods for evaluation of nutrient intake and status in a research set-up.
- To understand the principles behind basic statistical methods used for data analyses.

2. Skills:
   - Be able to use, and critically evaluate, all the mentioned methods used for nutritional study design.
   - Be able to perform basic statistical analyses and critically evaluate biological data.
   - Be able to design, perform, document and present own methodological study used for determination of energy and nutritional status.
3. Competences:
   - To evaluate and critically judge scientific results.
   - To work in a proactive manner to assure own learning outcome.
   - To work both independently and in a group.

In preparation for the course, I planned it out in as much detail as I could at the design phase, and created a detailed online page on Absalon that resembled a website (i.e. home page with links to other modules and course content; see Appendices A and B).

I also scouted my Department (of Nutrition, Exercise and Sports, a.k.a. NEXS) for available resources in terms of equipment, space, personnel, budget, etc., and created some parameters within which the students could navigate to design their experiment: they could use the metabolic kitchen

to design and create all sorts of meals for conducting a dietary intervention; exercise equipment to conduct an exercise intervention; sphygmomanometers to measure blood pressure; scales, stadiometers, and tape measures to assess body weight, height, and various circumferences; dual x-ray absorptiometry scanners to measure body composition and bone density; Visual Analogue Scales to evaluate appetite/hunger; Indirect Calorimetry carts to measure fasting and postprandial energy expenditure and substrate oxidation; and several lab chemistry auto-analysers to measure a series of metabolites in blood and urine samples (e.g. glucose, insulin, cholesterol, triglyceride, cortisol, inflammatory markers, vitamins, etc.). Due to obvious time restrictions, the experiment could include only two visits of the "study volunteers" (see below) to the lab for assessment, with approximately 1 week in-between (e.g. perform trial A today, and trial B in one week from today). This meant students could design experiments with an acute intervention (e.g. two different meals or exercise sessions on the two trial days in a cross-over fashion) or a short-term longitudinal intervention (e.g. diet provision or exercise training for the 1 week between trials, with assessments before and after).

The conduct

During the first week of the course, I gave a few lectures that included a general overview of the course, the ILOs, and the Absalon website; a brief overview of clinical trial design and the principles of nutrition research methodologies (here I mostly focused on providing the students with resources on how to look for this information by themselves); and a detailed overview of what the students could do when thinking about their own experiment (i.e. the parameters outlined above). Two colleagues of mine gave brief overviews of the ethical/responsible conduct of research and of good laboratory practices.

The 32 students were then allocated to groups (8 groups of 4 students each), and each group had to act as an independent research team with one member of the group acting as the "study volunteer" during the actual experiment. To be fair (or so I thought), I used a random algorithm to generate the student groups, but in retrospect, in the future I will probably look into their background training so I create groups with more or less equal educational background and mixed in terms of ethnicity. These points came to me during the conduct of the course when I realized one group consisted of stu-

dents with absolutely no background knowledge in nutrition-related fields (so they struggled a bit more), and two groups consisted only of Danes and were communicating in Danish, and thus not using English as an academic medium effectively.

For practical reasons, each group collected data from just 1 subject, however based on this data for n=1, I then created a random dataset of 14 additional ghost subjects for each group, so they ended up with a sample size of n=15, which would allow for doing statistical analyses. The data for the 14 ghost subjects were generated by an algorithm that created a normal distribution around a mean value close to the value of the real subject. For example, if a group measured a fasting glucose concentration of 4.8 mmol/L in their volunteer for trial A and 5.1 mmol/L for trial B, the final sample of 15 subjects (1 real and 14 ghosts) had a mean ± SD of 4.8 ± 0.5 mmol/L for trial A, and a mean ± SD of 5.1 ± 0.4 mmol/L for trial B. That is, I tried to keep the differences between trials true, but add some physiological variability (noise) to give the students a taste of inter-individual variability in biological measurements.

During the course, each group of students had to perform a number of steps that are typically involved in research (and in this order): allocate roles within the research team (i.e. student group) and create a group contract; define an area of interest; search the literature; identify a research question; formulate a hypothesis; design a study to test this hypothesis and write up a protocol; carry out the study; collect samples; analyse the samples in the laboratory; conduct statistical analysis on the raw data; put together the results and write a report; provide peer-feedback on another group's project (each group was paired with another; see below); revise own report based on peer-feedback; get detailed written feedback from me at that point; revise the report again and submit a final version; get more written feedback from me; present project orally in plenum and participate in Q&A with the paired group and myself (see Appendix C). This process resembles, to a large extent, the various steps researchers such as myself take in real life when we conduct a study and disseminate our results in written form (i.e. publish an article in a scientific journal) and orally (i.e. present study in a conference).

Throughout the course students had to submit a portfolio of assignments (group contract, protocol, laboratory exercise, 2 report drafts, peer-feedback, final report) used for evaluation, together with the oral presentation and the Q&A session (see Appendix C).

Each group was paired with another (4 pairs in total) in order for students to experience the way another team did things (i.e. how the other team designed their experiment, which additional details they thought about - or didn't think about, how they presented their results, and so on). In addition, this would help students experience the process of giving written feedback (comments on the first report draft) and oral feedback (questions during the presentation) on another team's project, and respond to that feedback both in writing (while creating the second report draft) and orally (while answering to questions). The reason for this was to engage the students to be active not only from their "natural" side (i.e. the student side) but also from the opposite side (i.e. be the person who evaluates, asks questions, and gives feedback). At the same time, I thought this would resemble the real-life paradigm of a researcher doing peer-review on someone else's manuscript (as we typically do for various journals), or responding to the peer-review received from others (as we typically do for our own manuscripts).

The reality

The first week of the course went pretty much as designed from my end, however the feeling I got from the students' expressions and questions was that they were quite confused about what they would have to do for this course! They could not understand why there is no fixed curriculum or textbook or reading material and that made them feel uneasy about the way they would be evaluated and what they would need to read and prepare for their final exam (I only gave them some suggested textbooks and websites and told them they would have to look for literature on the methods they use by themselves). At that point I honestly felt a bit unsure about how the course would develop and whether things would work out as planned. So, this initial introductory period is clearly a point I need to improve in the future (see later).

Nevertheless, week-by-week, I could see the dynamics developing within the groups and the interrelationships strengthening, and this slowly but steadily made students feel more secure and perform as intended. Each step of the way was a struggle for them – but for me as well – but each subsequent assignment (from the study protocol to the actual experiment, the submission of the first and second drafts of the report, and the final report) was a clear – and may I say quite rewording – improvement over the previous one.

I must say that my time commitment and emotional investment were much greater than I initially thought. I planned the course around the students making their own choices about pretty much everything that had to do with their study, and letting them do mistakes along the way in order for these mistakes to create problems later on during the research, which would help them learn during problem-solving. For example, I would not correct an inappropriate study design or an inappropriate choice of control meal, but I would let the project develop until the problem would manifest itself, and then guide the students towards discovering their mistake and its consequences, in order for them to realize what could have been done differently. This required a great deal of restrain from my end at various steps along the way, as I had to keep a fine balance between what I wanted to tell them and what I should tell them (i.e. I had to fight between my inner urge to treat their project as real research vs my intent to use their project as a teaching tool). At the beginning, I found it challenging to provide students with enough oral feedback without serving them the answer on a platter, but as the course progressed, I became better at this! I also ended up devoting much more time to the course than I originally thought; I had multiple meetings (each lasting 1-2 hours) with the student groups, particularly during the analysis and interpretation stages. Honestly, I anticipated students in the MSc Programme in Human Nutrition to have some basic knowledge of physiology and metabolism, as well as statistical analysis, but I was mistaken in my expectation, and particularly in that they would bring this prior knowledge into practice. This realization made me redesign the course for the future (see later).

The evaluation

The majority (>80%) of the students who responded to the course evaluation spent between 16-30 hours/week on the course activities; found the academic level of the course to be medium-to-high; the workload of the course to be medium-to-heavy; and felt they acquired the competencies described in the course objectives. They were generally satisfied with the teaching elements and materials. I was very happy to see that they felt they received adequate academic feedback from me, and thought the course was useful. They really seemed to enjoy the hands-on nature of the course, e.g. “I really liked that it was research and practice oriented, even though it was sometimes frustrating, it was frustrating in a good way.. and to overcome

the challenges was a big achievement which made us feel good after we have seen our final work as a group" – this pretty much summarizes what I wanted to achieve, i.e. to create a course that is real (and therefore somewhat hard), but still manageable and useful. Having said that, I think the students' evaluation of me as a teacher reflected this as well and I am quite happy with this feedback, which serves as a great reward for all the time and effort I devoted to this course.

On the other hand, some students commented that the structure of the online pages on Absalon was rather complex and confusing, and therefore I plan to redesign it to make it simpler, i.e. more linear, as I think the non-linear layout is what confused them. They also commented on the need for additional introductory lectures on the experimental techniques they will use, but particularly on the statistics, which I will incorporate in the future (see below). This will probably also save me a considerable amount of time, as I estimate that about one-fourth to one-third of the time during my meetings with the students was spent explaining these issues to them (and many times for that matter, as there were multiple groups).

I believe the most disappointing feedback I received on this course was some comments on the evaluation. In addition to the oral presentation and peer Q&A, I had put together a number of short questions that addressed several generic methodological issues, e.g. how does indirect calorimetry work, what are the limitations of DXA to measure body composition, what does the AUC mean as opposed to the shape of the curve, which research design is optimal to answer a particular research question, and so on – I actually spent a lot of time on this and I really thought these are things the students ought to know, regardless of whether they were applicable to their own project. These questions were administered in a random fashion, e.g. I had each student tell me a number which would correspond to a question. This created some anxiety and stress among the students, particularly those who thought they received the more difficult questions (although I honestly tried to make them as equal as possible). I am a bit torn about how to tackle this in the future. I have to say that as a person, and a teacher, I am not against stress, meaning all cannot be a smooth ride for the students, and I truly believe some stress is good as it makes students try harder. Maybe a much better explanation of how exactly they will be evaluated, presented to them in the introductory week of the course, will help. This way, at least they will know what will happen and anticipate this form of examination. And, I will add a written exam to count towards half of the grade, although I cannot make this change this coming year but rather in 2 years from now.

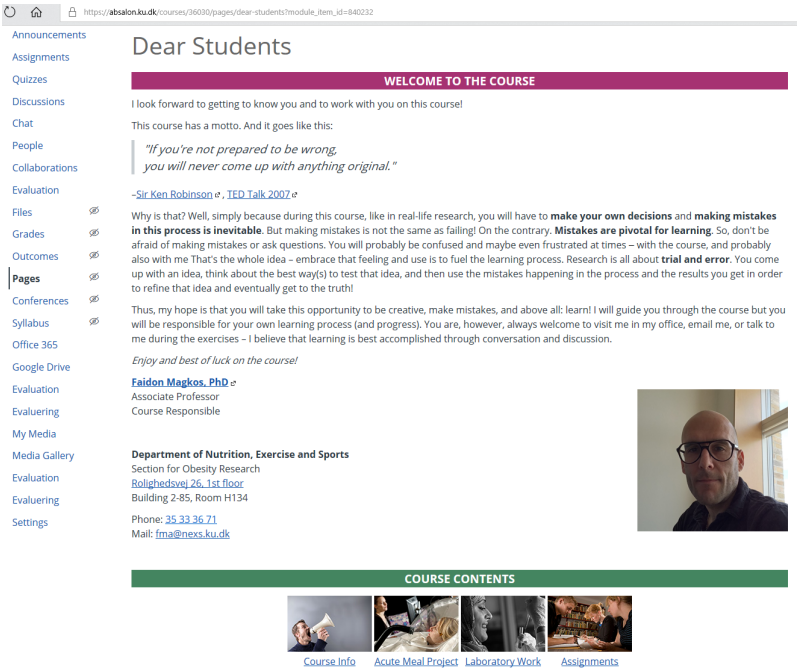
The take home message

Overall, I am pretty happy with the outcome. The course turned out to be an interesting and satisfying experience for the majority of the students, and a rewarding exercise for me. In the future, however, I plan to try a few different things.

- First, I will create more equal groups in terms of educational background and more mixed in terms of ethnicity.
- Second, I will incorporate some additional hours of lecturing during the first 1-2 weeks on the basics of research design and statistical analysis, and on the fundamentals of nutrition and exercise physiology. This will bring all students on the same page, so they know where to start from, what to expect, and what they might encounter during the conduct of their project. As there may not be enough time to cover everything during lectures, I will put together some offline presentations for some of these issues.
- Third, I will add some additional constraints on the design of the actual experiments, as monitoring 8 completely different projects at the same time turned out to be a bit challenging for me. I am confident I can still give students enough creative freedom while making sure they get exposed to the commonest study designs and types of data analyses they will encounter later on in their career.
- Last but not least, I will more clearly lay out – from the beginning of the course – the way the students will be assessed, and add a final written exam that will count towards 50grade. This will resolve the "problem" of students being evaluated solely based on my subjective judgement of their group's portfolio and their individual responses to the limited number of questions being asked after their group's presentation (which admittedly, gave me only limited ability to resolve the grades among students within the same group).

I am not sure how all this will turn out, but I know one thing for sure: I am looking forward to trying it!

A Homepage


https://absalon.ku.dk/courses/36030/pages/dear-students?module_item_id=840232
Announcements
Assignments
Quizzes
Discussions
Chat
People
Collaborations
Evaluation
Files
Grades
Outcomes
Pages
Conferences
Syllabus
Office 365
Google Drive
Evaluation
Evaluering
My Media
Media Gallery
Evaluation
Evaluering
Settings
Dear Students
WELCOME TO THE COURSE
I look forward to getting to know you and to work with you on this course!
This course has a motto. And it goes like this:
"If you're not prepared to be wrong,
you will never come up with anything original."
-Sir Ken Robinson , TED Talk 2007
Why is that? Well, simply because during this course, like in real-life research, you will have to make your own decisions and making mistakes in this process is inevitable. But making mistakes is not the same as failing! On the contrary. Mistakes are pivotal for learning. So, don't be afraid of making mistakes or ask questions. You will probably be confused and maybe even frustrated at times – with the course, and probably also with me That's the whole idea – embrace that feeling and use is to fuel the learning process. Research is all about trial and error. You come up with an idea, think about the best way(s) to test that idea, and then use the mistakes happening in the process and the results you get in order to refine that idea and eventually get to the truth!
Thus, my hope is that you will take this opportunity to be creative, make mistakes, and above all: learn! I will guide you through the course but you will be responsible for your own learning process (and progress). You are, however, always welcome to visit me in my office, email me, or talk to me during the exercises – I believe that learning is best accomplished through conversation and discussion.
Enjoy and best of luck on the course!
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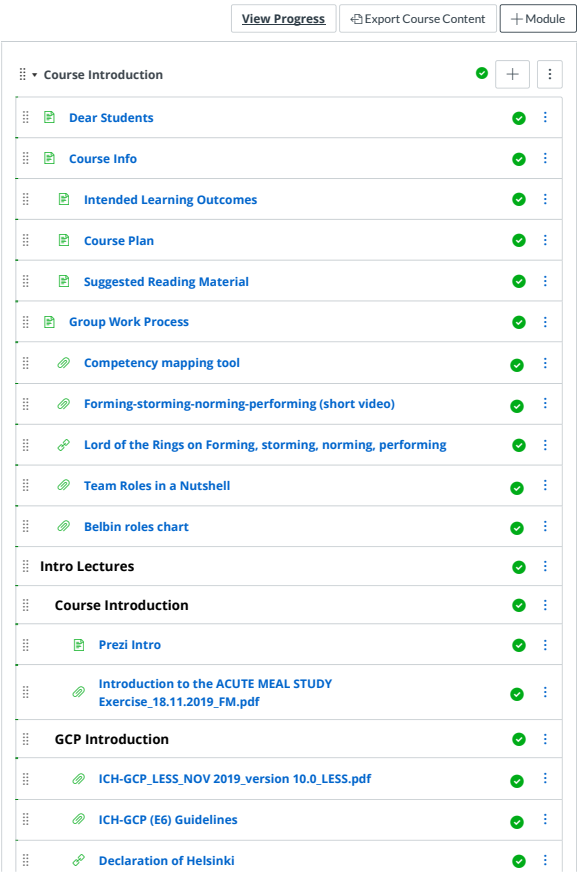
COURSE CONTENTS
Course Info
Acute Meal Project
Laboratory Work
Assignments

B Course modules



- Interdisciplinary Methods in Nutritional Research
  - Interdisciplinary methods. The GO Bypass Study (lecture slides 2018)
- Academic English
  - Tips and tricks for presentations.pdf
  - Memorable Academic Presentations.pdf

Acute Meal Exercise

- Introduction
  - The ACUTE MEAL EXERCISE guidelines
  - Nordic Nutrition Recommendations
  - Example of time table
  - Example of a Data Management Plan
  - Example of delegation log
  - Vitakost license
- The Methods
  - Anthropometry
  - SOP-6a body weight and height, waist, hip and thigh circumference
  - P06-I06-37, version 4, Lunar Prodigy
  - Information on DEXA scan
  - How to take a pregnancy test

- Indirect Calorimetry
- Visual Analogue Scales
- Calculating Area Under the Curve
- Laboratory Work
  - LAb-work 2019.pdf
  - Laboratory safety
  - Literature on Laboratory Safety
  - Laboratory Safety Test
    Dec 10, 2019 | 12 pts
  - Laboratory Safety Practice Questions
    11 pts
  - Lab equipment and analyses
  - Catalogue of Lab Analyses
  - Immulite 2000 Principles
  - Pentra 400 Principles
  - Assignment on Laboratory Assessment
  - Laboratory Assessment (Rastislav Monosik).mp4
  - Exercise on laboratory assessment
  - Answers to exercise on laboratory assessment
  - Answers for laboratory assessment questions
  - Lab analysis theory

Assignments

- Group Contract
  Nov 21, 2019 | 0 pts
- Laboratory Assessment
  Dec 10, 2019 | 100 pts
- Protocol
  Nov 28, 2019 | 0 pts
  - Protocol Structure
- Report, 1st draft
  Jan 2 | 0 pts
  - Screencast on report writing
  - TOEMI writing workshop
- Peer feedback
  Jan 3 | 0 pts
  - Screencast on the feedback process
  - Report Feedback Form
- Report, 2nd draft
  Jan 8 | 0 pts
  - Screencast on report writing
  - Screencast on the feedback process

NEXS Bibliotek / Library: "Good to know - Need to know"

Practical links

C Project outline