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Session: Implications of teaching Bayesian statistics to undergraduate psychology students

Chair: Henk Kiers (h.a.l.kiers@rug.nl)

Session leaders: Henk Kiers, Don van Ravenzwaaij, Jorge Tendeiro and Rink Hoekstra

Minutes: Sarahanne Field

Monday, July 8<sup>th</sup>: 14:45-16:15

Session Context:

- Discomforting in statistics teaching, motivated by the realization that although there are serious problems with NHST (and recommendations to improve the situation), leaving students with the issue that they're taught something, but never taught how to really use it properly.
- Need to be able to make statements about probability
- Have to go Bayesian one way or another. How are we going to teach it?
- Half the room with some Bayesian teaching experience.

Themes:

1. What to teach? (Don)
2. What type of software? (Jorge)
3. How to deal with the frequentist versus Bayesian debate in teaching? (Henk)
4. How to reach non-statistical colleagues? (Rink)

- Theme 1 leader: Don
  - Provide a framework for some general questions to think about, leading into a discussion, ideally.
  - The range of topics that are taught really range from not teaching Bayes at all, to extensive curricula that don't involve testing at all (in favor of model testing, BICs and lots of math etc). Good or not?
  - Do we want our undergrads to perform manual stats calculations? E.g., in the context of calculating the probability of a woman having breast cancer when the result is positive – a dichotomous example. A continuous example is the coin toss example.
  - Do we want to use software as a proxy for hand-calculations (or use it alongside hand calculations)? Jorge's topic delves into this aspect more deeply.
  - Do we want to restrict ourselves to estimation or testing? Or both, or neither are possibilities.
  - All of these are 'great', but what is *feasible*?

## Discussion:

- EJ – adding a new module to JASP teaching/learning statistics with a Bayesian component. Seems that you could do all conceptual learning without calculations. If you have them do it by hand, they can eventually do it, but do they understand it?
- If you program a nice interface, with lots of visualization, you have a better chance of them knowing what they're doing.
- Planning to write a course book – start with probability theory? Very dry, with the chapters thereafter interesting. Sounds like it would make people quit before even learning.
- EJ's point is that a conceptual approach is probably beneficial – students will understand.
- Balazs – interest in the topic in the first place, agrees with the conceptual point. Students will be able to solve things, and go through the process without 'loosing too much blood', and can build up their confidence. Students aren't motivated by issues in math or stats or probability – they're interested in conceptual things in the early stages. First interest then methods and statistics.
- Petr – Resources starting with interesting stories might facilitate this.
- Probability theory is dry but doesn't it matter how you present it? Counter to EJ's point.
- Casper – motivate them first, then the math? Is that what you mean. EJ says postpone it until their interest is sufficiently piqued. Equations are used, but they don't have to actually do it by hand.
- Jorge – Do you think they're actually deeply understanding enough? EJ counters with the idea that needing to know how a fridge works isn't necessary to use it properly. EJ wouldn't even put the math in an appendix, maybe instead a shadow version of a course book that's on a higher math level.
- EJ – we should concentrate on simple problems, but making sure that everyone knows the concepts. Once the concepts are known, it's easy to generalize to the tests.
- Don – who's got experience as a student? What do you want to know?
- Angelika – can we only teach Bayes? Without NHST?
- It *can* be done, but there are a lot of caveats. Rouder gets away with it at UCI, but most departments won't approve.
- EJ – people need to know what NHST actually is – we can't get away from teaching it, but maybe teaching Bayes helps us understand NHST better.
- Nicole – the perspective of not going too hard is patronizing. Maybe it's self-selection – people who 'run away crying' maybe shouldn't be taught the statistics.
- Julian – there's probably an interest in students knowing the stats/math – they are perhaps wanted by employers. Bachelor students probably won't get to a high level of complicated math in their careers. First year bachelors are afraid of stats, and don't even try.
- Marton – maybe it's good to have some confidence so students aren't afraid. A little, at the start, not too much.
- There's a balance to be struck in terms of how much confidence – drive people to be confident to learn, not overconfident with skills.

- Angelika – start early with why we need statistics. Many science students don't really know why this is the case. They think 'what for?' – begin with the mindset of why it is valuable. Before we even go to actual stats.
- Don – concepts are good, need confidence, some equations are good. If you can get away with numbers great, but if you can't don't try to do it anyway because it won't work.
- Casper – some universities (like RuG) – teach one version with numbers and some without (like English versus Dutch track). Get creative with meeting demands/needs.
- Henk says future PhD students are a different group and should be taught numbers.

- Session 2 leader: Jorge
  - What software should be taught.
  - At some point we want to do software data analysis, so software is a must.
  - Lots of options are available, but there is discussion about what is best. Options depend on hardness and flexibility etc.
  - How can we reach students while teaching intro to Bayes.
  - JASP – great approach!
    - Nice GUI
    - User friendly
    - Easily interpretable
    - Intuitive
    - Fast
  - R – Jorge's favourite
    - One-line commands
    - Not especially difficult to teach Bayes – comparable to NHST in terms of difficulty
    - Produce figures, reports.
  - R, teaching students to specify their own models of Bayes
    - They need to fully understand the value of priors, likelihoods etc
    - Have to work out all their own code and functions
    - Not easy to get into straight away
    - Complex in terms of understanding and executing

#### Discussion:

- Some markets: simpler software fine, but for many data analysis needs, teaching R is necessary. Teaching R to students who want concepts isn't useful. But in some courses like cog science who have a scientific approach from bachelor on, it makes sense to spend a lot of time to learn R and how to handle and learn to use data.
- Casper – 580 students run away at the idea of a t test would jump out of the window at getting students to write own Bayesian models. Good to teach students that there are multiple ways of doing things – statistics isn't ONLY SPSS. There are different packages to do statistics, show them what's out there. SPSS used when there's not much better. If you choose the full R way, you need a more technical course and more time (and/or different students).
- EJ – student population is key. EJ doesn't think universities should teach with any proprietary software. Later on, they can't afford the software. They're taught something that doesn't persist in being useful later on.

- Balazs– you can't choose one of the other. Stats can't be taught in one go, really. Who learns it in one go, we have to learn it a few times. If you want people to learn statistics, you should do something that allows them to get the ideas first. You can't become real scientists without using some kind of programming language.
- Jorge – progressive software goals might be the idea?
- Don – A concern: using a point-and-click software can teach you nothing. Is it possible for students to ignore the conceptual and only plug in once the examinable content and pointing and clicking starts?
- Jorge – it helps to look under the hood, if all we do is point and click, we are only scratching the surface. It might be a timeline – when and where do we increase the complexity of the analysis to the extent to where we use the model-making software towards the end when people are proficient with statistics.
- Maybe end up targeting interested students only? There's a price sometimes to teaching more complex things.
- EJ – what are our goals? What do students need 'all this stuff' for? That should drive what we teach.
- Don – Who are we actually targeting? The 580 or the 20? Will the 20 we are talking about go to a different master where they're taken more seriously?
- Jorge/Casper – the number might be higher than 20 in 600.
- Casper – risk of too simple statistics stuff means that people who like more complex statistics don't get something they think is really fun. Giving the option is valuable.
- Angelika – on what basis do students choose certain stats courses? Apart from interest in research, aren't you preselecting for a certain kind of student. Aren't you selecting people and missing others?
- Jorge – the ones that adhere, we are sure they're motivated.
- Summary – offer concurrent learning tracks. Adapt to the population and how deep in the track the students are.

#### Theme 3 leader: Henk

- Should we still teach NHST?
- Is NHST superfluous? At least teach what is done in the literature.
- The question is *how*?
  - Frequentist first? As default, then Bayes as modern alternative?
  - Bayes first? As default, then frequentism as obsolete approach?
  - Side-by-side (henceforth SBS)?
  - Bayes as extension of frequentism, correcting it?

#### Discussion:

- It'd be inappropriate if one or the other never taught. People wouldn't know how to interpret things. Side by side is a good approach. Even if Bayes never used, it's good to help better understand frequentism.
- EJ – UvA does two debates – frequentists versus Bayesians with student involvement. They see it's not a cookbook with absolute truths. They see people disagreeing about fundamental things, and find it interesting.
- Rink – some say: don't confuse students further. EJ doesn't think this is problematic.
- One suggestion – time constraints, how to get around them.

- Casper – teach in the first year how to really do and understand, then go from there are get more complex. Pays off in the first place, getting the conceptual stuff down. Forces people to think in concepts. In second year courses, then you can do the SBS stuff, and use point and click stuff.
- Jorge – SBS forces to look at stats in terms of comparisons. What do they offer in comparison with one another? Leads to clarification to have the two, rather than confusion.
- Don – students don't learn like in the matrix. There's a true cost. Either we double up on the stats hours, or we go less deep. What should we skip, or what should we get less deep with?
- Casper – doing it SBS, they learn good statistical thinking, then going complex later is easier.
- Henk – disappointment of supervisors in students later on that weren't taught deeply enough?
- Casper – counters: only one technique is really needed for bachelor thesis. Should fit in okay to focus not too deeply on very much.

#### Theme 4 leader: Rink

- How to teach non-statistical colleagues?
  - Some staff have no idea how to deal with Bayes. How should they be taught? Do they actually *want* schooling?
  - Is Bayes more complicated?
  - How to convince people that Bayesian statistics is needed?
- Are we ready for Bayes?

#### Discussion:

- Older colleagues don't want their syllabi to be 'messed with' perhaps?
- Some professors might want good SPSS skills. If goal is to bring students to the point where they're good at a master thesis, this is the idea. These colleagues are given more work.
- Casper – don't change everything immediately. Gradually change things. Provide workshops at the same time. Explain why we are changing. If those profs don't want to learn something new, then maybe they shouldn't be working at a university...
- Rink – what do we say to try to convince people?
- Replace the word 'modern' with 'simpler'. Modern might make people resistant (dogmatic language).
- Petr – lead by example. Informally make people curious by using it yourself. Create competition between profs with students, modern profs winning against others who have students who are publishing in less good ways and not winning awards.
- Proprietary software argument compelling here – obsolete (eventually) and expensive.
- EJ – advisors might end up with better students ultimately, because small changes in methods/software doesn't matter, students understand deeply enough to be resilient to changes.
- Rink – strategically approach staff. Couldn't the issue be framed as 'students have problems with statistics', we are giving a workshop about these problems, and

provide some solutions. Indirectly informs them about what are students starting to do, using updated methods. Would that help people feel less threatened?

- It's a problem when it's inconvenient, and a lot of work. You have to make it as easy as possible for people.
- Have to make the transition easy, and support people as they change their approach.
- EJ – the fact that curricula change over time is usually a good thing, can't this be framed as a similar thing.
- Casper – gradual change can cause trouble, older profs notice that students aren't as proficient in SPSS, and it might be good to make sure seniors are on board.
- Zoltan – acknowledge that a single supervisor can't know anything, maybe have a stats or methods consultant.
- EJ – UvA and RuG both offer methodology support desks. Students and staff both.
- Casper – doesn't like the idea of staff being able to cop out because they don't know some techniques.
- Jorge – we still have to deal with such people, so what do we do with them?
- Angelika – start a grassroots approach, e.g., from PhDs who are still willing to learn. Once the older prof is outnumbered, it might motivate them to learn what they're kind of missing out on.
- Henk – it might be time to make a bigger move than that.
- EJ – there are people outside the methods group that are already using Bayes. You only need a few to do this before other colleagues notice. UvA is already maybe near that critical mass, so it might start happening soon.
- Casper – other changes in addition to statistical changes might become overwhelming or too hard or too time-consuming. Department head can motivate?