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Forget the formula, reflect your results!
How to learn complex correlations with mobile apps

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Abstract
Traditional e-learning is an integral part of today's teaching and learning at the University of Natural Resources and Life Sciences, Vienna. While smartphones and tablet computers are widely used among students, the educational potential of these mobile devices are not exploited yet.
Interviews with teachers revealed that many students have problems to comprehend formula-based correlations with several variables. They neither have a clear idea how strong the influence of the individual variables is on the final result, nor about their mutual interference. Furthermore they often cannot even estimate the relevance of the result.
This is where "BOKU grasp" steps in. This mobile application enables students to actually comprehend the relationship while altering one or more parameters in real time and get instant feedback in different ways like interactively changing icons and intuitive colour codes. A history in graphical and tabular presentation enables the students to reflect on successful parameter combinations.

1. Introduction
Over the last decade traditional e-learning became established and now forms an integral part of teaching and learning, not only at the University of Natural Resources and Life Sciences, Vienna (BOKU). Alongside this development, mobile devices like smartphones and tablet computers have found a widespread use among students within a very short time. Unfortunately, the educational potential of these mobile devices in the context of BOKU's core issues like life sciences are not exploited yet.
As a first step, problem areas were identified that could benefit pedagogically from innovative use of mobile technology. Interviews with teachers revealed that many students have problems when it comes to comprehending formula-based correlations with several variables. Although the students succeed in applying the formulas, they neither have a clear idea how strong the influence of the individual variables is on the final result, nor about their mutual interference. Furthermore, they often cannot even estimate the relevance of the final result. The formula remains abstract. Thus learning is neither effective nor sustainable.

2. Theoretical background
If students are expected to develop practical professional competences – which usually means to be able to make the right decisions at the appropriate moment and within an acceptable timespan – it is not sufficient for them to learn how to derive or even how to apply a particular formula. They must understand its practical meaning and the practical consequences of all kind of variations of data in different combinations being processed by this formula. It is not the beauty or elegance of the formula (adored by mathematicians) that is relevant for the practitioner of any profession but its ability to facilitate useful decisions in real life.
This may be the primary reason for many teachers and educational systems to teach formula – which are constructs at highest level of abstractions - in all kinds of educational settings.
The problem is, however, that the human brain is not good in *learning* abstract content, although it can be outwitted even to do this. In fact our brain is perfect in *making* abstractions for itself by processing all kinds of information available from ongoing practical experiences.
He who has worked for some years as a logger does not need any formula to know where to position the harvester for achieving the best results. He has drawn the most efficient formula unconsciously from his experience in some hundred different practical situations.
So, do we have nothing to do than to send our students into vocational practice (e.g. in the woods) for 3 or 5 years? Maybe this is not the best solution we can think of. According to findings in brain

research we are entitled to hope that there are viable time-saving alternatives taking advantage of situated learning combined with technological enhanced fast repetition of practical experiences.
Spitzer sums up the chapter dealing with knowledge and competence as follows:
“We are highly competent and know little. Our competence relates to the fact that we can respond to a wide variety of input with the very rapid production of output, because our brain contains trillions of synaptic connections enabling it to do so. Only those of our ancestors have survived, who mastered this input-output-mapping adapted to the environmental conditions quickly and reliably and, above all, learned it quickly based on a small number of examples.” [1]
Following this insight, we propose four hypotheses for the best effects of a mobile app supporting students’ learning:
Hypothesis 1: Students must have the opportunity to make as *many* different realistic (or nearly realistic) experiences as possible within a given timespan.
Hypothesis 2: The *more authentic / realistic* the situation of these experiences is the better the learning outcomes will be.
This argumentation refers at the one hand to the finding cited above and at the other hand to the finding that the performance of learning outcomes will be as better the nearer the situations of learning and reproduction are.
“In a free recall experiment, divers learnt lists of words in two natural environments: on dry land and underwater, and recalled the words in either the environment of original learning, or in the alternative environment. Lists learnt underwater were best recalled underwater, and vice versa.” [2]
Hypothesis 3 relates to motivation: Students need as *relevant* practical situations (from a *personal* point of view) for the starting point for their own learning process in order to maintain a sufficiently high learning motivation.
Hypothesis 4 is based on the *motivating* and *intensifying* effect of *collaborative learning*: If students work together solving a problem they can discuss possible solutions and upcoming difficulties and so are able to stabilize or even enhance their motivation as well as improve their learning outcomes.

3. Methodology

According to the hypothesis formulated above there is a number of learning situations which can theoretically be supported by a mobile app like “BOKU grasp”. These settings are listed in descending order in terms of their expected impact on learning outcomes.

(a) The greatest impact can be expected if *several students* work together *on site* solving a *practical problem* / performing a particular task. All four hypotheses can be applied in this situation (hypotheses 1 - 4 are applicable).
(b) Slightly less a student is expected to learn if he or she works *alone on site* (hypotheses 1 - 3).
(c) Again a little less learning output can be expected if *several* students work together *indoors* at the *excursion quarter* (hypotheses 1 and 4, 2 and 3 only partially).
(d) Again one step back if a student works *alone indoors* at the *excursion quarter* (hypotheses 1 fully applicable, 2 and 3 partially).
(e) Several students work *indoors* (lecture hall, conference room, home office) with photo/video support (hypothesis 1 and 4 fully applicable; 2 and 3 only rudimentary).
(f) One student works *indoors* (lecture hall, conference room, home office) with photo/video support (hypothesis 1 fully applicable; 2 and 3 only rudimentary).
(g) *Several students* work *indoors* (lecture hall, conference room, home office) *without any visual support* (hypotheses 1 and 4 are applicable).
(h) And the smallest impact on learning outcomes is expected if a student works *alone indoors* (lecture hall, conference room, home office) *without any visual support* (only hypothesis 1 is applicable).

The expected positive impact on learning is based on the time saving effect of using the mobile app and may therefore be twofold: students should either reach the same learning outcomes within less time or better learning outcomes within the same time in comparison to learning without this technical support. Thus success can be defined in different ways (see table 1).
In our opinion most of these ratings are plausible. Only two of them might need an explanation. If students need more time to achieve better learning outcomes [c] you can rate this effect as not useful or as a success. It is a success if you appreciate the motivational effect of the app – or the situation of its application – that stimulated students to invest more time in learning. The second case [g] goes the other way round: if the (new) arrangement produces lower motivation to spend time for learning it is clearly counterproductive.

Comparison of input & outcomes		Achieved learning outcomes: worse	same	better
Time investment	more	[a] Big failure	[b] Failure	[c] Interpretation!
	same	[d] Failure	[e] not useful	[f] Success
	less	[g] Failure	[h] Success	[i] Big success

Table 1. Criteria of failure and success

Methodologically there are some difficulties to be overcome. Firstly, it will not be possible to record the learning time of students objectively. Thus we will have to use subjective individual estimations of the students themselves.

Secondly, different intervening variables will for sure distort the results. Technical problems on the one hand – e.g. time wise disconnection of the mobile devices when working on site – will make it difficult or even impossible to use the app appropriately. And inappropriate didactic designs or settings might fail to motivate students to apply the app productively. For this last reason, one of our main concerns is to work together with the respective teachers for co-operatively developing well-fitting designs for using mobile apps in excursions.

The mobile application, currently in a pilot phase, is implemented as a responsive website based mainly on open source software. The authentication via accounts is only necessary to generate reliable and unique data records for the scientific analysis, but the students are free to use any e-mail address. After the successful login the students choose the formula they want to work with. Since the authors assume that the learning situation of students is important for the learning process the mobile application asks two key factors prior to the tasks: the “location” and “learning setting”. The first one, specifies the physical environment, e.g. in the nature, in the lecture hall, in the library, at home, on public transport, the second one, records if the students are working alone or in groups. The main page comprises several sections that can be minimised independently. The introduction summarises the formula, its application and all involved parameters highlighted in different colours. This is followed by the formula itself, again using the same colour code as illustrated in figure 1.

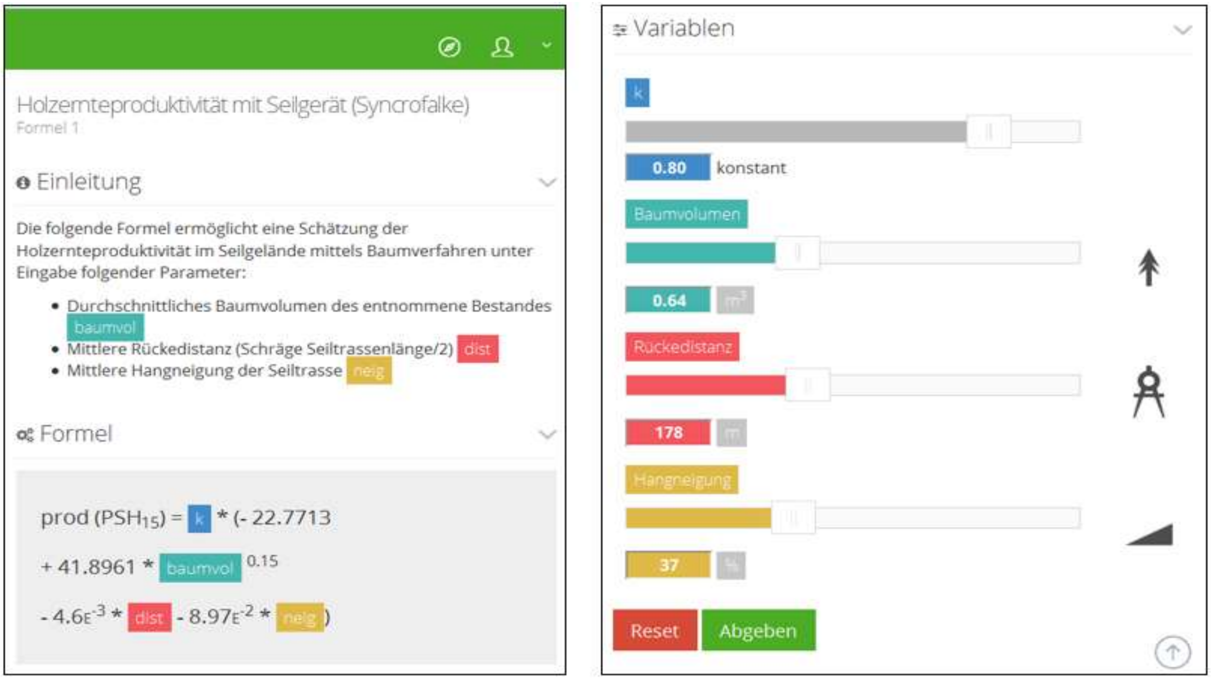

Figure 1. Screenshot of “BOKU grasp” depicting the description, the formula and the slide controls.

The next section shows different tasks that have to be applied by the students with the help of the current formula. The main part is the interactive one comprising of the slide controls that can be even manipulated parallel and touch-controlled if available on the device as well as the results presented in different ways: in numbers, as a graphical trend and a table presenting the combination of the variables. Again, the sliders use the colours of the variables. Beside the intuitive operation special attention was given to the visual feedback of the current value of the parameter settings, represented by changing icons that visualise the amount of the value. The presentation of the results uses a second colour scheme: ranging from red for poor performance to yellow for mediocre to green for good. When reflecting their results, the students can easily go back to good variable combinations by clicking either on a specific value in the graph or in the corresponding row of the table as shown in figure 2.

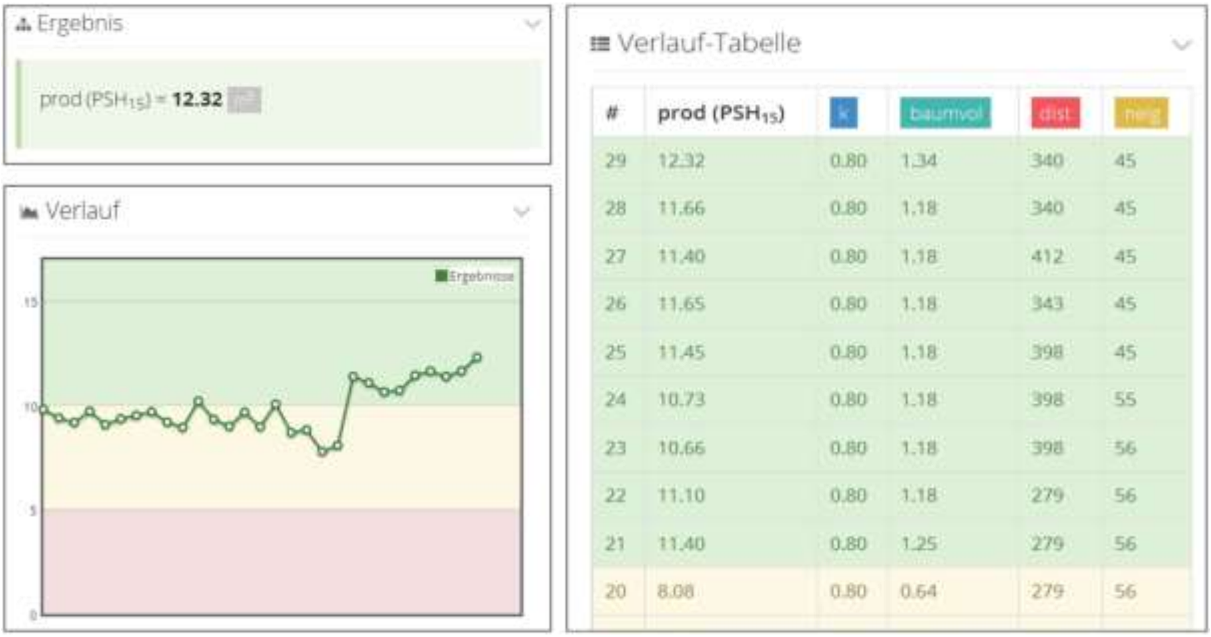

Figure 2. Screenshot of “BOKU grasp” depicting the three forms of visualising the results.

4. Discussion

First field tests with the prototype “BOKU grasp” were carried out during the course “Timber Harvesting Systems” in summer term 2015. The results show a mixed picture. While the general acceptance was rather low, those students who actually used the mobile tool were willing to invest some of their leisure time. Essentially, there were two reasons for the little usage: Firstly, the prototype was implemented as a responsive website instead of a real mobile application to keep it open for fast and easy changes in design and function during this development phase. Combined with an insufficient data connection in some forest plots it presented a major technical obstacle. Secondly, the usage of “BOKU grasp” was not necessary to complete the tasks assigned by the teachers but meant an additional investment with little obvious reward immediately or later. This inspired some students to use the application in the evening when they had stable internet access, detached from the situated learning process.

These experiences lead to two consequences: Firstly, technically, the application has to be a real mobile app which does not need data connection all the time. Secondly, pedagogically, the deployment must be an essential component of the course that is necessary for its successful completion. The challenge for the teachers is to design tasks for the different learning settings already mentioned earlier. When the calculation is outsourced to the mobile device creating the possibility to have a number of iterations within a very short time combined with the authentic location, then the students can fully focus on the interpretation and understanding of the formula.

References

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