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Teaching Mathematics and Statistics Using a CAS and a Statistical Software Package – Findings from Student Surveys

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Background

- **Schmalkalden University of Applied Sciences**
  - Established in 1991
  - 5 Faculties
  - 3,000 Students

- **Faculty of Business and Economics**
  - Established in 1992
  - 4 Bachelor programs
  - 1 Master program (English)
  - 1 MBA program
  - 600 Students

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History of Matrix Algebra course (50% of M2)

- **Until 2001**
  - Lecture hall (2 groups of up to 70 students)
  - Blackboard & overhead projector; pocket calculators
- **2002**
  - In PC lab: 2 of 15 weeks
- **2003 - 2004**
  - In PC lab: every other week (4 groups ≤ 40)
- **2005 - 2011**
  - Course and exam in PC lab (3 groups ≤ 40)
- **2012 - 2014**
  - Lecture hall (2012: PC labs) (2-3 groups ≤ 70)
- **2015 - 2016**
  - Course and exam in PC lab (3-4 groups ≤ 40)

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History of Intermediate Statistics course (S2)

- **Until 2001**
  - Regular classroom (2 groups of up to 70 students)
  - Blackboard & overhead projector; pocket calculators
- **2002**
  - In PC lab: every other week (4 groups ≤ 40)
- **2003**
  - In PC lab: 12 of 26 lectures (3 groups ≤ 54)
- **Since 2004**
  - Course and exam in PC lab (3 groups ≤ 40)

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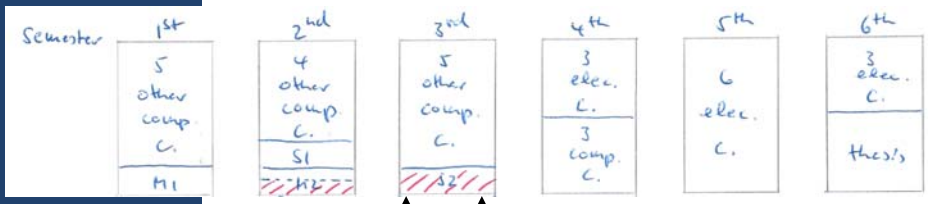
General design of Bachelor programs



2014 cohort: survey 14A (Oct 2015), survey 14B (Jan 2016)

2009 cohort: survey 09A (Oct 2010), survey 09B (Jan 2011)

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1st Questionnaire 2014 cohort (survey 14A)

1st Survey on the Use of Technology in Compulsory Mathematics and Statistics Courses at the Faculty of Business and Economics 2015/16

HOCHSCHULE SCHMALKALDEN UNIVERSITY OF APPLIED SCIENCES

Dear Students,
Last semester you attended the course "Matrix Algebra". The Computer Algebra System DERIVE was used regularly throughout the course that took place in the PC lab, which was certainly new for you. Such an approach is called "technology-supported teaching". As your experiences can help us with the future teaching at our faculty, we kindly ask you to answer the following questions.

After having worked with DERIVE for at least one semester, please give your opinion on the following 8 statements:

	definitely true			...		*definitely not true*
1. Working with DERIVE is no big problem for me.	○	○	○	○	○	○
2. DERIVE allows more vivid problem solving.	○	○	○	○	○	○
3. DERIVE helps to avoid computing errors.	○	○	○	○	○	○
4. I can work faster when using DERIVE.	○	○	○	○	○	○
5. ...	○	○	○	○	○	○
6. ...	○	○	○	○	○	○
7. ...	○	○	○	○	○	○
8. I like mathematics and statistics.	○	○	○	○	○	○

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2nd Questionnaire 2014 cohort (survey 14B)

2nd Survey on the Use of Technology in Compulsory Mathematics and Statistics Courses at the Faculty of Business and Economics 2015/16

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Dear Students,
This semester you attended the course "Computer-Assisted Statistics". The Computer Algebra System DERIVE as well as the statistical package SPSS were used regularly throughout the course that took place in the PC lab. Therefore, the course was "technology-supported" throughout.
As your experiences can help us with the future teaching at our faculty, we kindly ask you to answer the following questions.

After having worked with DERIVE for one or two semesters, please give your opinion on the following 10 statements:

	definitely true					*definitely not true*
1. Working with DERIVE is no big problem for me.	○	○	○	○	○	○
2. DERIVE allows more vivid problem solving.	○	○	○	○	○	○
3. DERIVE helps to avoid computing errors.	○	○	○	○	○	○
4. I can work faster when using DERIVE.	○	○	○	○	○	○
5. Working with SPSS is no big problem for me.	○	○	○	○	○	○
6. ...	○	○	○	○	○	○
7. ...	○	○	○	○	○	○
8. ...	○	○	○	○	○	○
9. ...	○	○	○	○	○	○
10. I like mathematics and statistics.	○	○	○	○	○	○

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1st Questionnaire: overall averages (survey 09A vs. 14A)

Stmt. No.	Statement	2009 cohort N=96	2014 cohort N=78
S1	Working with DERIVE is no big problem for me	4,5	4,4
S2	DERIVE allows more vivid problem solving	4,1	4,1
S3	DERIVE helps me to avoid computing errors	4,8	4,5
S4	I can work faster when using DERIVE	4,9	4,8
⋮			
S8	I like mathematics and statistics	3,0	3,2

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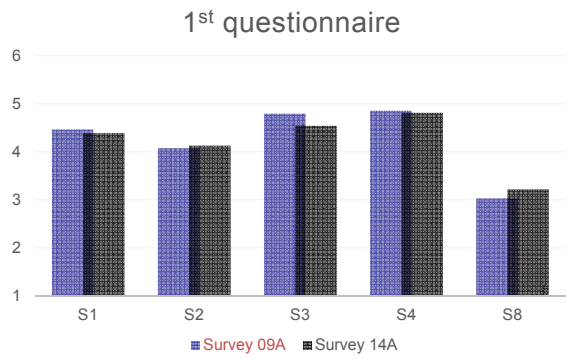
Differences between cohorts



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2nd Questionnaire: overall averages (survey 09B vs. 14B)

Stmt. No.	Statement	2009 cohort N=86	2014 cohort N=103
S1	Working with Derive is no big problem for me	4,3	4,2
S2	Derive allows more vivid problem solving	3,9	4,0
S3	Derive helps me to avoid computing errors	4,6	4,2
S4	I can work faster when using Derive	4,7	4,5
S5	Working with SPSS is no big problem for me	3,8	3,7
...			
S10	I like mathematics and statistics	3,7	3,5

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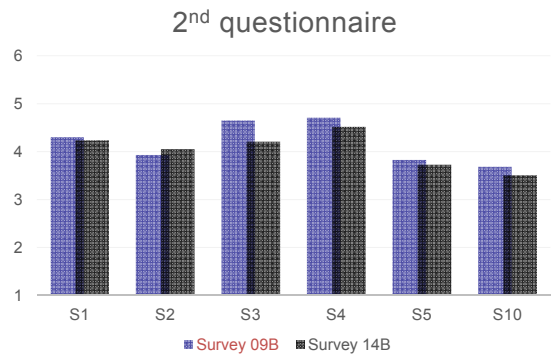
Differences between cohorts



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Frequency distribution of responses to statement S10 (survey 14B vs. 09B)

	definitely true		…			definitely not true
10. I like mathematics and statistics.	○ 6	○ 5	○ 4	○ 3	○ 2	○ 1
2014 cohort (N=101)	10	23	23	15	12	18
		Σ: 56			Σ: 45	
2009 cohort (N=85)	10	16	26	13	10	10
		Σ: 52			Σ: 33	

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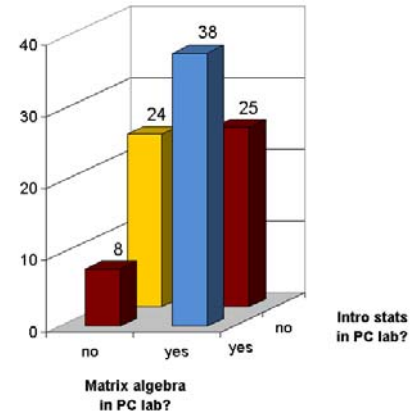
Students' attitudes towards technology (AtoT; survey 09A)



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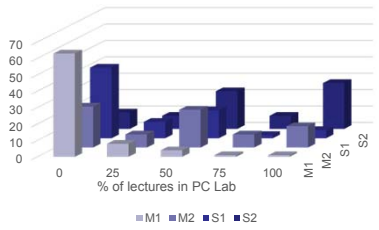
Students' attitudes towards technology (AtoT; survey 14A)

	quarters of lectures in PC Lab	% of lectures in PC Lab	V11A M1	V11B M2	V12A S1	V12B S2
only Lecture Hall	**0**	0	63	25	43	10
75% Lecture Hall	**1**	25	8	8	10	8
50% LH / 50% Lab	**2**	50	4	23	17	23
75% PC Lab	**3**	75	1	8	2	8
only PC Lab	**4**	100	1	13	5	28



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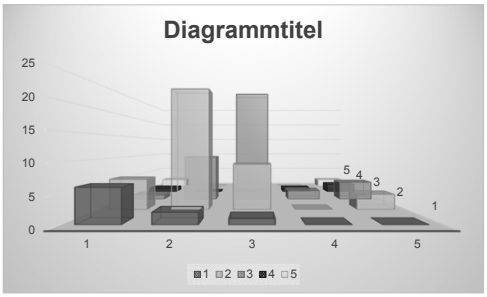
Students' attitudes towards technology (AtoT[3]; survey 14B)

AtoT[3]		grade IT II:					
		1	2	3	4	5	Total
grade IT I:	1	6	2	1	0	0	9
	2	6	24	9	0	3	42
	3	1	10	25	2	4	42
	4	1	0	0	1	2	4
	5	2	0	0	0	2	4
	Total	16	36	35	3	11	101



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Frequency distribution of categories of expected S2 results (survey 14B vs. 09B)

Please assess yourself realistically: which result do you expect in the upcoming "Statistics II" examination?

	○ 0-50%	○ 51-65%	○ 66-80%	○ 81-100%
2014 cohort (N=102)	***18***	***42***	***31***	***11***
2009 cohort (N=83)	*8*	*38*	*29*	*8*

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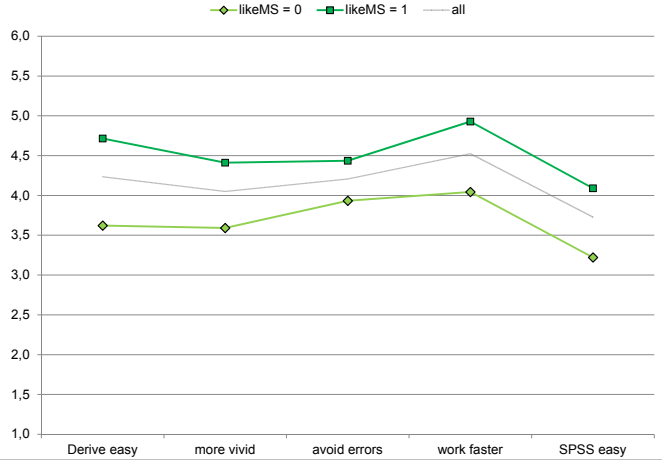
"Don't like maths & stats" vs. "Like maths & stats" students (survey 14B)



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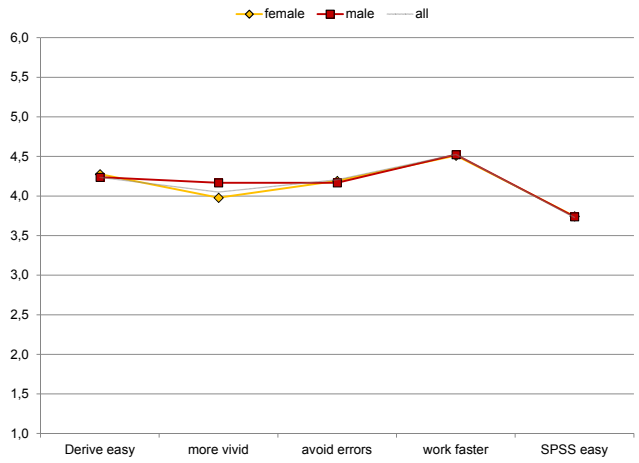
Female vs. male students (survey 14B)



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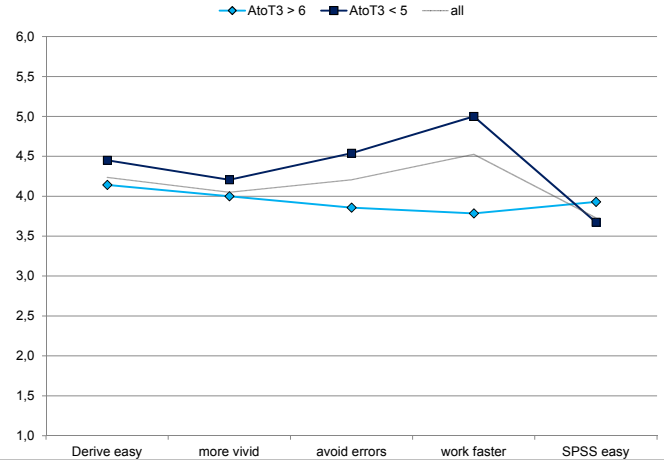
Students with below-average vs. students with above-average grades in 2 IT exams (survey 14B)



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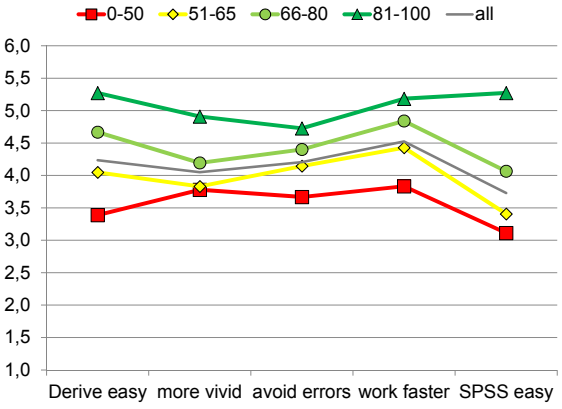
Expected performance in "Statistics II" examination (self-assessment of students; percentage of points; survey 14B)



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Hypotheses based on previous results

- The attitudes towards the use of technology in mathematics education do not significantly depend on the sex of the students
- Students who are more open to computer use in teaching **OR** perform better in IT exams, respectively, have in general more positive attitudes towards the use of technology in mathematics education
- Students who are better in mathematics and statistics have more positive attitudes towards the use of technology in mathematics education

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Regression models (survey 14A)

$$Sx = b_0 + b_1 Male + b_2 AtoT + b_3 likeMS + b_4 PercMA$$

Independent variables:

- *Male* dummy variable: 1 if male, 0 if female
- *AtoT* "Attitude towards Technology" (this is defined as the number of quarters (of all four compulsory courses in maths and stats) a student would like to sit in the PC lab instead of in a lecture hall (possible values: 0 to 16))
- *likeMS* dummy variable: 1 if "I like maths & stats" ≥ 4, 0 if "I like maths & stats" ≤ 3
- *PercMA* percentage of points in Matrix Algebra portion of "Mathematics II" exam (generated by replacing the categories of the variable with the Matrix Algebra results of the previous semester by the actual mean percentages of the 7 categories in the questionnaire)

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Linear regression results (survey 14A vs. 09A)

Oct2015 dependent variable:	R^2	const.	*Male*	*AtoT*	*likeMS*	*PercMA*
S1 no big problem working with	0,28	2,14	**0,49**	**0,13**	**0,26**	0,007
S2 more vivid problem solving	0,21	2,70	0,06	**0,17**	0,10	0,002
S3 helps to avoid computing errors	0,14	3,00	0,41	**0,12**	0,10	0,006
S4 work faster when using it	0,45	3,13	0,27	**0,15**	0,14	0,006
Oct2010 dependent variable:	R^2	const.	*Male*	*AtoT*	*likeMS*	*PercMA*
S1 no big problem working with	0,28	2,98	0,10	**0,28**	0,20	**0,011**
S2 more vivid problem solving with	0,11	3,23	-0,02	**0,38**	0,07	0,006
S3 helps to avoid computing errors	0,32	3,67	**0,47**	**0,39**	0,07	**0,009**
S4 work faster when using it	0,22	3,72	0,30	**0,46**	0,03	**0,010**

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Regression models (survey 14B)

$$Sx = b_0 + b_1 Male + b_2 AtoT + b_3 likeMS + b_4 PercS2e$$

Independent variables:

- *Male* dummy variable: 1 if male, 0 if female
- *AtoT* "Attitude towards Technology" (this is defined as the sum of the grades of the two (compulsory) IT courses (possible values: 2 to 10))
- *likeMS* dummy variable: 1 if "I like maths & stats" ≥ 4, 0 if "I like maths & stats" ≤ 3
- *PercS2e* expected percentage of points in "Statistics II" exam (generated by replacing the categories of the variable with hypothetical mean percentages of the 4 categories in the questionnaire)

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Linear regression results (survey 14B vs. 09B)

Jan2016 dependent variable:	R^2	const.	*Male*	*AtoT*	*likeMS*	*PercS2e*
S1 no big problem working with	0,38	1,05	-0,05	0,10	**0,28**	**0,028**
S2 more vivid problem solving	0,16	2,09	0,26	0,05	**0,29**	0,008
S3 helps to avoid computing errors	0,11	3,10	*-0,11*	0,09	0,14	0,017
S4 work faster when using it	0,19	3,65	*-0,03*	***-0,15***	0,14	0,018
S5 no big problem working with SPSS	0,30	*-0,89*	*-0,10*	**0,25**	0,10	**0,048**

Jan2011 dependent variable:	R^2	const.	*Male*	*AtoT*	*likeMS*	*PercS2e*
S1 no big problem working with	0,33	1,58	*-0,40*	0,44	0,02	0,035
S2 more vivid problem solving	0,29	1,69	0,32	0,45	0,10	**0,020**
S3 helps to avoid computing errors	0,22	3,60	*-0,00*	0,60	*-0,09*	0,010
S4 work faster when using it	0,21	2,97	0,49	0,57	0,05	0,010
S5 no big problem working with SPSS	0,25	1,44	*-0,02*	**0,40**	0,06	0,026