Why Good Students Fail

(And what we can do about it)

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2nd Ates Tanin Lecture, January 2010

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http://www.chem.utoronto.ca/~dstone/Research/ROP299.html

Chemical Education Survey:

- Pilot study in 2006-7
- 1st major survey in 2007-8
- 2nd major survey in 2008-9
- Mixed mode study (qualitative/quantitative)

What factors contribute to a successful high school–university transition?

What can schools and universities do to help students manage this transition?

The Survey Cohort:

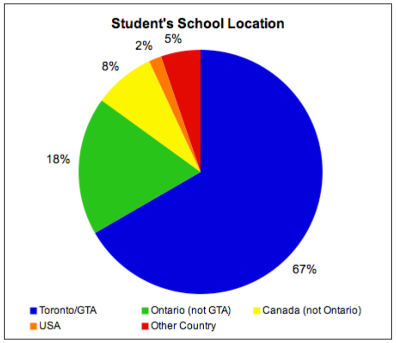
- CHM 138F (Introduction to Organic Chem.)
- CHM 139F (General Physical Chemistry)
- CHM 151Y (Advanced Introductory Chem.)

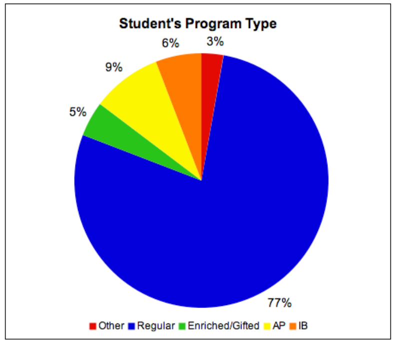
Year	Enrolment	Surveys	Response
2006-7	1830	320	17.5%
2007-8	1803	536	29.3%
2008-9	1723	414	24.0%
Total:	5356	1270	23.7%

Who Are Our Students?

Category	2006-7	2007-8	2008-9
Female:	–	60.6%	59.4%
Male:	–	39.4%	40.6%
Toronto/GTA:	–	68.9%	69.1%
Total Ontario:	86.4%	84.4%	84.5%
Regular stream:	68.1%	82.3%	78.8%
Semestered:	–	58.4%	65.1%
Native English-speaker:	–	44.8%	45.9%*
Independent Study:	56.0%	57.7%	44.9%

Aggregate Demographics:





- Over 430 different schools
- ~ 200 Toronto/GTA schools
- ~ 100 other Ontario schools

- 69% public board students
- 19% catholic board students
- 12% private school students

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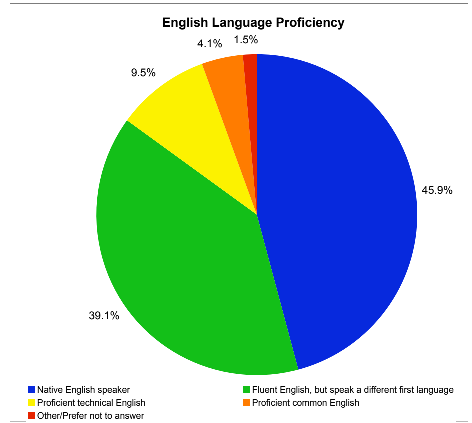
English Language Skills:



- Self-reported level
- Low ESL students may not have participated
- Several ESL tests recognized
- Some students memorize test essays

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Student Voices – University:

"tests ... were for failing the students and discouraging students to go on with their hopes and dreams"

"I feel my high school teachers prepared my very well for university, even though it was a big jump. Sometimes, change and challenge are nice and necessary for progress. Without challenge, we would all stay stagnant and there would be no scientific, political, social, or personal progress."

"I found that the university chemistry experience was too hectic. Although I spent quite a bit of time studying the material, the ... exams were almost impossible for me to complete"

"The university instructors are somewhat surprisingly good - they teach well, are interesting etc. compared to high school teachers in general."

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Educational Research (1):

"Teaching is a messy, messy business"

Peter Bloch (High school teacher)

– but educational research is messier!

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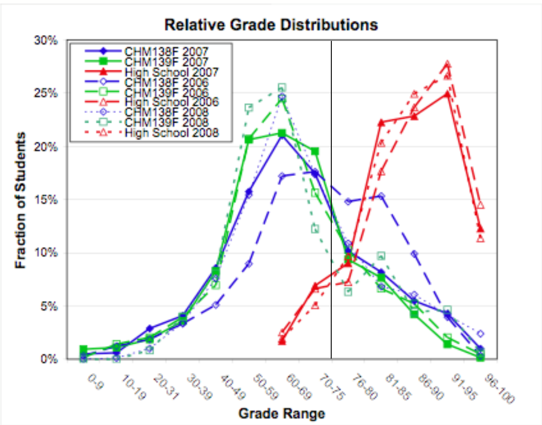
A Grade Disappointment:



High School:
- 87.3% (2006)
- 87.1% (2007)
- 87.3% (2008)

CHM 138F:
- 69.7% (2006)
- 65.0% (2007)
- 67.2% (2008)

CHM 139F:
- 63.8% (2006)
- 63.3% (2007)
- 64.6% (2008)

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Student Voices – Grades:

"Even though most of us expected that [university] is going to be challenging, I think that a lot of people believed that because they did well in high school, it automatically translate into doing well in university..."

"In high school, although I was able to achieve an adequate grade, I didn't really knew how to understand chemistry. Now in university, it is pretty much the opposite. I don't get the mark I used to get in high school but I actually understand how and why things happen"

"I am doing very poorly ..., and this is really depressing me after getting a 94% in grade12 chemistry. I find some of the concepts hard to grasp."

"Overall, I was very lucky. My teacher taught us how to learn chemistry and always discouraged memorizing concepts. As a matter of fact, I've been told that most people achieve higher marks in [university] than in his class"

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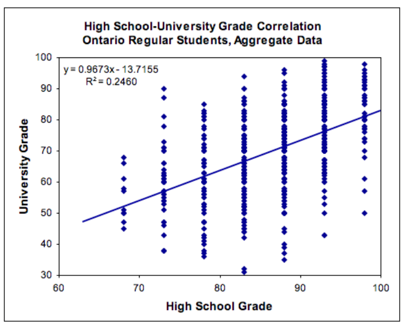
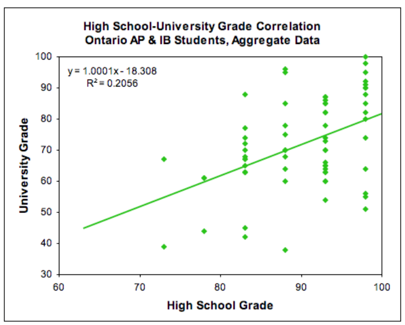
Aggregate Correlations:





- High school grades assigned as central value for each range
- Data for missing high school/university grades omitted
- Data for Ontario students who wrote 1st-year final exam only
- Regular stream n = 584; AP n = 39; IB n = 28

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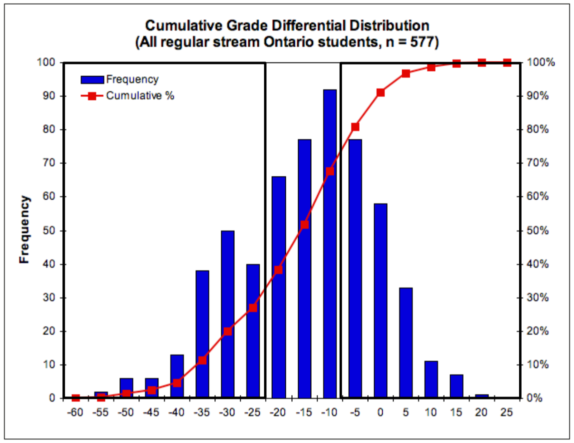
Grade Differential (Aggregate):



GD = Uni – HS

Regular:
 –16.7 ± 13.7
AP:
 –15.5 ± 12.7
IB:
 –20.3 ± 14.2
CHM138:
 –15.7 ± 13.8
CHM139:
 –18.3 ± 13.5

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Educational Research (2):

Educational research repeats itself.

Has to.

Nobody listens.

(With apologies to Steve Taylor)

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Predicting Chemistry Success:

• Everhart & Ebaugh (Denison)	1929
• Scofield (Syracuse)	1930
• Hermann (Marquette)	1931
• Steiner (Oberlin)	1932
• Clark (Muskingum)	1938
• McQuary *et al* (Wisconsin)	1952
• Hadley *et al* (Southern Illinois)	1953
• Brasted (Minnesota)	1957
• Hovey & Krohn (Toledo)	1958, 1963
• Ozsoggomonyan & Loftus (Berkeley)	1979

(and so on...)

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Top Grade Predictors:

Five-year US Study:

1. Last HS Math Grade (AP and/or calculus) – SAT Math score also highly significant
2. Last HS science grade (not specifically chemistry)
3. Time spent on stoichiometry (*recurring topic*)
4. AP instead of regular chemistry; emphasis on understanding *vs.* memorization

Tai and Sadler

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Metrics of Learning:

"There is some indication that taking high school chemistry may be used as an indicator of success in college chemistry. There are indications that a math/physics background, high placement scores, achievement tests scores, intelligence, and age may be better, or at least as good, as indicators. There is also evidence that no indicator is all that good"

W. R. Ogden, School Sc. & Math. **1976**, *76, 122-126.*

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Ontario Grading Policy:

- The 70/30 Rule
  - Final evaluation 30% of course grade
- KICA (assessment breakdown)
  - Knowledge & Understanding
  - Inquiry & Thinking
  - Communication
  - Application & Making Connections
- No late penalties
- No exam board (except IB and AP programs)

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Student Perceptions - School:

1. I expect to do well in university chemistry
2. I found high school chemistry challenging
3. Tests emphasized memorization
4. Classes emphasized memorization
5. My teacher performed effectively
6. I used the text extensively
7. I always completed homework
8. I procrastinated a lot
9. I was organized and used my time effectively

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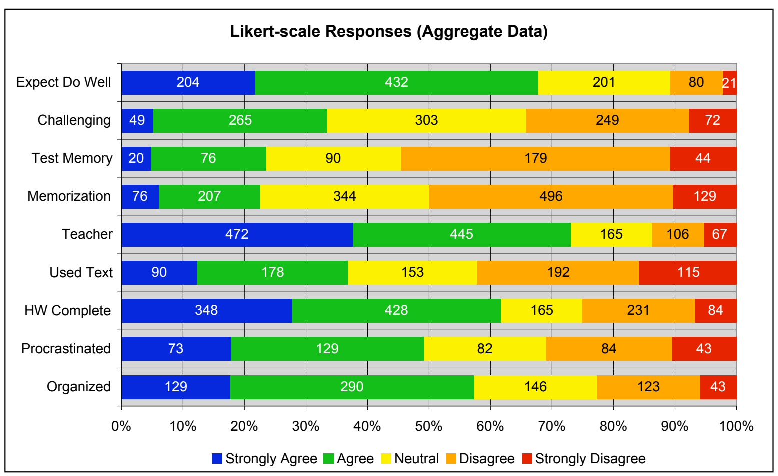
Student Perceptions - School:



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Educational Research (3):

Quantitative educational research is…

…the art of using statistics to state the obvious!

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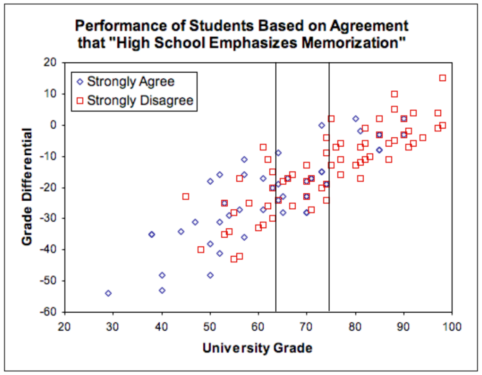
High School Memorization:



Statistical tests:

- Same mean high school grades
  $(p > 0.01)$
- Different mean university grades
  $(p < 0.0001)$
- Different mean GDs
  $(p < 0.001)$

- Students who feel that high school emphasizes memorisation tend to do worse in university

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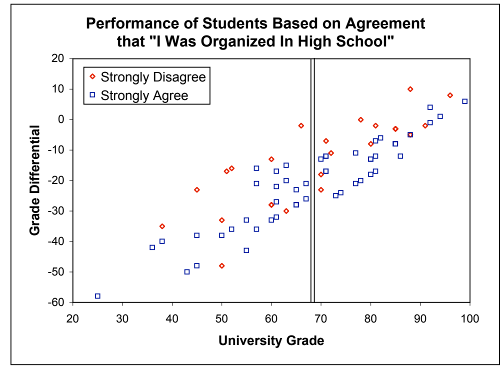
High School Organization:



Statistical tests:

- Different mean high school grades
  $(p < 0.005)$
- Same mean university grades
  $(p >> 0.01)$
- Same mean GDs (?)
  $(0.01 < p < 0.05)$

- Students who were “organized & efficient” in high school do not appear to perform better at university

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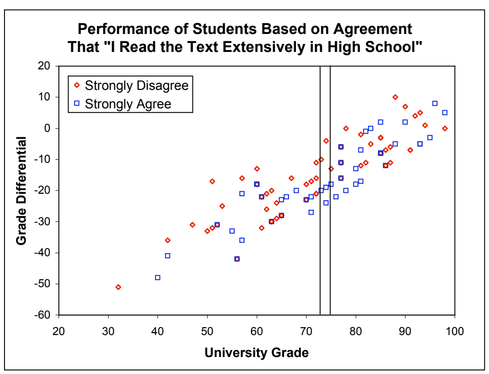
High School Text Use:



Statistical tests:

- Different mean high school grades (just!)
  $(p = 0.0099)$
- Same mean university grades
  $(p >> 0.01)$
- Same mean GDs
  $(p >> 0.01)$

- Students who used the text in high school do not appear to perform better at university

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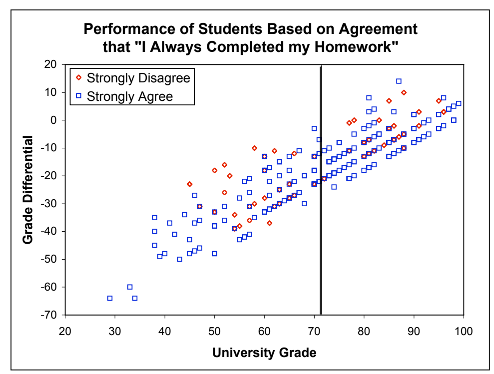
High School Homework:



Statistical tests:

- Different mean high school grades
  $(p < 0.005)$
- Same mean university grades
  $(p >> 0.01)$
- Same mean GDs
  $(p > 0.05)$

- Students who completed high school homework do not appear to perform better at university

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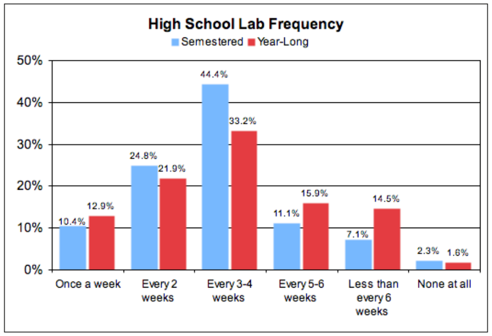
High School Labs:



Aggregate data, 2007-8 and 2008-9
Semestered n = 577, Year-long n = 365

- Quality of labs highly variable
- Funding depends on school/board priorities
- No technical help!
- Highly restricted list of "allowed" chemicals

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Ontario Science Curriculum:

Effective Fall 2009 (academic/university prep.):

- Grade 9:
  - biology, chemistry, earth & space science, physics
- Grade 10:
  - biology, chemistry, earth & space science, physics
- Grade 11:
  - periodicity, bonding, reactions, stoichiometry, solutions & solubility, gases & gas laws
- Grade 12:
  - organic, structure & properties, energy (enthalpy) & rates, chemical equilibrium, electrochemistry

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Topical Content:

- Forces & Bonding (VSEPR, van der Waal's, *etc.*)
- Electrochemistry (redox, galvanic & voltaic cells)
- Organic Chemistry (reactions, products)
- Organic Chemistry (naming, groups, structure)
- Thermodynamics & Kinetics (energy, Hess' Law, *etc.*)
- Gases (properties, gas laws)
- Equilibria (reactions, acid/base, solubility)
- Stoichiometry (chemical reactions & equations)
- Atoms & periodic table (electron config., periodicity, *etc.*)

Ontario Curriculum: Grade 11 and Grade 12 (2000-8)

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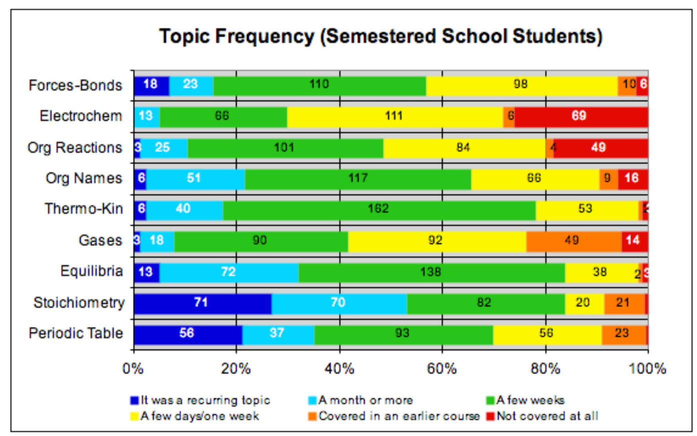
Topical Content - Semestered



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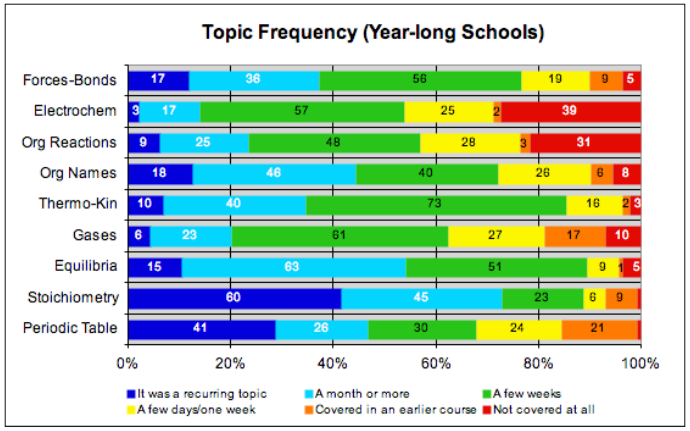
Topical Content - Year-long



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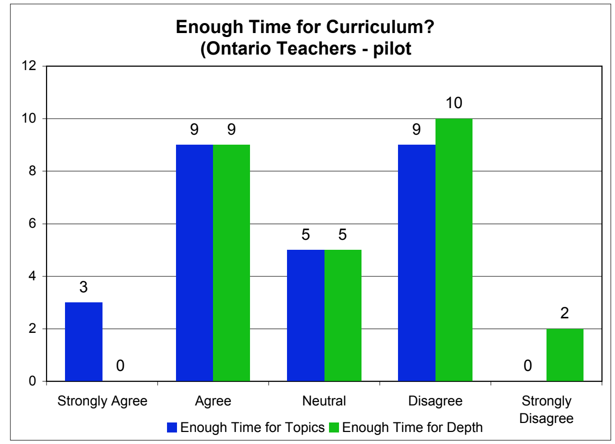
Teacher Survey - Time:



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Useful Diagnostics:

"At least some [students] erroneously consider the college course to be merely a repetition of the matter presented in high school. This type of student depends entirely upon acquired knowledge and drifts along nonchalantly until the mid-semester period, when he is suddenly jolted into the realization that he has been idling away his time and that the theoretical discussions have reached a point where they have transcended his intelligence."

George A. Herrmann, J. Chem. Ed. **1931** *8(7) 1376-1385*

"The most accurate predictive measure of degree results is generally first-year grades, but the highest proportion of failure occurs during the first year. Similarly, the best predictors of failure in the end of year assessments ... are assessments carried out earlier that year."

Tait & Entwistle, Higher Ed. **1996** *31(1) 97-116*

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Diagnostics - Content:

"The decline in A and B grades has been accompanied by a marked increase in F and dropped grades."

Nelson Hovey & Albertine Krohn, JCE 1958 (35) 507-509

- **Toledo Placement Exam**
  - ACS Examinations Institute

Hovey & Krohn, Niedzielski & Walmsley

- **California Chemistry Diagnostic Test**
  - ACS Examinations Institute

Arlene Russell, JCE 1994 (71) 314-317

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Diagnostics - Content:

Canadian equivalents?

- **CIC Chemistry Exam (Part A)**
  - based on Pan-Canadian Protocol, Grade 12
- **Chemistry Pre-test**
  - U of Toronto, U of Guelph
    - **Dr. Lori Jones, Chemical Education Colloquium, Department of Chemistry, Friday March 12th.**

Response to Diagnostics:

- Streaming into separate courses
- Transfer to "pre-course"
  - learning skills in subject context
- Streaming into lab/tutorial sections
  - extra help/support
- Supplemental instruction
  - student workload issues

Learning How To Learn:

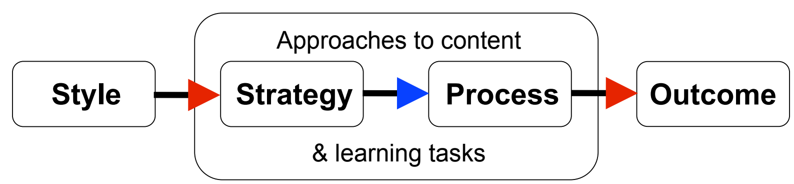
"There are differences [in how] concepts are represented in the classroom ... approaches to instruction and [...] assessment, all of which require students to "change gear" as they move from school to college. The problem for students is that there is nobody to help them make this transition; there is no manual for coping with learning in college."

Schollen et al, College Mathematics Project Final Report 2008

"I think the difficulty of university chemistry is overrated. [...] As I have learned how to learn already, for me, university has simply meant a more diligent approach..."

Psychology of Learning:

- Information input & processing – VARK
  - http://www.vark-learn.com/english/index.asp
- Approach to learning and learning tasks:



(After Entwistle, Marton, Pask, Biggs, etc.)

Learning Styles & Strategies:

Orientation & intention	Motivation/ personality	Style	Process: Stage I	Process: Stage II	Outcome
Understanding (Deep)	Intrinsic (Autonomous, syllabus-free)	Deep approach / versatile	**All four processes below used appropriately**		**Deep level of understanding**
		Comprehension learning	Building overall description of content area	Reorganizing & relating data, personal meaning	**Incomplete understanding (*globetrotting*)**
Reproducing (Surface)	Extrinsic, fear of failure (Anxious, syllabus-bound)	Operation learning	Attention to evidence & logic of argument	Relating evidence, objective stance	**Incomplete understanding (*improvidence*)**
		Surface approach	**Memorization**	**Over-learning**	**Surface level understanding**
Achieving high grades (Strategic)	Hope for success (Stable, self-confident)	Organized / achievement orientated	Any combination of six above processes considered appropriate to *perceived* requirements of task and criteria of assessment		**High grades with or without understanding**

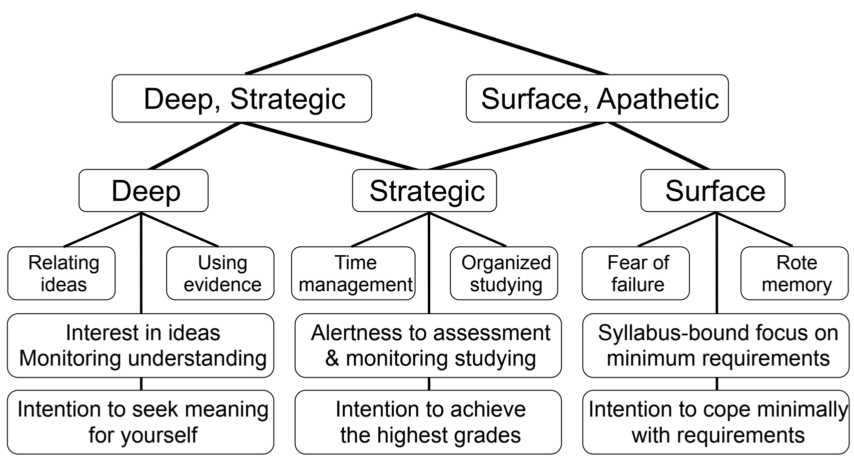
Diagnostics - Style/Skills:

Approaches & Study Skills Inventory for Students (ASSIST)

Deep	Surface
Strategic	Apathetic

- *I manage to find conditions for studying which allow me to get on with my work easily*
- *When working on an assignment, I'm keeping in mind how best to impress the marker*
- *I usually set out to understand for myself the meaning of what we have to learn*
- *I find I have to concentrate on just memorising a good deal of what I have to learn*

ASSIST Concept Map:



Pitfalls – Teaching:

- Teaching approach
  - Transmission learning *vs.* student-focussed
  - Content-driven delivery (external forces)
  - Dependence on TAs ⇒ effective training
  - Pratt's Five Teaching Perspectives (TPI)

"*... we have found no research reporting on the outcomes for teachers from their approaches to teaching.*"

Trigwell et al, Higher Ed. 1999, 37, 57-70

Student Voices – Evaluation:

"My biology teacher … took a university exam and structured his questions on those questions"

"I think the multiple choice was something that I was really worried about."

"In high school, the [tests] were more memorizational and less conceptually based (i.e. one could get an A without knowing chemistry"

"They [university] test your ability to take tests"

"Questions on high school tests involving higher thinking are rare."

"In AP they gave us more application questions and its basically what they are giving us now."

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Pitfalls – Evaluation:

- Style of assessment
  - 'Transformational' (deep) *vs.* 'reproducing' (surface) for essay *vs.* multiple-choice

    Thomas & Bain, Human Learn. 1984, 3, 227-240
  - Instructor intention *vs.* actual questions
  - Problems *vs.* exercises
  - Nature of assigned *vs.* assessment questions
    - Use categorization scheme *e.g.* Bloom's taxonomy

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Student Voices – Pace:

"[The pace at university] is quite a lot faster, and it requires a lot of motivation on your part and independent learning"

"There's always pressure being put on you"

"I found that my time management skills were the only thing that was keeping me alive."

"There's four other mid-terms [in other courses] between the first and second midterm and like I didn't even go to any chemistry lectures and by the second mid-term two days before that…"

"I think it would have been better if, like, at the end of high school , they cranked it up a bit"

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Pitfalls – Workload:

- Perceived workload

  "Students could work long hours and still obtain poor grades because they used inappropriate learning approaches"

  Kember et al, Studies Higher Ed. 1996, 21, 347
  - Average cap of 50 hours/week for *all* tasks
  - Increasing class time decreases studying
  - Surface approach related to lower English proficiency:

    "A surface strategy of memorising key words or phrases is consistent [with those] who operate at the word or sentence level"

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Pitfalls – Intervention:

- Misplaced intervention

"The overall consequence of allowing the interventions to develop their own character ... was that most of them focussed on skills which were considered important by the students for successful learning in each course."

Ramsden et al, Human learn. 1986, 5, 151-164

- Difficulty of implementation

"Study skills advice and training has been criticised as being ineffective, largely because it is so often offered as an adjunct to a course and students have difficulty in transferring the advice they read into their own context"

Tait & Entwistle, Higher Ed. 1996, 31, 97-116

The ROP299 Teams:

2006-7:
- Robin Baj
- Michael Lebenbaum
- Sujan Saundarakumaran
- Derrick Tam
- Jakub Vodsedalek

2007-8:
- Mena Gewarges
- Cindy Hu
- Gordon Ng
- Jana Pfefferle
- Curtis Wang

2008-9:
- Marlena Colasanto
- Lauren Cosolo
- Darrin Gao
- Inna Genkin
- Kelly Hoang
- Justina Lee
- Bryan Nguyen
- Emily Plobner

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http://www.chem.utoronto.ca/~dstone/Research/ROP299.html