Leveraging online courses to increase student success in a Computer Science degree

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- Addressing the problem of underprepared students in CS1
- Look at secondary school and undergraduate skills/outcomes requirements
- Overview of online courses
- Propose online courses to help students to become more prepared for CS1

Typical content of a secondary school CS curriculum:

- using basic software
- searching for information on the internet
- programming
- learning to solve complex problems

Peter Hubwieser, 2012
Computer Science Education in Secondary Schools - The Introduction of a New Compulsory Subject
ACM Transactions on Computing Education

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- using basic software; and
- searching for information on the internet

... can be seen as softer ICT related content.

- programming; and
- learning to solve complex problems

... are seen as more difficult and relate to CS content.

Two secondary school curriculum specifications:

- Computing At School School (CAS) curriculum from the UK
- K-12 Computer Science Standards (CSTA K-12) which is developed by CSTA and ACM in the USA

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CAS

CAS sees CS as a STEM discipline, characterised by:

- S - following a scientific approach
- T - understanding, appreciating and applying many technologies to a problem
- E - following a process for the construction of artifacts in the discipline, specifically the design-construct-test cycle
- M - a mathematical foundation

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CAS cont.

CAS skills outcome - *computational thinking*

Some clarification is required....

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CAS cont.

The learner needs to be able to *recognise* computational aspects in the world, *apply* tools and techniques to the recognised systems, and then *understand* and *reason* about these system. In order to do this, the learner must be able to *abstract*, both by *decomposition* and *generalization*, and *model* the systems. This forms part of the design of the system, which then needs to be constructed by programming it before it is tested. Understanding the construction of the system will require fundamental programming, algorithm and data manipulation skills. CAS also requires that learners have a basic understanding of computer architecture as well as the internet.

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CSTA K-12

Characterises a curriculum using strands, these strands define the outcomes of the curriculum.

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CSTA K-12

These strands are:

- *computational thinking*;
- *collaboration*;
- *computing practice and programming*;
- *computers and communication devices*; and
- *community, global and ethical impacts*

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Secondary school CS outcomes

After successful completion of a secondary school curriculum in Computer Science, a learner should:

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Secondary school CS outcome S1

S1 have a thorough understanding of theoretical fundamentals of Computer Science which includes algorithms, communication channels such as the internet, data manipulation;

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Secondary school CS outcome S2

S2 be able to recognise computational problems and then analyse, model, develop and test a computational solution for the problem;

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Secondary school CS outcome S3

S3 be able to work with other learners in order to solve a problem; and

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Secondary school CS outcome S4

S4 understand the implications of computers on society.

Skill-set required in an undergraduate curriculum as specified in the ACM/IEEE proposed CS2013 Strawman curriculum.

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Undergraduate CS outcomes

After successful completion of an undergraduate degree programme, a student should have:

Undergraduate CS outcomes G1/2

G1 an in-depth knowledge of topics in Computer Science;

G2 the ability to apply Computer Science in a project environment;

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Undergraduate CS outcome G3/4

G3 the ability to solve problems on multiple levels of abstraction;

G4 organisational and communication skills;

Undergraduate CS outcome G5/6

G5 an understanding that Computer Science is a dynamic discipline and be able to change; and

G6 the ability to interact with other domains.

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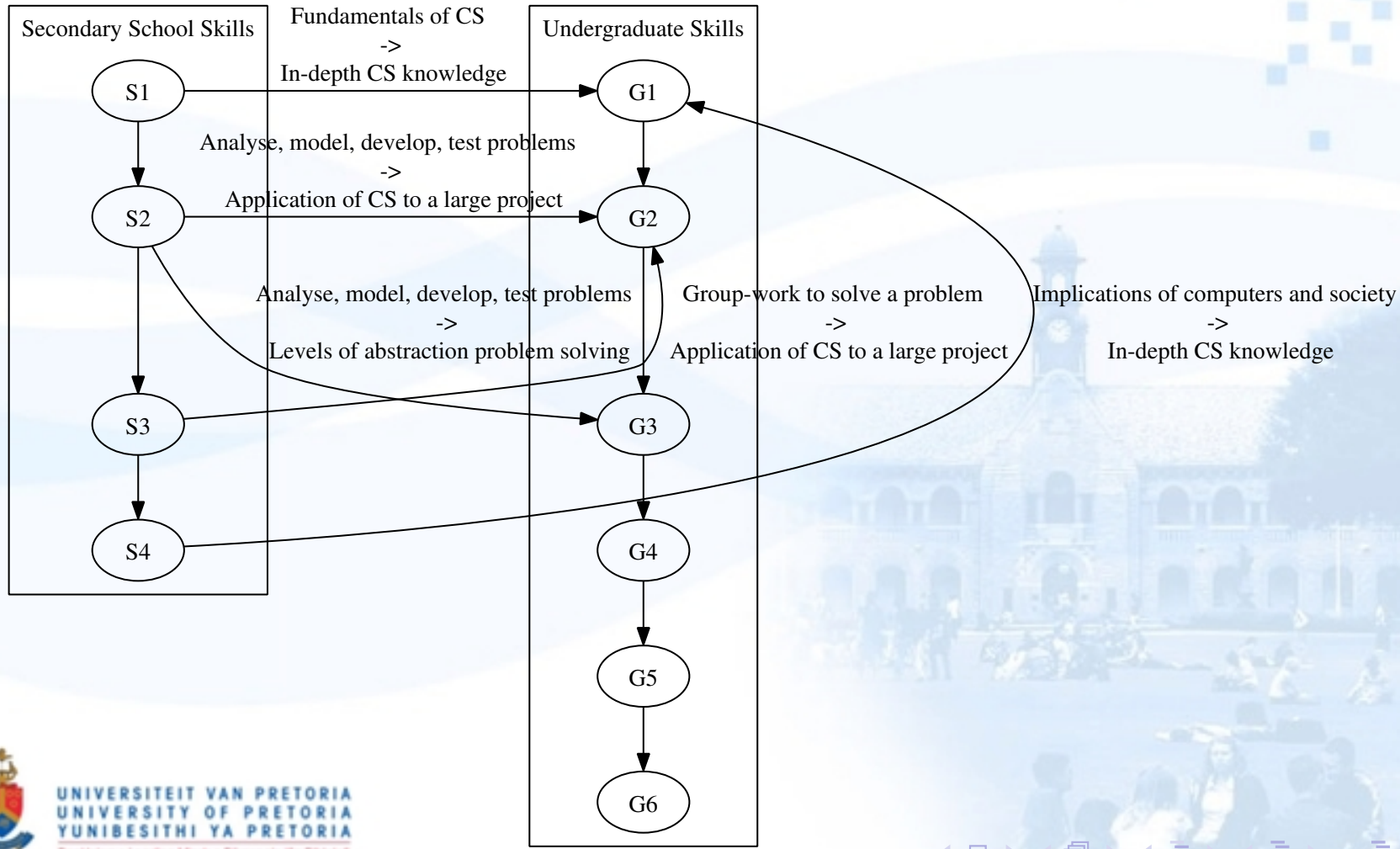
Secondary School Skills
Undergraduate Skills
S1
S2
S3
S4
G1
G2
G3
G4
G5
G6
Fundamentals of CS
->
In-depth CS knowledge
Analyse, model, develop, test problems
->
Application of CS to a large project
Analyse, model, develop, test problems
->
Levels of abstraction problem solving
Group-work to solve a problem
->
Application of CS to a large project
Implications of computers and society
->
In-depth CS knowledge

University admission control mechanisms include:

- using the results of the secondary school to gauge ability and specify relevant admission criteria
- requiring students to write a standard admissions/placement/credit test
- conducting interviews

There is evidence that prior learning has a marked effect on pass rates in first year CS. A study by Morrison and Newman [2001] showed that:

- 66% of first year students with prior learning pass CS 1 with at least a C-grade
- only 50% without prior learning pass CS1 with a C-grade.

Criteria	Coursera	edX	Udacity
Launched	April 2012	April 2012	February 2012
Founding Partners	Andrew Ng and Daphne Koller, two CS professors from Stanford	MIT and Harvard	Sebastian Thrun, David Stavens and Mike Sokolsky, originally all from Stanford
Categories CS related	20 4	unknown	3 3
Courses CS related	213 71	15 6	15 (19) 10 (14)
Time release/Self study	both	time	self
Certificate of Completion	Not for selfstudy	yes	yes
Partners	33	6	No official university partners
URL	`https://www.coursera.org/`	`https://www.edx.org/`	`http://www.udacity.com/`

For each course, the following information was captured from the course websites:

- a unique number was assigned, C*n* for Coursera, E*n* for Edx and U*n* for Udacity
- the course title and/or code
- the affiliated institution
- the prerequisites
- the outcomes

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For each course, the following information was determined:

- secondary school skill-set being addressed
- pedagogical setting rating
- whether the course provided a certificate of competence/attendance
- whether the course is self-study or presented in a specific time-frame

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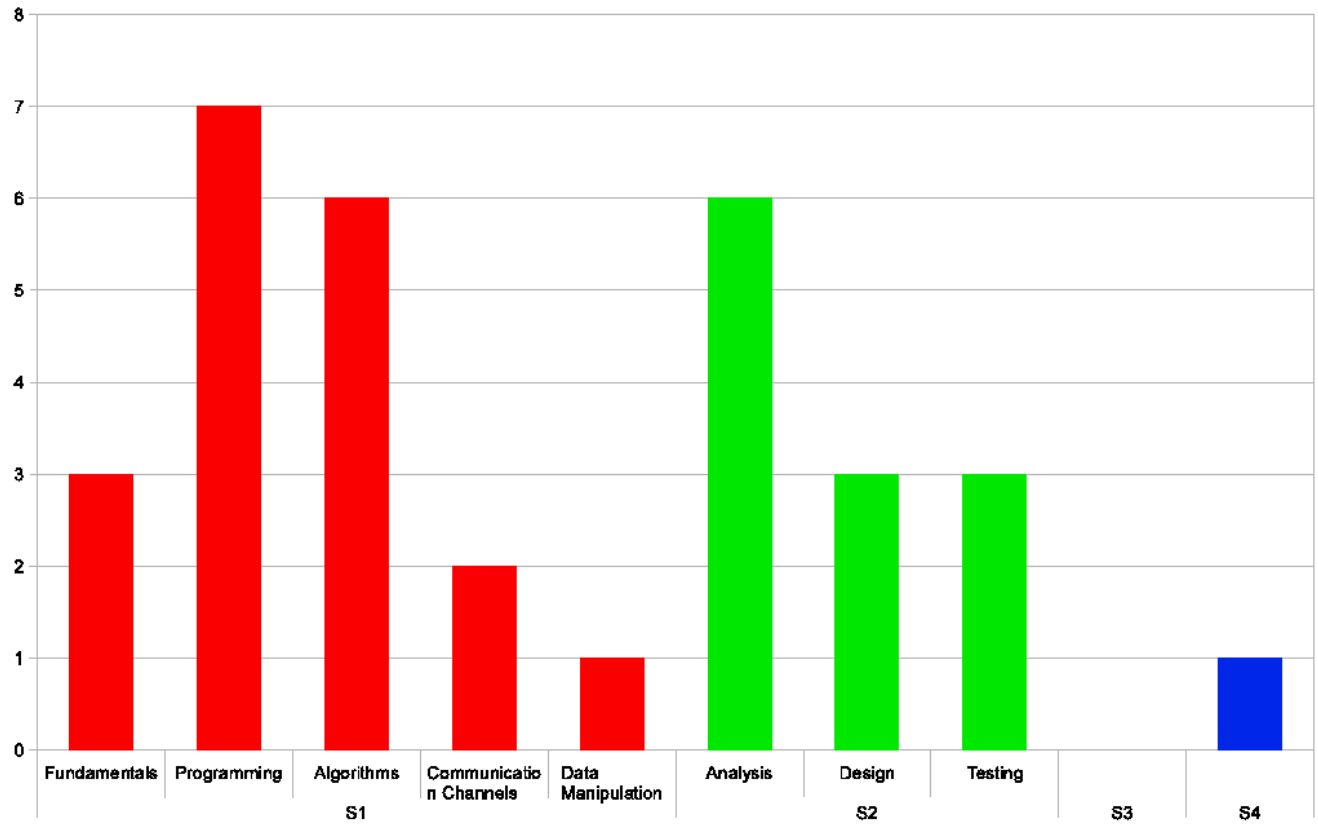
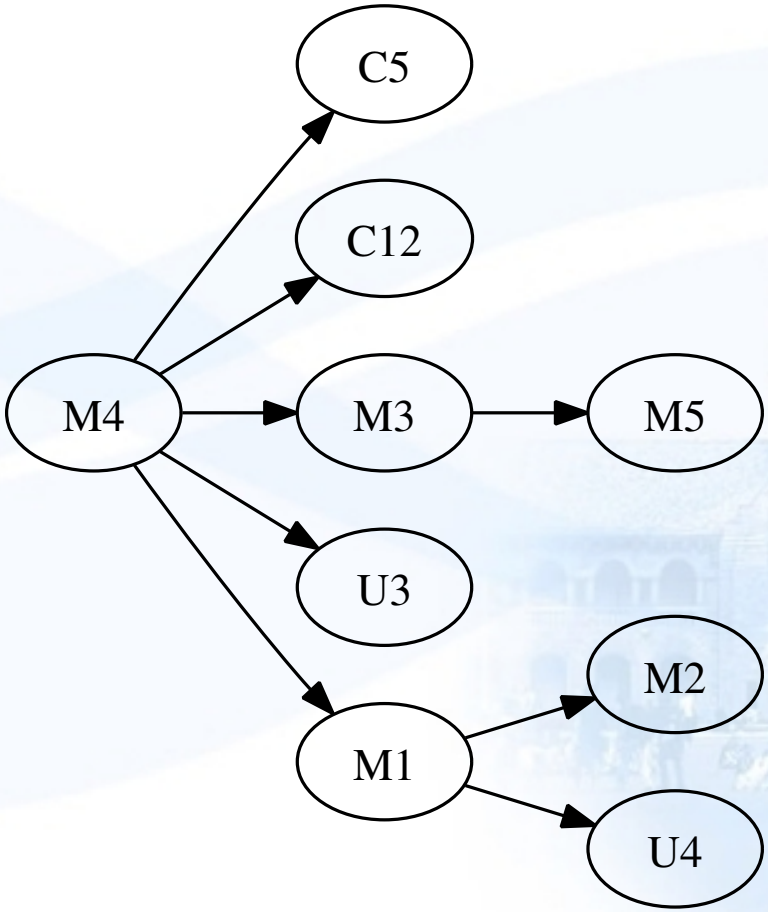


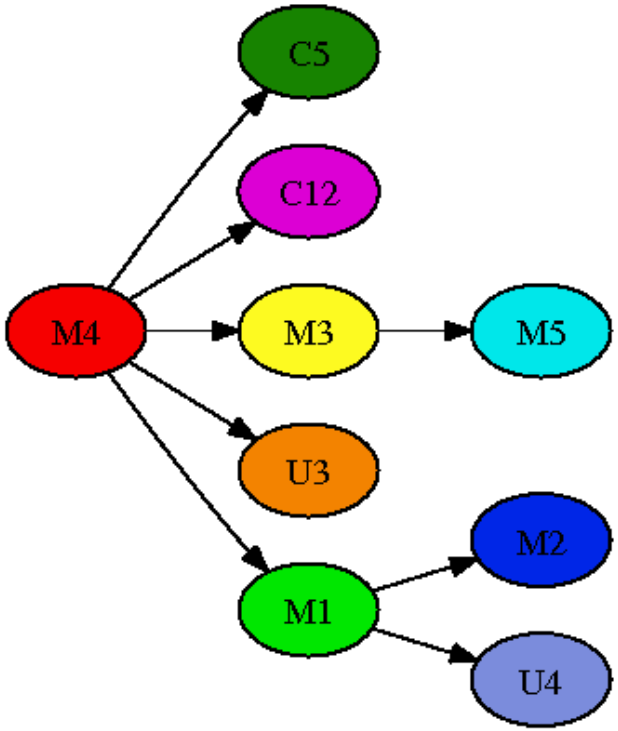
Secondary school skills distribution

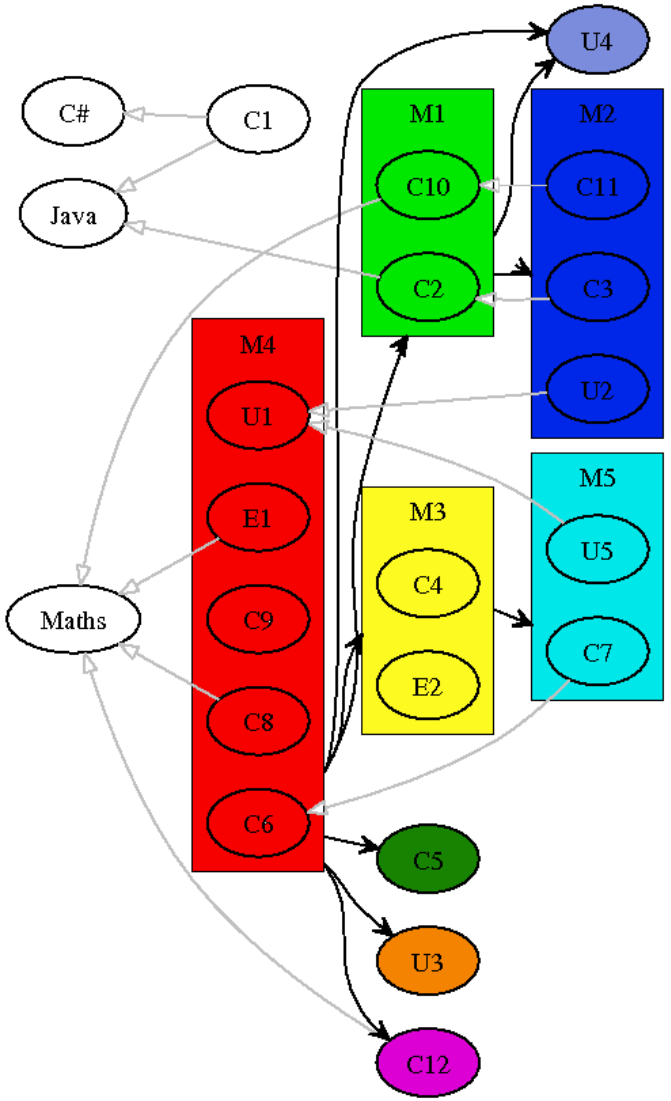
Pedagogical setting for a good online course:

- takes different learning styles into account (Visual, Auditory, Kinesthetic)
- encourages contact between instructor and students as well as between students
- facilitates active learning
- gives feedback and encourage according to expectations
- schedules activities
- fosters a strong sense of belonging online as online learning can be very lonely

	Equivalent courses	Skills	Comments
M1	C2(5) and C10(4)	S1 - Algorithms	Foundation in programming required. C2 requires Java.
M2	C3(5), C11(4) and U2(5)	S1 - Algorithms	Advanced Algorithms and data structures. C3 follows on from C2 in Java. C11 follows on from C10.
M3	C4(7), E1(4) and E2(3)	S2 - Analysis and Design	E2 includes basic programming, while C4 and E1 do not
M4	C6(4), C8(5), C9(3), E1(4) and U1(5)	S1 - Programming	Beginner programming, C8 and E1 are more Mathematical
M5	C7(5) and U5(5)	S2 - Testing	Both require a programming foundation


C5
C12
M4
M3
M5
U3
M2
M1
U4





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- Online introductory courses focus mainly on programming and algorithms
- Limited coverage of secondary school skills still have a positive contribution to undergraduate skills
- Self-study vs teacher guided study, influenced by learner maturity
- Following a curriculum of online courses will have a positive influence on first year undergraduate throughput
- With no guarantee of course delivery, the proposed online course curriculum needs to be reviewed annually
- Universities need to develop their own admissions tests if they wish to use them and do their own analysis of the results
- Maturity in online courses required, particularly with regards to the pedagogical setting