

## Proposal for second-year SENG-stream reorganisation

→ Affected courses:

COMP 2111	System modelling and design,
COMP 6721	(In)-formal methods,
SENG 2011	Workshop on reasoning about programs,
COMP 1511 <sup>1</sup>	Programming fundamentals.

→ Distribution so far:

This draft has been seen by Johannes (whose course would move to T3) and Albert (whose course would move to T2). Johannes said (effectively) “fine”; Albert was positive, and offered some suggestions to be carried out during the process. Christine has received it, but has not commented.

**Christine** is “overseer” of COMP 2111 and has a grasp of the overall Theoretical group of courses generally;

**Johannes** is current (and future?) lecturer of COMP 2111;

**Albert** is current (and continuing) lecturer of SENG 2011;

**Carroll** is current (and continuing) lecturer of COMP 6721 and, with Fethi, originator of these plans;

**Fethi** is in charge of the SENG stream.

**Aaron** has a copy (previous draft) and is supportive generally, and in particular of the idea of “upping” the tutorial allocation for COMP 6721 this year temporarily so that we can “train up” people to be able to do this kind of teaching (i.e. not just Carroll and Albert). He might not have time however to read it thoroughly, so we are not assuming that he is on top of the details.

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<sup>1</sup>Affected only incidentally.

→ Aim of this document:

To make a proposal for second-year re-arrangements (described below) in time for this month's (April) Teaching-Committee meeting.

→ Contents:

- 1 Summary of proposed changes, initially
- 2 Rationale for proposed changes
- 3 Overall workload
- 4 Overall summary, and long-term aims

## 1 Summary of proposed changes, initially

The initial changes would be almost exclusively achieved just by re-ordering some courses in Second Year, with some small “syllabus invisible” swapping of material between them. That’s all.

COMP 1511 would be very little affected.

### 1.1 Changes to COMP 2111

#### System modelling and design

This is essentially a “theory” course that has two aims: to explain why formal approaches to computer science are sound and effective, and to provide material that will be needed later (in Year 3 and beyond) for those who will specialise in Theory and machine-assisted proof.

**Change to schedule** Move COMP 2111 from Term 1 → Term 3.

**Change to content** There would be little change to COMP 2111’s content. Its present role in introducing the topics needed later would continue so that it would remain almost as it is now.

It would acquire however the additional focus of supplying the “inner workings” of material delivered earlier (in the proposed new ordering)<sup>2</sup> in

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<sup>2</sup>At the moment COMP 6721 and SENG 2011 are delivered only *after* COMP 2111.

COMP 6721 (to be in T1) and SENG 2011 (to be in T2). It does this already — but (sub-optimally) it explains the theoretical foundations of the other two “practical courses” *before* the practices those two courses advocate have themselves been taught.

## 1.2 Changes to COMP 6721

### (In-)Formal methods

**Change to schedule** Move COMP 6721 to Term 1 ← Term 2.

**Change to content** COMP 6721’s content would be expanded with simpler, more elementary material, so that it can reach a larger number of students. Its present purpose is to introduce programming practices *based on* Formal Methods, but not Formal Methods itself.

At present its enrolment (six times offered, a seventh this T2) has varied between  $\sim 10$ – $\sim 40$ , and its students have mostly (but not all of them) been “high achievers”. To cater for the whole of the SENG stream (say) it would have to be expanded to  $\sim 150$  students. In preparation for that a text book has been written, to be used for COMP 6721 itself for the first time in 2021T2 (i.e. this year, next term); the book has already been introduced as background material for COMP 2111 in 2021T1 (i.e. right now), and it also is being used in a similar (small) course at Macquarie University. ANU are considering using it for a similar course after their (currently underway) reorganisation of their theory courses. ETH Zürich teaches this course, but not (yet, I think) using the textbook.

It would acquire the additional focus of supplying the rationale for the “What’s true here?” -style of commenting that would have been used to some extent in COMP 1511, mainly with no more justification than “This is good commenting style.” That is, the ideas would have been introduced to the first years “by stealth”. (That was planned for 2020, but derailed by COVID.)

## 1.3 Changes to SENG 2011

### Workshop on reasoning about programs

**Change to schedule** Move SENG 2011 to Term 2 ← Term 3.

**Change to content** SENG 2011’s content would be re-targeted slightly to include in its already-extensive use of Dafny (an automatic program verifier) some of the programs that were verified/developed by hand in COMP 6721, in other words *solving* a problem that we have introduced into the students’ lives (intricate calculations with Hoare logic, carried out by hand). Beyond that, it would not change. Note that (as far as I know) SENG 2011 does not explain *how* Dafny does its magic (SMT solver); that would be done (for the higher-achieving students who care) in COMP 2111 in (i.e. to be moved to) Term 3, which it partly does already.

## 1.4 Changes to COMP 1511

### Programming fundamentals

**Change to schedule** None

**Change to content** Almost none. The commenting style in its exercises and examples would be reworked<sup>3</sup> to become more the “What’s true here?”-style of comment, which in itself leads to better program documentation and construction. *Why* and *how* it does that is explained in COMP 6721 at the beginning of second year, but to a smaller cohort: COMP 6721 is not compulsory, whereas COMP 1511 is.

## 1.N Changes summarised

Only COMP 6721 would change substantially in content, but even so simply expanding with simpler material and using its new textbook. The other courses COMP 2111, SENG 2011 and COMP 1511 would change hardly at all. They would simply be given in a different order: the order would become



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<sup>3</sup>This reworking of exercises’ and examples’ comments has *already* been done, over the summer of 2019/20 in preparation for COMP 1511 teaching in 2020. However the pandemic in 2020 and the increase workload that resulted –preparing remote lectures, just surviving under the new conditions– prevented its being put into action.

<sup>4</sup>(The order is currently COMP 2111→COMP 6721→SENG 2011.)

There would be some minor swapping back and forth of extant material between the three second-year courses.

## 2 Rationale for proposed changes

The effect of having the four courses COMP 1511 (first year, taught all three terms), COMP 6721, SENG 2011 and COMP 2111 (second year, in successive terms) in that order would be that each of them would introduce *earlier* a technique *in practice* that would lead to better program construction for reasons explained, amplified and theoretically justified (that last for those inclined to theory) in a *later* course.

The earlier-to-later strategy (first practical and, only then, reasons for and theory of) is terribly important pædagogically; not doing that in the past is one of the reasons assertion-based reasoning (even for first years) has never taken hold as it should have.

The courses are given below in their proposed “new” order (unchanged of course for COMP 1511):

**COMP 1511 (y1)** The “recommended commenting style” (Year 1) would give explicit guidance in *how* to comment, but the *reasons* for its effectiveness of that commenting style would be explained in COMP 6721 at the beginning of Year 2 (Term 1), mainly for SENG students but not restricted to them. However even those students who *do* take COMP 1511 (compulsory) but do *not* take COMP 6721 would still benefit from the “commenting style” suggestions they will have seen as a result of the above suggestions.

The cost to the teaching staff for COMP 1511 would be minimal; all the COMP 1511 students would benefit, wherever their course-path led subsequently.

**COMP 6721 (y2t1)** The use of assertions as comments etc. that is a current feature of COMP 6721 would no longer be novel: everyone would have seen it, and *already* be used to it, from COMP 1511. Most students would be delighted to discover how much more they can do with that style than they realised in Year 1.

**SENG 2011 (y2t2)** The use of the automatic program-prover Dafny will no longer be a novelty (as it is now), because Dafny is used towards the

end of COMP 6721 already (its third assignment) and the thing that Dafny automates (Hoare Logic) will *also* be thoroughly familiar to the incoming students. The students will however probably be weary of doing the program-proving by hand, even though it's informal, and the benefit of writing their assertions in a more rigorous form (i.e. using logic) will be *justified* (rather than being merely a notational nuisance, i.e. simply another way to generate syntax errors) because they will see and understand that it is necessary to do that if you are to take advantage of a program-assistant automatic tool.

COMP 2111 (**y2t3**) The more theoretically inclined students will by now be wondering how all this stuff is implemented, and how we know it is sound, i.e. that it actually works. COMP 2111 will tell them that: in fact, it already does. But at the moment (in Term 1) tells them “too soon”, i.e. it answers questions that they have not yet asked.

## 2.N Rationale summarised

Introduce techniques in a *practical* way so that by the time the students are taught *why* it should be “done this way” they *already* know what “this way” is, and have at least a term's experience of using it.

## 3 Overall workload

Carroll will have to expand COMP 6721 between now and when these changes take effect; that's planned for T3 (when he is not teaching). But the textbook has *already* been written. The other three courses would not have to change much at all.

We do need however to increase the number of people who can teach this way, so that (for COMP 6721 at least) it does not depend on a single person.

A proposed route for this is to train these people by allowing them to tutor COMP 6721. Such people exist already at CSE, as graduates of earlier deliveries of COMP 6721 — *and you know who they are*. They are still here; but of course they have their own workloads already. Once “trained up” they could not only take over lecturing of COMP 6721, but also (continue to) tutor COMP 1511 with now a background understanding of “Why comments should be this way.”

## 4 Overall summary

**Stage 1** Existing courses are re-ordered in Year 2, and COMP 6721 is expanded with more elementary material. The other courses are largely unchanged.

**Stage 2** After Stage 1 has settled down (perhaps even in its first year 2022), there will be structural changes (perhaps as early as 2023):

- The T1 course –call it ASSERTIONAL PROGRAMMING– will become part of the SENG stream, and thus compulsory for SENG students.
- The T2 course –call it MACHINE-ASSISTED REASONING ABOUT PROGRAMS– will remain part of the SENG stream.
- The T3 course –call it BASIC THEORY OF PROGRAM AND SYSTEM DEVELOPMENT– will remain a course for those who are either curious about why “ASSERTIONAL PROGRAMMING” and “MACHINE-ASSISTED REASONING ABOUT PROGRAMS” actually work, or who intend to specialise in theory — or both.
- The solid and rational core above will be used to “anchor” existing courses in the SENG stream –many in Year 3– that are now somewhat adrift.

**Caveat** We don’t know how long the administrative aspect of doing this would take. It might possibly not be able to occur until say 2023 (in which case we would continue for one more year as now, but with COMP 6721 expanded to say ~60 students.) It seems to depend on whether the proposed changes are seen as “adjustments of content” (better) or “structural” (not as good).

In the long run, COMP 6721 might become a SENG course (as suggested above, in Stage 2), thus compulsory for them, and the entry point to the second-year SENG stream. That *would* be a structural change.

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