CENTRE FOR GLOBAL HIGHER EDUCATION

STEM Teacher perspectives: aims, aspirations and values

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Insights from the two projects:

Understanding Student Knowledge and Agency

Graduate Experiences of Employability and Knowledge

E·S·R·C ECONOMIC & SOCIAL RESEARCH COUNCIL
Office for Students ofs
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Exit Interviews

- Key informant
- Disciplinary specialist
- Programme overview and experience
- Leadership / curriculum design role
- Most in long-standing positions in their departments, eg over 20 years

What?: What is Chemistry/Chemical Engineering?

How?: How do we teach Chemistry/Chemical Engineering?

Why?: Why do we think the teaching of Chemistry/Chemical Engineering matters?

CHEMISTRY

Chemistry - Argon

Family atmosphere, small department – 1st year, Professor will know your name

World renowned research culture

Problem solving skills

Working towards independent projects - Scaffolded by pre-requisites to do other classes

Institution moving to experiential learning requirement

Outside the classroom, undergrad research or internship

Chemistry - ARGON

"I would say problem-solving skills, if you had to pick just one."

"I mean as far as world view, we hope that we have set a culture, respect and acceptance and cooperation and teamwork. You know, we do have some of that in lab, and in classes as well."

Chemistry - Astatine

Small dept, so focus on expertise of those there to teach

“Unique” opportunity for undergraduate research

“they are going to have skills beyond what you would expect from a student who just went to labs that were standard labs attached to classes.”

“By the time they are seniors and are taking these advanced electives, that they are pretty independent and good thinkers and critical thinkers.”

Chemistry - ASTATINE

"Well, I would say the access to undergraduate research is huge. I would also say our faculty is really, really open-door…. So I would just say that undergraduate research piece seems really, really big, but, also, I guess what I was getting at is the accessibility to the faculty. So students really will drop by and knock on our door. I mean probably not freshmen, that is probably less common for freshmen, but by the time I see them and they are second semester sophomores and above, most of them are pretty willing to come by and ask questions or things."

Chemistry - ASTATINE

"They are fairly serious students; they are serious about their academics. Sometimes I worry they are a little bit more serious or too serious."

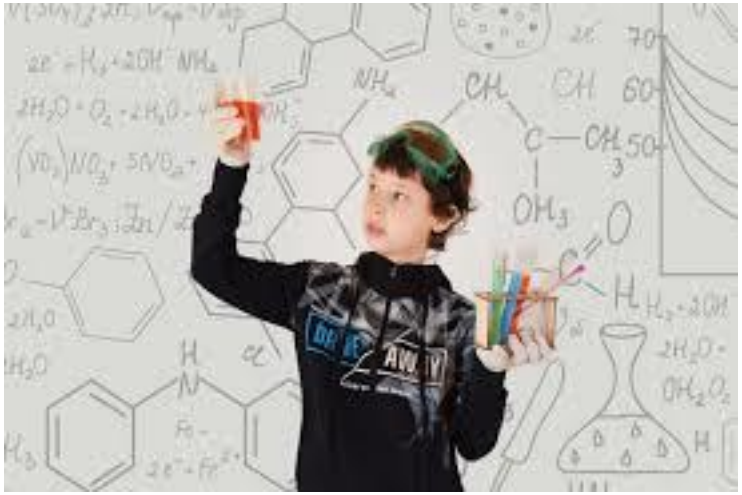
Chemistry - Erbium

Very low staff numbers, hence not a lot of flexibility

Enables to cover the basis very , very well

Unusually large computational component

Specialism by third or fourth year when do own project



Chemistry - ERBIUM

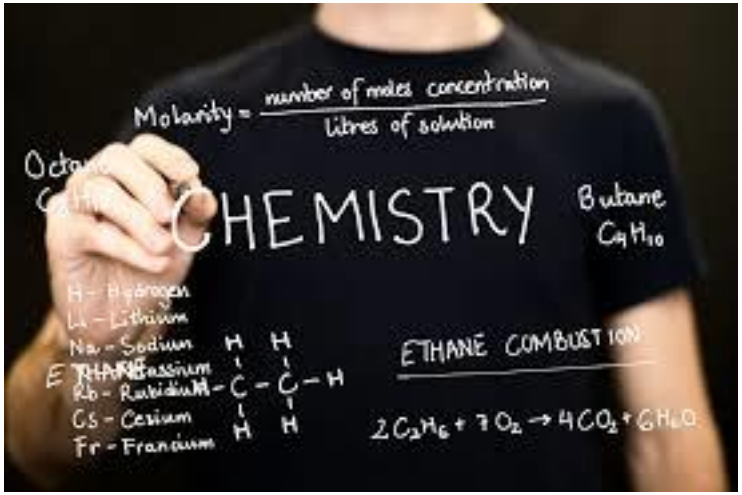
Mags: This is a strange question to be asking for science, perhaps, but is there anything in terms of world view or character that you, kind of- I am just thinking in that graduate attribute space, is there anything?

Respondent: Yes, I would say that is one of our downfalls, we don't have that. So **we don't really have much on sustainability and green chemistry** and that kind of- Yes, **we don't really do much of the wider-picture**, I will admit but, yes, that is lacking, definitely.

Mags: But you have got good, strong, well-rounded chemists?

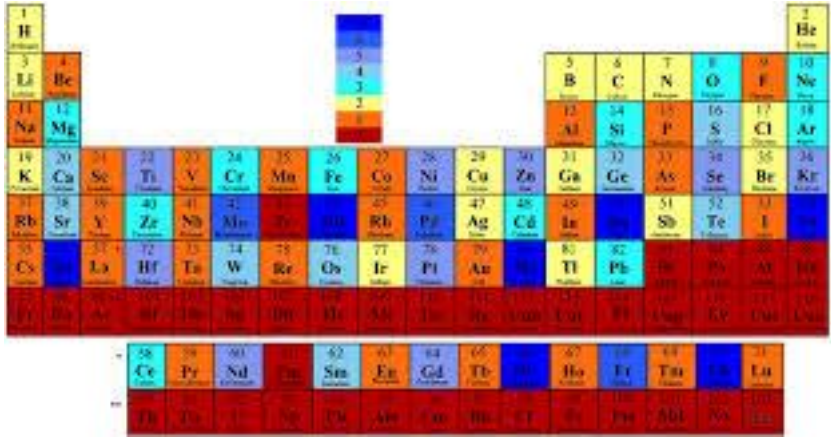
Respondent: Yes, yes very much. Yes, **the degree has very much been set up to produce a chemist that can go and work somewhere**

Chemistry - ERBIUM



["Erbium] has very much a community vibe to it. I actually say to students, "If you are someone who wants to hide at the back of the classroom and never get noticed, then don't come to our department because we do know every single student and everyone works together. And it is a community."

Chemistry - Europium



Unusually, all UG do a research project

Large focus on analytical chemistry

"Analytical science still remains
the big employer, and we really do drive the analytical."

Focus on employability

Push placements hard, but for some reason students increasingly less interested

Chemistry - EUROPIUM

"it is going back to those laboratory-based skills. I think it tells employers that they're going to get a competent laboratory scientist and that that laboratory scientist will relatively unusually be trained in and understand, to some level of depth, analytical chemistry as a specialism. So I think that is the big seller, and it seems to be reflected in the fact that those types of employer do continue to take to take our students into employment."

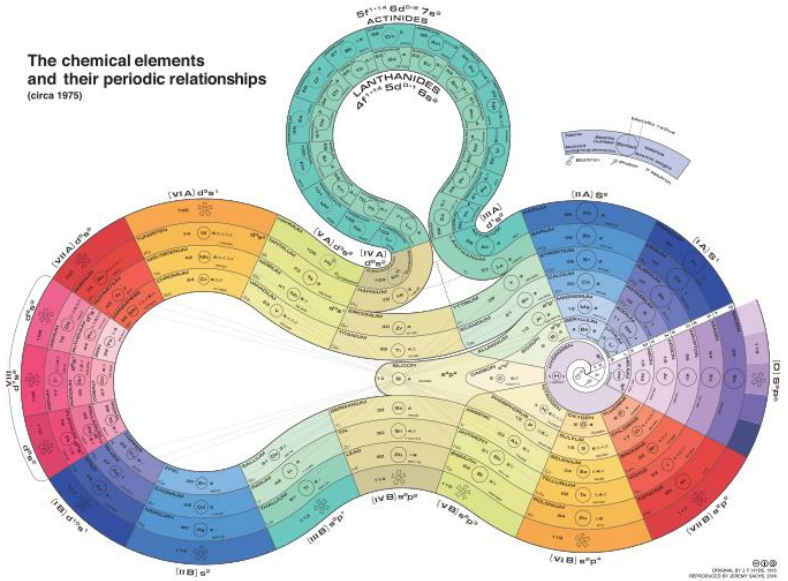
Chemistry - EUROPIUM

Broader social issues

University priority

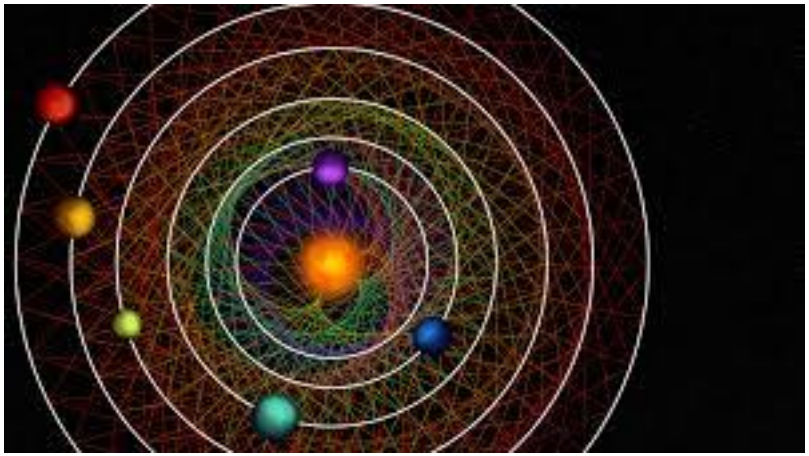
But running alongside courses, not embedded within

Inevitably means not mandatory to engage.



Chemistry - Samarium

Integration of different branches of chemistry – organic, inorganjic, physical



One large first year course,
second year etc..

“it hasn’t worked that well”

No flexibility in the chemistry part of degree, but second majors encouraged

“Astronomy” and “music”

Chemistry - SAMARIUM

Chemistry is beautiful.

> “I actually think Chemistry is an amazing subject, and what I hope that we get through in our degree is just some appreciation of, first of all how broad the topic is, so how many different branches and areas.”

“one of the amazing things about chemistry is the creativity that comes in”

Chemistry - SAMARIUM

"So if you are interested in Chemistry this is fantastic because there are so many different ways that you can go and be a chemist. But if you are not interested in Chemistry it is also quite a fabulous underpinning to so many other things that you can go and do.

So I think, what I would like to think people come out with is a good appreciation of the scientific method, the way that science actually operates, feels quite important right now. "

Chemistry - SAMARIUM

"what I think we are aiming for, is people who have an understanding and an appreciation of the place of science and chemistry in the world. So things like an ethical underpinning to, "What are you doing and why are you doing it? And should you be doing it at all?""

Chemistry - Sodium

"I think the thing about chemistry is it is incredibly broad. …Because it's incredibly broad…They learn how to bring some very disparate concepts together in order to understand the overall field. "

"The interior of Chemistry is multi-disciplinary – if you miss one of the elements, you cannot "get" it"

"It's about a holistic worldview of where does chemistry fit into everything else? "

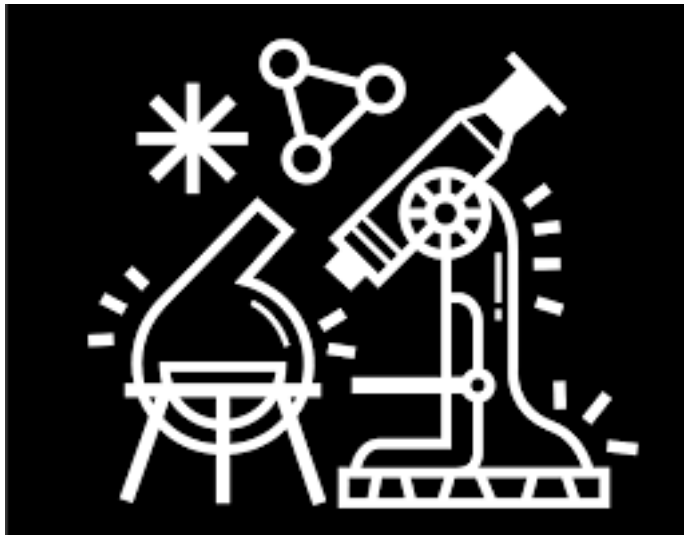
Chemistry Summary

Emphasis on parts and the whole

Emphasis on breadth

Emphasis on problem-solving

Portal into the scientific method



Centre of the world – but varied sense of what they means, eg social responsibilities

CHEMICAL ENGINEERING

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What is Chemistry/Chemical Engineering?

Significant difference.

Chemistry – not even a question.

Chemical Engineering – more complex

What is Chemical Engineering?

Chemistry at scale

Mass Production using chemical processes

Industry-based application of chemistry at scale

Responses vary in priorities and nuance.

Chemical Engineering - Argon

Argon: preparation for industry, much more than graduate school etc: but producing students of highest level

Stong focus on experiential learning and importance of a semester in industry

Although this is not yet mandatory – strongly encouraged -40-% take up

Extends into final capstone project – shaped by strong industry links

Teaching done by tenured researchers – open culture inviting students to be part of that lab work

Very reluctant to identify a distinctive “Argon style”

Chemical Engineering - Astatine

Selling point: focus on Programme Educational Objectives - ”exciting”

5 “Cs”

- competency in the discipline of chemical engineering,
- critical thinking ability,
- capacity to learn,
- cooperation, “so that’s team work”
- communication ability.

Very student focused: deep and personal connection

Chemical Engineering - ASTATINE

"We're a very student faculty. We strive to educate students from a much broader perspective than simply competency in the discipline and that plays into the five C's. We really promote students to engage in practices and activities that go beyond the classroom, that will give them this life perspective on the ambiguity of the world and science and their approach to it."

Chemical Engineering - ASTATINE

"I think that gets to the idea that we really value the life of the mind. We don't have a football team but for many years we had a world championship chess team."

Chemical Engineering - Erbium

More than oil and gas

Focus on sustainability, renewable resources and the environment

Chemical Engineering is about processes
– unlike civil engineering

Chemical Engineering - ERBIUM

Fairly conventional teaching outlook

One colleague different: pioneered team-based approach

Students hated it at first, but came to accept it

Small teaching team of 8 leads to lack of variety and not adventurous

Don’t attract “entitled” top students – but enthusiastic “tail”

This motivates their teaching

Student focused and friendly

Chemical Engineering - Europium

Traditionally, falls within two identities: core engineering and broader applied sciences

But not at Europium! Chemical Engineering is about connections

Chemical Engineering “uniquely” deals with mass transfer

Also process integration and process systems engineering

Europium: Chemical Engineering that is much stronger on Chemistry

“unambiguously properly chemical engineering”

And yet process of compromises and trial – things in and out

Chemical Engineering - EUROPIUM

Lab skills cannot be taught properly twinned with other purposes

Aim to encourage confidence and courage – use of calculations

Breadth as a power not a weakness

Even if it means sacrificing some maths

Chemical Engineering - EUROPIUM

"I think it's very important to emphasise the idea that these are problem solvers within the engineering context, people able to operate in complex environments and use fundamental skills and fundamental knowledge; that they've learned to solve problems that they won't necessarily have seen before, [or] again, set within the engineering context, and specifically, of course, chemical engineering"

Chemical Engineering - EUROPIUM

"[Europium] genuinely is an excellent teaching university. It's also research active, and it has important research ambitions, but it's pursuing those without losing its focus on the students. So we genuinely do have a context in which our ambition to deliver the best chemical engineering programme in the country is a realistic one."

Chemical Engineering - EUROPIUM

Someone once said: "Chemical engineers are either in love with chemistry or are in love with mathematics."

“Chemistry is much more sexy and glamorous than chemical engineering is “

"What I want our graduates to graduate with is, I want them to be in love with chemical engineering. I don't want them to be wannabe chemists or wannabe mathematicians. I want them to love chemical engineering-"

“We are not attracting the best and the brightest. We are attracting students who, I firmly believe, will do better, because they've had the quality of education that we're giving them.”

Chemical Engineering - EUROPIUM

Europium: chemical engineering as
a “powerful education”

Chemical Engineering - Samarium

Elective trek that allows for choice between breadth and depth

Students must do a language elective

Electives to allow research-led teaching

Move towards a more project-centred curriculum – designed to deepened understanding of theory

“just in time” approach to teaching – misxing theory and practice

Over time more comfortable with open-ended problems and projects

Teamwork – including working across cultures

Chemical Engineering - SAMARIUM

Samarium – many students wanting to save the environment

Focus on complex problem-solving skills – not perfect, but workable solutions

“there is a tendency to try and go into the smaller, fast-moving type of engineering sectors like water treatment, things which are in a way on the growth: water treatment, energy, start-up, not traditional energy, but your sustainable energy start-up type of things, environmental stuff”

Chemical Engineering - SAMARIUM

"And then the other one was, again, as a result of the FeesMustFall thing, there was a strong push to say, "Look, we do these projects, and they're always like big industry. It's always like a big petrochemicals plant, a big minerals mining operation or something like that. We want something where we could use our skills in a local community context."

And that was why we then brought in …the anaerobic digestion in a township setting. So we got some funding, we developed a whole new project around that, and we brought that in. So those are two ways, and we managed to still keep the deepening of the theory."

Chemical Engineering - Sodium

"the core that identifies chemical engineering as opposed to mechanical engineering that we sprang from, or electrical engineering or whatever else it may be, is the idea that we've got to have the skills to take the raw materials, produce the products that society wants on a large scale, and to do it so that the entities that are doing this actually are profitable."

Chemical Engineering - SODIUM

Flexibility decreased due to economic pressures on class sizes

General engineering first year – focus on problem solving skills

Solid technical grounding

“bell curve of abilities”

Ultimately it is about the end result of problem solving, variances in how that develops along the way are not important

Compare Europium, Erbium, Samarium

Chemical Engineering - SODIUM

"In addition, it's become apparent to engineers that we are not simply people who sit on chemical plants or whatever it may be and work in isolation from the rest of the world.

So we need of course, to be involved and understand how the rest of the world works and how we interact with it. And that can be things that are quite peculiar to the South African context but are also maybe a little bit more general than that. And we've introduced modules that we hope give our students that kind of exposure as well."

Chemical Engineering Summary

Emphasis scale

Challenging the old “oil and gas” image

Sense of discipline in transformation, responding to world events

Problem solving – like Chemistry

More variation in approaches