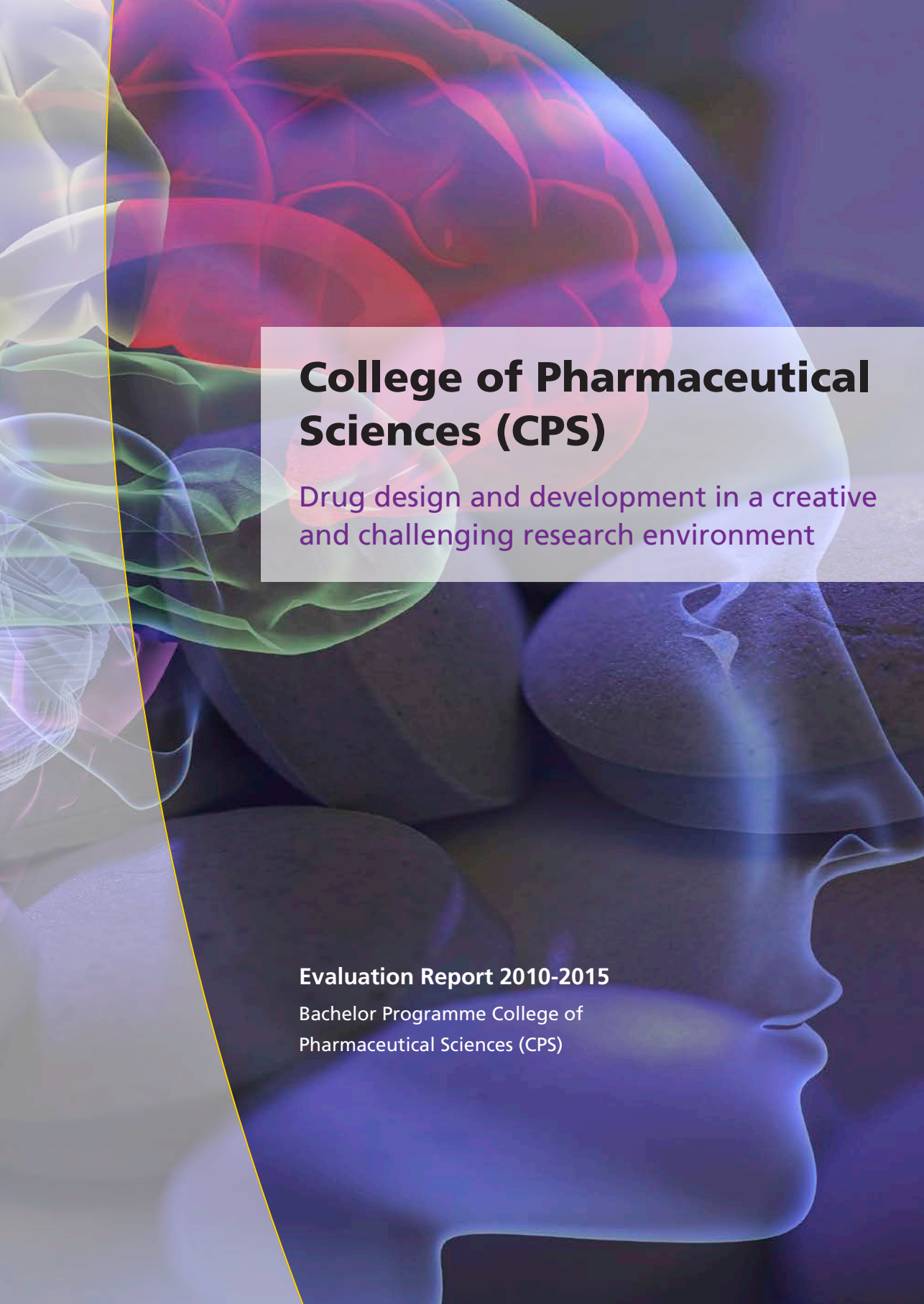

College of Pharmaceutical Sciences (CPS)

Drug design and development in a creative and challenging research environment

Evaluation Report 2010-2015

Bachelor Programme College of Pharmaceutical Sciences (CPS)

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Bachelor Programme College of Pharmaceutical Sciences (CPS)
December 2015

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1. Executive Summary

New worrying trends, such as the decrease in the number of new drug launches, the increasing costs of developing new chemical entities, and the many pharmaceutical projects that fail in the early stages of research, indicate that the translation from basic science to applied drug development is a weak link (Kaplan & Laing, 2004; Kaplan et al., 2013). In 2010 the Faculty of Science started the College of Pharmaceutical Sciences (CPS) to train students to make this translation from fundamental basic knowledge to the development of new, innovative drugs. This is the main aspect that distinguishes the CPS from bachelor programmes such as Molecular Life Sciences (MLS), Chemistry and Biology.

College of Pharmaceutical Sciences

- Graduated students are optimally equipped for a scientific research career in drug discovery and development
- Honours programme
- International
- Student-activating
- Individual approach
- High study success
- Strong (learning) community

In five years' time CPS has proven itself to be an indispensable addition to the other bachelor programmes offered by the Faculty of Science. Not only is the content clearly distinguishable, as it approaches basic life science from a drug development perspective, it also has a research-based educational approach throughout the whole bachelor unique in the world. The small-scale, student-activating, honours approach contributes to the educational vision of Utrecht University and is in line with the ideas of the Association of Universities in the Netherlands (VSNU) and the Ministry of Education, Culture and Science (OCW).

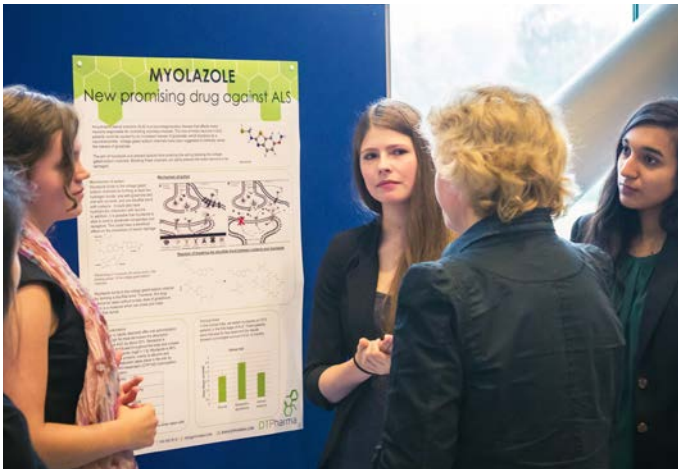
The first results of the student evaluations, the study success, and the extensive CPS audit, as presented in this report, show that the implemented curriculum is very successful. With the ambitions formulated for the future, CPS will further strengthen its valuable position as the link between the more fundamental science programmes and the Pharmacy programme. The effectiveness of the curriculum and its benefit for the work field of pharmaceutical science and drug development will be investigated in the coming years.

Ambitions for the future

- Strong alumni network
- Joint development and implementation of Faculty wide English-taught, honours (elective) courses
- Collaboration with pharmaceutical industry and third parties
- Educational research on effectiveness of the CPS curriculum
- Fit teaching in Teaching Load Model (TLM)
- Further Internationalization

2. Background

Six years ago the Faculty of Science of Utrecht University (UU), The Netherlands, took the initiative to design and implement a new bachelor programme in pharmaceutical sciences: the College of Pharmaceutical Sciences (CPS).
One of the main reasons to start this initiative was the lack of a bachelor programme that focuses on drug development and discovery, and that connected to the already existing Master Drug Innovation. Furthermore, it was felt that a new pharmaceutical science research bachelor could relate better to the research expertise in pharmaceutical sciences present at UU, such as Immunopharmacology and Neuropharmacology, compared to the existing Pharmacy programme, that focuses on training students for the Pharmacy profession.
In addition, the need for a pharmaceutical science programme arises from the fact that there is a gap between the type of educational output from the universities and the demands of the industry for pharmaceutical science graduates. Several studies have indicated that the education of pharmaceutical scientists should involve more scientific breadth, multidisciplinary problem solving skills, communication skills, working in teams, dealing with professional and research ethics, developing leadership competences, project management skills, self-organization and creative, critical and strategic thinking (Borchardt & Summerfield, 1997; Breimer, 2001; Brueggemeier et al., 2011; Klech et al., 2012; Mooney, 2001; Serajuddin, 1998).
These requirements for pharmaceutical scientists arise from challenges that pharmaceutical industry, academia and government face, such as the decrease in the number of new drug launches, the increasing costs of developing new chemical entities, and many gaps between the need and availability of drugs (Gaspar et al., 2012; Kaplan & Laing, 2004; Kaplan et al., 2013). The College of Pharmaceutical Sciences (CPS) therefore intends to train undergraduate students to become innovative and creative pharmaceutical scientists who can deal with the new challenges of drug discovery and development (Borchardt, 1997). No other research bachelor offers these contents and skills.



The aim of this report is to give an overview of the first five years of this new and innovative bachelor programme. Besides a description of its content and the facts and figures, it also gives an overview of the current status, its strengths and weaknesses, and the opportunities and challenges for the programme in the coming years.
The report is the result of an extensive audit in which meetings were organised with many people involved in the CPS; teachers, students and supportive staff (overview in attachment 1).

The overall conclusion of this report is that the CPS is a really unique programme that has been successfully developed and implemented by the department of Pharmaceutical Sciences, Faculty of Science. It trains students to be creative, innovative pharmaceutical researchers optimally equipped to function in a multidisciplinary research environment. The CPS is a programme that, with the right attention and adjustments, will stay valuable and sustainable in the future, and an indispensable addition to the bachelor programmes offered by the Faculty of Science.

3. What makes the CPS unique?

Drug discovery and development

To discover and develop new and innovative drugs, integration and use of (fundamental) knowledge from a broad range of disciplines is needed. Pharmaceutical scientists need to have a broad overview over the whole drug development process to be able to come up with creative and innovative ideas for new drugs that can benefit patients. In addition to fundamental knowledge about chemical and biological processes, the drug developer therefore needs to have knowledge about drug targeting, pharmacology, synthesis of drugs, preclinical and clinical testing of drugs, and the use of medicines in clinical practice. The CPS-students are therefore trained to be able to apply knowledge from other disciplines to develop a new drug, taking drug development principles into account. The CPS is therefore of an added value to other programmes at UU, such as Biomedical Sciences (BMW) and Molecular Life Sciences (MLS). MLS and biomedical students are trained to obtain (fundamental) knowledge about diseases and disease related processes in the human body, and chemical properties of (bio)molecules. The CPS student additionally steps in to integrate and apply this knowledge for drug development. Together, the programmes offered by UU, Faculty of Science, cover the broad range from fundamental knowledge to applied science that will benefit future health care. By using a unique, integrative and applied approach, in which basic biological and chemical knowledge is used immediately from year one in the context of drug design and development, the CPS clearly distinguishes itself from other pharmaceutical science programmes in the Netherlands (Bio-Pharmaceutical Sciences Leiden, Pharmaceutical Sciences, Amsterdam). These programmes have a traditional approach where students first learn basic knowledge in chemistry and biology, before they continue to apply this knowledge in more pharmaceutical science related subjects.

Figure 1: Poster used at information days, showing the relationship and added value of the different bachelor programmes offered by the UU.

"The CPS chemist is very well acquainted with every aspect of drug development and has therefore an added value to the organic chemistry lab" – Roland Pieters, Professor Molecular Pharmacy, Faculty of Science

Research- and Inquiry-based learning

The requirements for innovative pharmaceutical scientists make it very clear that more is needed than just theoretical knowledge and basic laboratory skills. Higher order thinking skills, and a critical attitude are important, in addition to research skills such as defining a (multidisciplinary) research question, developing an experimental design, critically analysing data and literature, and present and discuss results orally or in writing (Breimer, 2001; Coil, Wenderoth, Cunningham, & Dirks, 2010; Feldman, Divoll, & Rogan-Klyve, 2009; Mooney, 2001). In addition, to be able to come up with new and innovative ideas for new drugs, students have to be creative, be able to think 'outside the box', and recombine knowledge. To achieve this, Inquiry Based Learning (IBL) was chosen as the leading principle and format throughout the whole bachelor programme (figure 2). IBL is a research-based, student-centred pedagogy, based on authentic tasks, that has been shown to stimulate a deep learning approach (Healey & Jenkins, 2009a; Healey & Jenkins, 2009b; Justice, Rice, & Warry, 2009; Khan & O'Rourke, 2005; Prince & Felder, 2006; Spronken-Smith & Walker, 2010) (figure 2). Although there are examples of using IBL on course level in (pharmaceutical) sciences (Meijerman, Storm, Moret, & Koster, 2013; Powell et al., 2007; Sattenstall & Freeman, 2009) we are not aware of any designs using IBL-approaches at curriculum level, making this approach unique in the world.

CPS curriculum

Research-based
Student focused with an emphasis on research processes and problems

Inquiry based learning
Learning driven by questions and complex realistic problems

Authentic context
Learning environment reflecting the future profession (pharmaceutical research)

Autonomy
Room for personal initiative, freedom of choice

Scaffolding
Right amount of teacher support at the right time

Furthermore, IBL is a student-centred way of teaching, thereby contributing to the view of UU that education should be individual and student activating. In addition, within IBL the students are offered flexibility and freedom of choice, also within courses, giving them room for their own initiatives and personal development, which is in line with the mission and strategy on educational diversity as expressed in the Strategic plan of UU (Universiteit Utrecht, 2012).

Figure 2: Model of the Inquiry process (based on Justice et al, 2002, 2007).

Honours programme

The CPS programme has been developed as an honours programme for gifted students with an interest in pharmaceutical sciences. They get the opportunity to participate in a programme that will suit their needs for a challenging, demanding and creative educational environment. Designing the programme as an honours programme is in line with the widely accepted idea that there must be more differentiation in teaching strategies to match the talents and needs of the varied student population (Biggs & Tang, 2011; Scager, 2013). It contributes to one of the key performance indicators in the Strategic plan of UU (Universiteit Utrecht, 2012) stating that the amount of students involved in honours education is 12% of the total student population in 2016. Participating in the CPS requires more effort, autonomy and self-regulation of students. Gifted students have been shown to benefit from such an educational environment. Their learning skills ask for more speed, less repetition and more challenges. They profit from a less structured environment that leaves room for personal initiative and space for experimentation (Renzulli, 2005; Scager et al., 2012; Seehusen & Miser, 2006; Wolfensberger, Van Eijl, & Pilot, 2003; Wolfensberger, 2012).

"This CPS course has been one of the best learning experiences I've had. We were very lucky that our teachers trusted us, encouraged us, and believed that we as students could actually make a valuable contribution to the scientific community, and I hope that many people will follow this example" – Jolet Mimpen, CPS student (Mimpen, 2015).

International

The CPS is an international programme. English was chosen as the official language in all courses to attract international students and create an international student community. In addition, using English will train students in the language mostly used in research environments and scientific communication. Furthermore, students are encouraged to study abroad for their elective courses at one of the partner universities of UU (e.g. League of European Research Universities (LERU)). Other, CPS-specific, exchange programmes are in preparation.

Community and small scale.

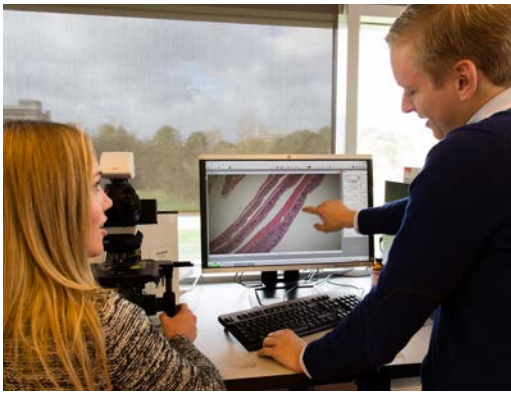
One of the key points of the educational model of UU is community building, personal and small-scale education (Universiteit Utrecht, 2015). By having a limited amount of students starting every year, a small-scale learning environment is created in the CPS programme. This environment encourages the formation of a strong (learning) community.

The IBL activities are organized as collaborative work in small project groups giving the advantage of improving teamwork and project management skills (Khan & O'Rourke, 2005). Furthermore, by working in small teams students have to verbalise and discuss what they know, which supports and promotes collaborative construction of knowledge, reflection and learning the 'language' of science.

4. Outline of the CPS-programme

Just like all B.Sc. programmes offered by Utrecht University, the CPS is a 3-year programme (180 European Credits; EC's). The programme consists of major mandatory courses (75 credits), major elective courses (60 credits) and a free part, the electives (45 credits) (figure 3). Every academic year consists of 4 teaching periods of 10 weeks, with each period having one course worth 15-credits (400 hours) or two courses of 7.5-credits (200 hours). The final undergraduate research project is worth 30-credits and lasts 1 semester. The courses are given at level 1, level 2, or level 3 (table 1). Year 1 will be only level 1 courses (with the exception of the final assignment), year 2 has level 2 and 3 courses, and year 3 only level 3 courses. With increasing level there is an increasing complexity of the tasks, and more independence, and self-regulated learning is required from the student (table 1).

Content



With respect to the content it was decided to choose the "drug development pipeline" as the organizing principle for the first year of the curriculum; from drug discovery to drug development (figure 4). Most Pharmaceutical Sciences and Pharmacy undergraduate programs start with courses about the basic chemical knowledge of drug molecules. Many students experience these subjects as difficult and they often fail to see why this knowledge is important to them in the light of their future profession, leading to demotivation and lack of interest of the students. Therefore, in order to connect to the incoming students' world as good a possible and to follow a natural course of interest-driven study at progressively more detailed physiological, cellular, biochemical and molecular levels later in the year, the students of the CPS follow the drug pipeline in reversed order: from therapeutic application to molecular design (figure 4). In year two and three the students have three more mandatory and major elective courses (figure 3). In addition, they have a wide choice of electives in the chemical, biomedical and pharmaceutical field. The students can even further broaden their field of expertise by going abroad to a university that is part of the League of European Research Universities (LERU) or, worldwide, Utrecht University Partners (UUPs). To better connect to the semester system of international universities, and to make the procedure to apply less complex, the compulsory pharmaceutical biotechnology course was moved from period 2 in year 3, to period 3 in year 2 in study year 2015-2016. As the last part of their bachelor programme students perform 6 months of undergraduate

"CPS is a top academic training in life sciences. The students involved are a unique selection of highly motivated students. Interaction between students and professors/teachers is very good and leading to lots of synergy in research and education" – Prof. Dr. Johan Garssen, Immunopharmacology, Faculty of Science

research in a research group of their own choice within the UU. On top of the regular CPS bachelor programme, with all courses being at honours level, students also participate in the honours programme of Pharmacy, and the interdisciplinary honours programme of the Faculty of Science.

Skills development

On top of the regular courses, workshops on group work and collaboration skills are offered, especially in the first year of the programme. In addition, several workshops on chemical calculations, academic writing and presenting are incorporated in the different courses. During the research project meetings are organised in which the students share their experiences and get support in writing their undergraduate research report. To improve their metacognitive skills the students have to work on a reflective portfolio, and are stimulated to expand additional activities on top of their regular curriculum (e.g. organize symposia, extra research activities, social activities). Every student is assigned a tutor for support during the whole bachelor programme. The tutor guides the students throughout the CPS-programme and helps them to make study-choices and discuss the portfolio with the students. In close cooperation with the study advisor, they also support students with more personal problems. In the first year there are several group meetings with the tutor in which the students themselves organise workshops on topics of their own choice, like time management, effective studying, taking notes, career planning, and how to prepare for exams.

Assessment

According to the principles of constructive alignment, the assessment of the students in the CPS is aligned to the intended learning outcomes and the teaching and learning activities (Biggs & Tang, 2011). In every course there is an individual exam after 6 -7 weeks about the theory of the course. This individual exam consists of open-ended questions that require a high level of understanding from the students. The last 3 -4 weeks of every course are completely dedicated to the IBL activities and the assessment of the (group) products. The IBL-projects are assessed using authentic assignments and criteria from the professional field of (pharmaceutical) science. Examples are writing papers according to the guidelines of peer-reviewed journals, grant proposals, presenting posters, design experimental protocols, and giving presentations. Formative (peer)-feedback to the students is integrated into every course on a regular basis during the process of working towards the final product and to help the students prepare for their individual exam.

Organisation

In every major course two or three teachers of the department, including the coordinator, are responsible for the guidance of the project teams and involved in grading the assignments. These teachers come from different research groups within the department of Pharmaceutical Science. The team is therefore multidisciplinary and there is real 'team-based teaching' environment. Other teachers of the department assist in giving lectures on specific topics, guiding discussions and laboratory work. For the CPS at least one of the teachers of every course has to be a principle investigator, spending at least 70% of the time on research. The other teacher is more involved (e.g. 70%) in education. Before the start of the curriculum all the teachers participated in several workshops and meetings to get acquainted with IBL and its principles. Furthermore, after the start of the program in 2010 there were regular teacher meetings to exchange experiences, making sure that the content and skills of all courses are aligned, and giving support to the teachers.

The main activities of the students are the IBL (group)projects. To support the students with their projects, teaching activities are organised, such as lectures and student-centred workshops. In addition, the project groups have meetings with a teacher on a regular basis. The laboratory work can either be supportive, when students learn basic laboratory skills, or be part of the IBL-project. In table 2 an overview is given of the time that students spend with teachers on certain teaching activities.

Figure 3: CPS-curriculum (2015-2016)

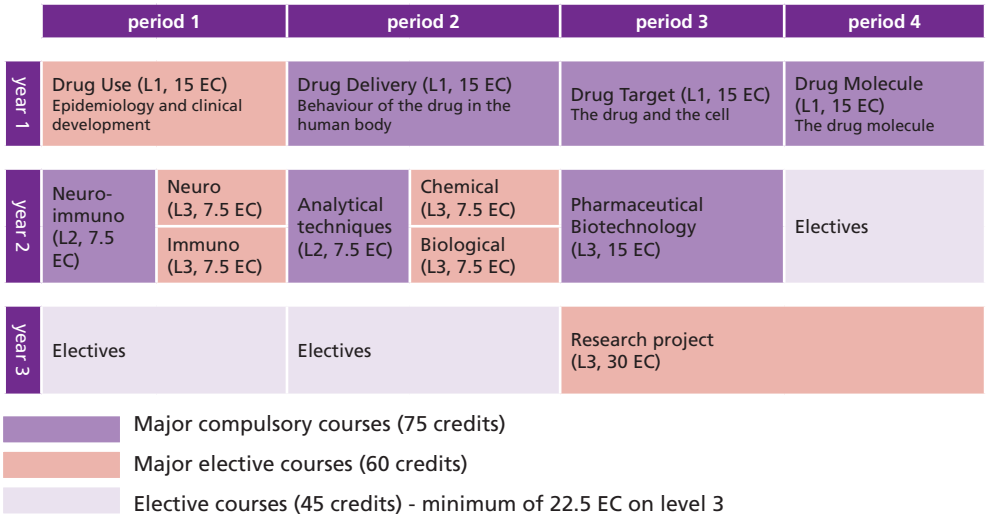


Table 1 - CPS-curriculum design

	COMPLEXITY LEVELS Increased independence and self-regulated learning → LEVEL 1	LEVEL 2	LEVEL 3
CURRICULUM COMPONENT			
Content	Learning new basic concepts and techniques. Practice with basic, simple, examples under guidance of the teacher	More complex, multidisciplinary, concepts and theories. Practice with more complex examples under guidance of the teacher	Complex, multidisciplinary, concepts and theories. In small groups or independently work on assignments and projects.
Learning activities	Project-work, guided by lectures, meet-the-expert sessions, introductory laboratory work, workshops	Project-work, including guided laboratory work, lectures, meet-the-expert sessions, workshops	Project-work or research project, performed in small groups or independently
Teacher role	Mainly guided inquiry	Guided and open inquiry	Open inquiry
Materials and resources	Mainly books and review articles. Starting to learn to use databases, find, use and cite primary literature. Learning how to judge the value of different resources (eg. Internet, newspapers, peer-reviewed literature)	Mainly primary, peer-reviewed, literature and review articles, some books. Students must be able to analyse and critically evaluate literature and resources	Primary literature that is relevant to the students own research and projects. Student can search, critically analyse, and evaluate sources independently
Grouping	Fellow CPS-students	Fellow CPS-students, sometimes coupled to PhD students or other researchers	Independent, or in collaboration with (PhD) students and researchers
Location	Educational facilities at UU, introduction into research laboratories of the department of Pharmaceutical Sciences	Educational facilities at UU, research laboratories of the department of Pharmaceutical Sciences	Educational facilities at UU or elsewhere, research laboratories of the department of Pharmaceutical Sciences or of a Life Science Faculty of choice (research project) at UU
Assessment	Learning to use the most important products of science: scientific posters, oral presentations, scientific articles, documents for ethical committees and registration authorities, study- and experimental protocols	Using the most important products of science, including a grant-proposal, to present data to peers and teachers.	Student can independently choose, and use, the best way to present their own scientific data for a specific purpose. The final assessment of the research project is a scientific publication and presentation.

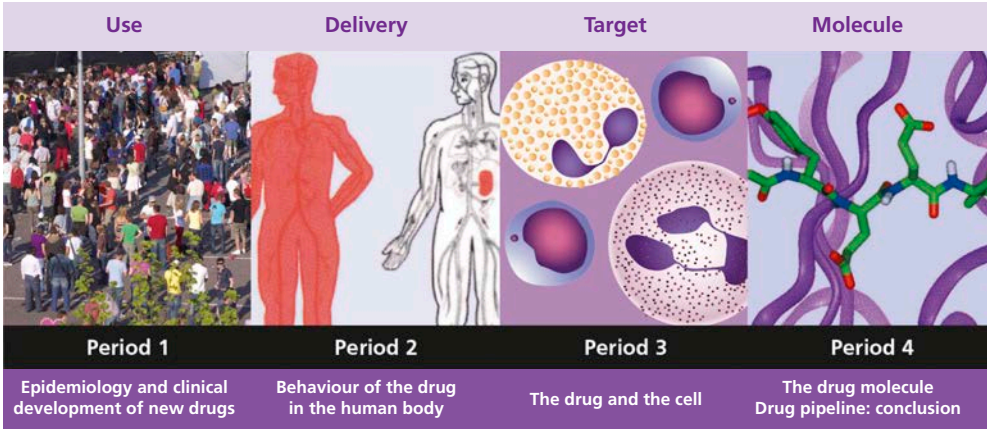


Figure 4 – CPS year one.
The first year of the CPS is organised according to the principle of the 'reversed drug pipeline'.

Table 2 – Contact hours of students in the compulsory CPS-courses
(L=lecture, W=workshop, P=projectwork, Lab=laboratory work, E=excursion, A=assessment)
Note: not all hours mentioned are under direct supervision. Contact hours are most of the time hours spent at the university, also including those hours were students work on their own project without direct contact with the teacher.

Course	L (h)	W (h)	P (h)	Lab (h)	E (h)	A (h)	Total (h)	Teaching (h)	Contact (%)
Drug use	23.5	63	23	8	15	5	400	137.5	34.3
Drug delivery	25	33	47	88		3	400	196	49.0
Drug target	26	37	6	57	16	3	400	145	36.3
Drug molecule	8	45	98	53	3	5	400	212	53.0
Neuro- and immunopharmacology	50	27	13	20	16	3	400	129	32.2
Analytical techniques	30	50		192		2	400	274	68.5
Pharmaceutical biotechnology	14	61		60		8	400	143	35.8
Average	25.2	45.1	37.4	68.3	12.5	4.1	400	176.6	44.2

5. CPS in numbers

Facts and figures

Since the start of the programme in 2010, 151 students joined the CPS (table 3). In the beginning the number of students was low, mainly due to unfamiliarity with the programme. In the subsequent years of the programme more (international) high-school students became acquainted with the programme and interest in CPS increased (table 3). The study success of the CPS students is high, which is shown by the percentage of students that has obtained a positive Binding Study Advise (>45 EC) after year one, and the percentage of students that has graduated within three or four years (table 3). The percentage of students that passes the compulsory and major elective courses on average is 93%. The lowest success rate is 81% for a compulsory course in year 1. This output indicates that, although the programme is considered challenging by students, the study success for the courses is high.

The success of CPS-students is also shown by the fact that three CPS-students have already been the first author of a publication in a peer-reviewed journal, and several others are co-authors of scientific peer-reviewed publications (Boere, Soliman, Rijkers, Hennink, & Vermonden, 2014; De Vooght et al., 2013; Jordan et al., 2015; Koopmans et al., 2015; Lau et al., 2013; Roda et al., 2015) (see also attachment 3).

The autonomy and freedom of choice experienced by the students is reflected in the choices that students have made for their elective courses (45 EC). Not only do they choose a wide range of courses and topics for their research project (attachment 3) within the department of Pharmaceutical Sciences, they also participate in courses from other departments (biology, chemistry, biomedical sciences) and Faculties (medicine, economics, veterinary, psychology, humanities and geosciences). Until now, seven students have gone abroad (United Kingdom (2), Australia (1), Singapore (1), Sweden (1), and South-Korea (2)) to take courses at one of the partner universities of UU.

Almost all of the students that graduated until September 2015 proceeded with a research master within the area of Life Science. Most of them continued with the Master Drug Innovation, which coincides with one of the aims of the CPS: having a bachelor programme that connects with this Master programme.

> ***"The CPS Master is vital to sustain top-research in the Pharmaceutical Sciences in Utrecht"*** – Prof. Dr. Albert Heck, Biomolecular Mass Spectrometry and Proteomics, Faculty of Science

Table 3 - CPS in numbers

	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Visitors information days	291	321	580	812	1054
Complete applications	13	39	29	42	52
Enrolment year[1]					
- Dutch students	7	12	13	22	23
- International students	1	7	5	7	15
- Country of origin	India	Denmark, Nigeria, France, UK, Hong-Kong, USA, Sweden	France, UK, Jordany, Germany, Egypt	Zimbabwe, UK, Belgium, Israel, Spain, Greece, China	UK, Germany, Spain, Finland, Italy, Vietnam, Greece, Philippines, Canada
Total number year 1	8	19	18	29	38
% Positive binding study advise (BSA)	75 (75)[2]	72 (86)[2]	61 (83)[2]	83 (89)[2]	97 (97)[2]
Enrolment year 2[3]	6	13	11	24	37
% Bachelor degree 3-yr	33	58	82	--	--
% Bachelor degree 4-yr	100	92	--	--	--

1 In the study year 2015-2016 there were 79 complete applications. The total number of student that started in year 1 was 39, of which 32 Dutch students and 7 international students (Ireland, Switzerland, Greece, Egypt, Italy, Slovenia)

2 The %BSA based on the number of students that finished the first year

3 This includes those students with a postponed BSA due to personal circumstances

	2010-2011	2011-2012	2012-2013
Master Drug Innovation	3 (50%)	7 (54%)[4]	3 (27%)[4]
Master Life Sciences UU and School of Pharmacy	3 (33%) (Infection and Immunity, Pharmacy, Regenerative Medicine and Technology, Science and Business Management)	4 (30%)[4] (Science and Business management (2), Neuroscience and Cognition (2))	3 (27%)[4] (Infection and Immunity, Neuroscience and Cognition, SUMMA)
Other Master/PhD		1 (8%)[4] (Analytical Chemistry, University of East Anglia)	1 (9%)[4] (Pharmacology, Oxford)
Other		1 (8%)[4] (Break year)	3 (27%)[4] (Break year)

4. Based on number of graduated students so far

Evaluation

The results of the student evaluations, completed by the students after every compulsory CPS course in 2010-2014, show that the CPS students feel challenged, motivated to learn, and that their creativity is stimulated (table 4). They like to work in teams on the different projects and put a lot of effort in the courses. The teachers of the courses helped in the way that they encouraged the students to think independently and students felt inspired. The students appreciate especially the fact that they could work on a research topic of their own choice, and they find determining their own research methods very stimulating. These results are confirmed by the remarks made by the students in the open questions (table 5). Students often mention the added value of group work and the stimulation of creativity, critical thinking and the development of research skills. Furthermore, the remarks show that they feel that they are becoming part of a research-community as one student puts it: *"…. it makes you feel like a real scientist and you really want to find an answer".* The students mention two points of attention. The first one being the guidance by the teachers, as students often mention that they would like to have more instruction and feedback from the teacher. In addition, they sometimes find it difficult to accept that they are graded as a group and not as an individual.

The general experience of the teachers is also very positive. They especially like the fact that the students are highly motivated, and very creative and enthusiastic. Furthermore, they feel that the students are really developing research skills. Their general impression is that the level of the students often exceeds their expectations. Some teachers had to adjust to the way of (thinking about) teaching, especially considering scaffolding and providing autonomy for the students. The teacher meetings provided them with help and a platform to exchange ideas and experiences.

Table 4 - Students' evaluation, Post-courses survey results

The results depict the average results of the student evaluations of the first 6 compulsory coursed of year one and two of the CPS curriculum in the academic years 2010 until 2014. The cumulative response is based on a Likert scale on which 5=strongly agree, 4=agree, 3=neutral, 2=disagree and 1=strongly disagree. N= the total amount of evaluation forms over the six courses where the question has been filled in by the students.

SURVEY ITEMS	N	MEAN	SD
Overall, I am satisfied with the quality of this course	298	3.9	0.7
I learned a lot as a result of this course	299	4.1	0.7
I found this course intellectually challenging	299	4.0	0.8
My creativity was stimulated during this course	299	3.7	0.9
My independence was encouraged in this course	299	3.9	0.8
This course increased my motivation to learn	299	3.6	0.9
I enjoyed this course	299	3.7	0.8
I put a lot of effort in this course	299	4.0	0.8
Working in a group had an added value to me	299	3.8	0.9
Our supervisor was inspiring	278	3.6	0.9
Our supervisor encouraged us to think independently	277	3.9	0.9
The feedback from our supervisor was helpful	278	3.7	0.9
Our supervisor was available	278	3.8	0.9
The course challenged me to give my best	298	3.7	0.8
In this course there was a good balance between project work and supporting lectures/workshops	138	3.4	1
Working in an 'interdisciplinary' group stimulated me to do my best	145	3.5	0.9
Working on the (different) project(s) stimulated me to do my best	152	4.0	0.7
Working on a research topic of our/my own choice stimulated me to do my best	132	4.0	0.7
Determining our/my own research methods stimulated me to do my best	148	3.9	0.8

Table 5 - Examples of open remarks of the students about the courses in the CPS-curriculum

What are the most important insights you acquired in the course?
"Good team work is the key to success" "You don't need lectures to learn" "Do research before you start something, think outside the box" "Talking to other groups often leads to new insights" "I learned how to work with other people, time management, better knowledge of the scientific field and how research is carried out" "Using my creativity, for example to determine our own research methods" "Learn how 'real life' investigators use the techniques we learned"
Did the course add to your research competence?
"I feel like I now got a bigger perspective for my future and a greater understanding of the pharmaceutical world" "I learned to look at all the different ways to interpret results" "I got a lot of insight in the possibilities in the research field" "Letting us formulate the research question and performing experiments makes you feel like a real scientist and you really want to find an answer" "Learning about research strategies made me aware of pitfalls and challenges in research" "I feel much more 'at home' in the lab environment now" "All the freedom we had helped us grow and develop our own thinking skills"
Did the student driven approach work for you?
"Yes, I like to find out stuff for myself. I don't like that teachers say how to do it" "The student driven approach challenged my level of reasoning and views on scientific subjects" "The fact that students have to take the initiatives is very stimulating. I enjoyed not spending every day listening to lectures but actually produce work. The fact that students have to think instead of absorbing information is a definite plus" "With so many different ideas coming from the whole group, one learns to think further than the horizon and push their limits" "It enabled me to think more critically and improve my creativity" "It helped me to develop my research skills"

6. SWOT-analysis

To obtain a better insight in the CPS-programme an extensive audit was performed in which there were meetings with teachers involved in all the courses of the CPS-programme, including the elective courses. In addition, there were interviews with supportive staff and representatives of students of every CPS year (overview of meetings in attachment 1). Also, some professors and leaders of research programmes within the department of Pharmaceutical Science were asked for their opinion about the CPS.
A SWOT-analysis of the reports of the meetings was performed and the results are depicted in table 6.

In the coming years, based on the SWOT-analysis, major, and minor adjustments will be made to the programme to solve the weaknesses and to make the most of the opportunities. Below, some of the major points of attention and opportunities are summarized.

Future position CPS
For the future position of the CPS it is recommended that CPS continues under the CROHO label of Pharmacy. This strengthens the connection between Pharmacy and the CPS programme and guarantees the pharmaceutical research base necessary for the CPS. Furthermore, a joint CROHO label with Pharmacy contributes to the clear visibility of the CPS for students interested in drugs and pharmaceutical research.
There are some minor problems that are related to the fact that the CPS is no independent programme but falls within the Pharmacy programme: the learning outcomes (attachment 2) of the programme cannot be specified specific enough and it sometimes leads to confusion by (international) students. In addition, the entrance requirements for CPS students are the same as those for the Pharmacy programme. This is especially a problem for international students as those students often have a combination of biology and chemistry and no physics. Furthermore, international students who do have physics as part of their final exam often have no biology, and experience difficulties with the more biology oriented courses of the CPS. For UK-students this problem has been partly solved by changing the entrance requirement and accepting physics at a GSCE-level, however, for students from other countries, like Germany, this remains a problem. To solve this problem and to attract more international students, entrance requirements for the Pharmacy programme should be a point of discussion in the coming years. Changing the entrance requirements, could also be possible when the CPS has its own CROHO-label. The CPS has enough unique characteristics that distinguishes it from the bachelor of Pharmacy and other bachelor programmes within the Faculty of Science and the UU to justify independency of the programme through a CROHO label (see Chapter 2 and below-content). A joint CROHO label with the Molecular Life Science programme (MLS) is another

option. The major threat of this approach would be a decreased visibility of the CPS and the disruption of the strong link with the Pharmacy programme. Not with standing these alternative possibilities the most viable option for the future of CPS is its current position within the Pharmacy programme.

Internationalization

About one third of the CPS-students is currently from outside the Netherlands. This could be increased by changing the entrance requirements (see Future position CPS). In addition, more attention should be paid to international visibility. Together with the communication department a plan will be made to interest more international students for the CPS. Until now several students went abroad for their elective courses at other universities. To increase this exchange programmes will be established in the coming years to provide better opportunities and more interesting possibilities for students.

Collaboration

More collaboration, with pharmaceutical industry and other universities, but also within UU, offers unique opportunities for the CPS to extent its visibility and to further improve the content of the programme. Contacts with (pharmaceutical) industry, and other institutes or companies related to pharmaceutical science could give students a better idea of their possibilities, and contribute to their knowledge about drug discovery and development from an industry perspective. International contacts with other universities could offer more opportunities for students for an exchange and strengthen the international aspect of the programme.
An important point of attention is even more collaboration between the different departments of the Faculty of Science, and between Faculties, like Science, Medicine and Veterinary Medicine. All departments and Faculties offer elective courses, but many of them are only available for students of their own programme(s) or have limited access for students of other programmes. In addition, there are very similar elective courses that are being offered by different departments and faculties. CPS students indicate a need for more, English-taught, elective courses, preferably at honours level. More collaboration and setting up an elective programme together could increase exchange of students between different programmes, and broaden the choices that students can make. Furthermore,

> ***"Student X research placement in our group exposed him to many facets of the drug development process. Starting from an initial idea on paper, followed by its implementation in the exciting discovery stage, leading to the filing of a patent application, student X made key contributions along the way. While such an experience is surely exceptional, I also believe that it was student X involvement in the CPS program that made it possible."***
> – Dr. Nathaniel Martin, Molecular Pharmacy, Faculty of Science

this would increase the knowledge of teachers and coordinators about the skills and knowledge of each other's students, which can be an aid when selecting students for Master programmes.

Group size

One of the major strengths of the CPS mentioned by both teachers and students is the small-size education. There is a very strong (learning) community, not only between students, but also between students and teachers. The small group size creates a safe environment for students, which encourages an active attitude, discussion and feedback. Teachers have control over, and attention to, the individual learning process of their students. A small group size is also considered necessary to give an optimal learning environment with sufficient guidance and facilities, like laboratories, and laboratory equipment and materials. Furthermore, small-scale education gives room for more creativity, autonomy and flexibility, all necessary conditions for optimal research- and IBL-based teaching. In addition, when group size increases there are not enough opportunities within UU for all CPS students to perform their research project. Students and teachers therefore consider 30-40 students as an optimal group size.
So far, the small-scale IBL set up has been labour intensive. Time was needed for teachers to adjust to this way of teaching and to develop and optimize their courses according to the educational view of the CPS. Coming study years, with all the experience obtained, teaching in the CPS will follow the Teaching Load Model (TLM) of the Faculty of Science and part of the education will be adjusted (see below - Education). According to the TLM courses will be achievable with groups of 30 students. With 30-40 students, CPS will fit perfectly into the TLM model and be financially feasible.

Education

In the development process of the CPS a deliberate choice was made for student-centred, research- and IBL-based learning. This approach has turned out to be very successful. Students feel challenged, motivated to learn and their creativity and self-regulation is stimulated. Students, alumni, teachers, and also supervisors of the research projects in both the CPS-programme as well as Master programmes, report the advantages of this approach. They all state that they feel that CPS students are far ahead of other bachelor, and beginning master, students when it comes to literature research, setting-up and performing experiments, and presenting their work, both orally and written. The students 'learn by doing' and obtain research skills that are necessary for their future profession.
Some problems with the teaching approach have been reported, the main one being the balance between structure and the autonomy and independence of students. Students sometimes feel a lack of guidance in how and what to learn. Teachers must be aware that their expectations should be made very clear to the students and that providing structure is necessary and does not interfere with the concept of IBL.

Professional development of the CPS teachers is therefore essential and should continue, just as regular meetings between teachers to exchange experiences. Innovative ways of teaching, such as blended learning and the flipped classroom, are interesting opportunities for teachers to improve their courses. This will also contribute to an improved, structured, IBL-environment and fitting the teaching activities into the TLM model.

Content

The CPS clearly distinguishes itself from other bachelor programmes, both within the Faculty of Science and the Netherlands, by its strong drug development and discovery approach (see Chapter 2), with a focus on immunology and neurology. Already from the beginning of the first year students have to use knowledge from other disciplines, like biology and chemistry, and apply this knowledge to come up with innovative ideas for new drugs. To keep its unique position, it is important that the programme stays broad and focuses on the content and skills needed for drug discovery and development.
Contact between the teachers and coordinators of different (elective) courses is essential to monitor the content of the programme, make sure that the drug development approach is the basis of each course, and keep a watch on the alignment between the different courses. This will be achieved by regular meetings with coordinators and teachers of the different courses. In addition, lines of disciplinary content and skills will be further developed and used as guidelines.

Communication

Commissioned by the Faculty of Science the company Young Works performed a study amongst high school students about their ideas and impressions about the CPS. They had several recommendations; some of them are already incorporated into the communication to high school students. Two points still deserve attention: the name ‘College’ is confusing and experienced negative by students, and the honours aspect and limited acceptance hold some students back to apply for the CPS. Both of them are important to consider when it comes to the impression students have about the CPS and in the future attention should be paid to them.

	Strengths	Weaknesses	Opportunities	Threats
Programme	• Strong involvement student and teachers	• Several Master programme coordinators do not know CPS Graduates from other programmes get priority • Lack of visibility and appreciation within the faculty and the University • CPS often not mentioned in contracts with international Universities, making exchange of students difficult • Final learning outcomes currently the same as those for the Bachelor of Pharmacy	• More international contacts and exchange opportunities for students • Set up an alumni network • Stronger connection with other bachelor programmes: biology, chemistry, (veterinary) medicine, biomedical sciences • Contacts with industry and other people outside university, more input from (pharmaceutical) industry will give students better perspective of future career perspectives • Have an own CROHO-label for the programme	• Shrinkage of the labour market for (pharmaceutical) scientists
Students	• Motivated, ambitious, eager to learn, enthusiastic students • At the end of the programme student have excellent research skills • International environment, meeting international students	• Not all students have honours level • Not enough interaction between students of different study years	• Portfolio set up more to personal development and achievements, with more reflective meetings between students and focus on metacognitive skills • Joint meetings with students and teachers of all three study years • More attention for professional attitude of students	

	Strengths	Weaknesses	Opportunities	Threats
Education	• 15 EC compulsory and elective courses offer more integration of practical and theoretical knowledge. More depth is reached in the 15 EC courses compared to 7.5 EC courses • IBL contributes very well to the academic training and research skills of students • Freedom of choice and autonomy, not only between courses but also within courses • Students feel challenged, motivated to learn and their creativity and self-regulation is stimulated • Clear, strong educational vision • Student-centred • Attractive, motivating, and inspiring way of teaching for the teachers • Students obtain skills needed for future profession (e.g. communication, research) • "Learning by doing" • Resit within every course	• Teachers not always have insight in the individual learning process of students during group products. • Students find that group grades have too much influence on the final grades, especially in the first year. • Students feel a lack of structure and guidance in how and what to learn • Students feel that books are not used (enough) • Too many small assignments • Group work not always experienced as having an added value • More diversity in assignments needed • Principle of IBL and choices made, focus on research, not always clear for students • New teachers not always aware of the principles of IBL, not enough support • Time intensive • Resit within every course sometimes difficult to plan	• More lecturers from outside university, like pharmaceutical industry • Give the students the feeling of living real science, involve them more in ongoing research • Innovative ways of teaching and feedback (eg. electronic feedback and assessment, flip the classroom, blended learning) • Professional development of teachers: honours-teaching, IBL • Train or guide guest speakers	• IBL-concept might be lost due to financial cut-backs, increased student numbers, staff shrinkage • Educational vision might not be supported by new teachers or management • Teaching Load Model might have a negative impact on the educational vision and the IBL concept of the CPS

	Strengths	Weaknesses	Opportunities	Threats
Content	• Focus on drug discovery and development • First year well balanced, good flow of topics, with a link between the first and last project • Reversed pipe-line approach • Guidance and meetings during research project helpful and informative • Interesting courses and subjects • Courses and products are related to, and relevant to, ongoing research and a scientific career • Training of academic and research skills • Broad scientific programme with a research focus • Lot of laboratory work, with opportunities to use specialised equipment • Interdisciplinary	• More background knowledge, and integration of knowledge and concepts, is needed • Not enough options for (English taught) elective courses due to limited capacity • Difficult to find a research group for the final research project • Statistics should be more incorporated in the whole curriculum • Reversed drug-pipeline sometimes experienced as difficult. Epidemiology least attractive for students. • Balance between theory and research is not always optimal according to some students and teachers • Lack of contact between coordinators different courses, content line should be looked after	• Broaden perspective to research beyond (Pharmaceutical) Sciences, focus on different research Masters • Broader offer of elective courses at honours level in cooperation and collaboration with other bachelor programmes (biology, chemistry, MLS, biomedical sciences) • Summer courses or research opportunities in summer • Scientific internships in the summer in external companies	• Become too specialised instead of being broad and focused on the wide range of knowledge and skills needed for drug discovery and development • Loss of specific content expertise within the department/faculty (e.g. bioanalysis)
Honours	• Challenging • Offers opportunities for personal initiatives • Stimulates self-directed learning	• Science and Pharmacy honours programme compulsory and not special, and challenging enough for the students • Students experience the Science honours programme very rigid and not attractive. It does not offer flexibility, freedom of choice, autonomy challenge and room for creativity • Students would prefer honours programme together with Medicine/Biomedical Sciences instead of Science	• Strengthen honours (science) community with an honours room with separate work-space • Make joining to Medicine and Biomedical Science honours programme possible (in addition to Science honours programme) • Free of choice honours course • Make honours programme more challenging • Undergraduate research conference and journal	

	Strengths	Weaknesses	Opportunities	Threats
Group size	• Strong community building • Teachers know students, personal approach • Strong interaction with teachers • Small group size creates a safe environment with room for discussion, feedback and reflection with other students and the teachers • Small scale education activates the students			• **Increasing group size** - Less insight, control over, and attention for the development and learning process of individual students - Professional behaviour of students decreases (eg. attendancy, behaviour in class) - Laboratory facilities (also of research groups), equipment and support - Scheduling of classes - Available (time) staff-members - Number of available places for research projects - Decreased community feeling - Negative effect on group dynamics - Less open and free atmosphere in class (eg. asking questions might become more difficult for some students) - Less room for creativity and freedom - Honours programme not prepared for large group students
Quality control	• Students give a lot of feedback to teachers, they feel that their input is taken seriously and that actions are taken to improve courses.	• Quality control is not on the right level yet, especially curriculum wide. • Caracal is not functioning very well, response is very low • Not all teachers are open for dialogue	• Exit questionnaire after completing the bachelor programme	

	Strengths	Weaknesses	Opportunities	Threats
Organisation	• Facilities • Laboratories	• More information needed on libraries, the campus and the city • CPS – Pharmacy introduction camp is not foreign student friendly • Introduction camp planned together with UU orientation day • Students need more information on elective choices, possible research projects and available master programmes • Students not always know where to go with questions	• Provide a booklet by email (not post) for (international) students with information on the study and the Netherlands. • Help finding a room for international students • Have student mentors for students of the first year (organised by country)	• Separate building for education and research. Interactivity, feeling of 'living' real science by students can be lost.
Admission and Selection procedure	• Good communication with, and help of, CPS staff with the procedure (like Studielink)	• Studielink very difficult to understand for international students • Entry demand physics causes problems for international students (most have combination biology – chemistry) • The name "college" appears to work negative for some high school students • The honours aspect and limited acceptance of students turns out negative for some students	• More focus on intrinsic motivation of students • Provide a guide with step-by-step directions for the application procedure • Make future prospects more clear to high-school students	

	Strengths	Weaknesses	Opportunities	Threats
Language	• Attention to speaking and writing skills in workshops by native speaker • Students' English improves very quickly due to the programme • English taught programme	• Written English in course manuals and exams is not always perfect • Teachers and students sometimes speak Dutch, making foreign students feel that they miss out on information • Some teacher experience difficulties in teaching in English and/or feel that teaching in English makes them less "spontaneous"		
ICT			• Social media: Facebook, blog • Showcase examples CPS products (e.g. movies, publications) on internet • Electronic lab journals • Use ICT more in assignments (movies, blogs, webpages) • Use ICT in educational design: e.g. flip the classroom, blended learning	
Communication and recruitment of students		• Pharmacy students at information days are not always informed enough about the CPS	• International visibility • More interesting website with videos of projects and/or presentations • Offering scholarships for international students	

7. Conclusion

A research- and inquiry based approach was successfully used for the development and implementation of the new pharmaceutical science undergraduate programme, the CPS. The first evaluation and audit shows that the curriculum is successfully implemented and is experienced very positively by students and teachers. The IBL-based curriculum has been a successful way of motivating students and teaching them essential research skills for pharmaceutical research. The students learn and perform at a high level, indicated by the level of their products and the experiences of the teachers.

The World Health Organization (WHO) describes new worrying trends such as the decrease in the number of new drug launches, the increasing costs of developing new chemical entities, and the many pharmaceutical projects that fail in the early stages of research, making the translation from basic science to applied product development a weak link (Kaplan & Laing, 2004; Kaplan et al., 2013).
The CPS trains students to make this translation from fundamental basic knowledge to the development of new, innovative drugs. This is the main aspect that distinguishes the CPS from bachelor programmes such as Molecular Life Sciences (MLS), Chemistry and Biology. The CPS-student must be able to apply fundamental knowledge, using drug development principles, to be able to come up with creative ideas for new drugs. CPS therefore has an added value to the other programmes offered by the Faculty of Science. Together, all these programmes cover the whole basis of the drug pipeline: from the fundamental biological and chemical knowledge needed for the discovery of new drugs (MLS, chemistry) to the application of this knowledge to design and develop new drugs (CPS), and the use of medicine in clinical practice.

The main ambitions for the coming five years for the CPS is to further improve and fine-tune the content and the educational model and further extend (international) cooperation. By incorporating blended learning, flipped classroom and other, evidence based, educational methods, the IBL principle will be further improved. Furthermore, these adjustments will make sure that the CPS curriculum will fit in to the TLM model and will be financially feasible with groups of 30-40 students per year. Contact with pharmaceutical industry will make the relevance and context for the students more clear. Attracting more international students and arranging exchange possibilities with other universities will improve internationalization of the CPS.

The development of a new curriculum is a cyclic process and may take many years (Van den Akker et al., 2009). In the first five years we have mainly focused on the relevance, content, consistency and practicality of the curriculum (Van den Akker et al., 2009). This process was presented at a conference, which has resulted in a book chapter. Another publication recently has been submitted (attachment 4). However, one of the most important criteria in the development of a new curriculum is its effectiveness; do the students of the CPS indeed have the essential skills to become an innovative and creative pharmaceutical scientist? (Van den Akker et al., 2009) And are they better trained to solve the complex multidisciplinary problems they will face in the pharmaceutical industry compared to students from other, more traditional curricula? This will be the challenge to investigate in the next years, thereby contributing to building on the knowledge about successfully implementing IBL-based learning environments within academic undergraduate research programs. To do so, building a strong alumni-network and following the careers of former CPS students is essential.

Overall one can conclude that the CPS programme is highly appreciated by all teachers and students involved. Furthermore, it is a unique programme, both the drug development related content and the educational approach. The CPS is therefore of an added value to the programmes offered by Utrecht University.

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Attachments

Attachment 1 – Overview CPS-audit

All meetings were led by Irma Meijerman. Notes were made by Anita van Oyen (teachers) or Sophia Jordan (students). The meetings lasted on average 90 minutes.

Code	Description	Present
CPS101	Drug Use	Andries Koster, Rob Heerdink
CPS102	Drug Delivery	Anneke van Houwelingen, Gert Folkerts, Roel Maas-Bakker
CPS103	Drug Target	Monique Slijper, Robbert Jan Kok
CPS104	Drug Molecule	Dirk Rijkers, Johan Kemmink
CPS211/212/213	Neuro-immunopharmacology	Liesbeth Bijlsma
CPS221/222/223	Analytical Techniques	Frits Flesch, Maarten Altelaar, Gerdien Korte-Bouws, Frank Redegeld
CPS322	Pharmaceutical Biotechnology	Enrico Mastrobattista
CPS380	Research project	Monique Slijper
CPS333	Pharma and nutrition	Linette Willemsen
CPS311	Organic chemistry II	Nathaniel Martin, Dirk Rijkers, John Kruytzer
CPS335	Proteins and disease	Monique Slijper
CPS336	Psychoneuropharmacology	Eric Hendriksen
CPS337	Bio-analysis	Frits Flesch
CPS312	Medicinal Chemistry	Dirk Rijkers
CPS339	Advanced Immunopharmacology	Aletta Kraneveld, Jolet Mimpen (student)
CPS338	Advanced Epidemiologie	Rob Heerdink
	Tutors	Ferdi Engels, Karin Slot
	Study Advisor	Carmen Janssen
	Honours programme	Tina Vermonden, Enrico Mastrobattista
	English writing and presenting workshops	Curtis Barrett
	Student office	Nel Annen, Edith van den Ham
	Information and communication	Daphne Deurloo, Carmen Janssen, Jolet Mimpen (student)
	Selection procedure	Daphne Deurloo, Andries Koster
	Students – year 1	Eline, Anita, Sophie, Alex, Igor, Pedro, Henry
	Students – year 2	Esmee, Koen, Xiouchun, Carla, Thomas, Moska, Erik
	Students – year 3	Anne Metje, Bastiaan, Phi Ngan, Lucas, Lotte, Sophia
	Alumni	Cedric, Tom, Amanda, Charlotte, Jimmy, Penelope
	International students	Ilias (Greece), Lynea (Canada), Inés (Spain), Eric (Zimbabwe, Germany, Netherlands), Xiaochun (China), Casellas (Spain), Kai (UK), Lucas (France, USA), Sophia (UK, Japan, Israel)

Attachment 2 - Learning outcomes

Learning outcomes have been defined for the Bachelor of Pharmacy and the College of Pharmaceutical Sciences.
The graduate should have developed knowledge, insight, skills and attitudes as specified below, at the level of an academic bachelor.

Knowledge and insight

The graduate has knowledge of and insight into:

- the most important processes and mechanisms involved in the disease processes;
- the different levels of organization (molecules, cells, tissues and organisms) and their interactions, in humans and animals;
- the major clinical pharmacological, epidemiological and (bio)-analytical research methods and techniques used in pharmaceutical research.;
- methodology and statistical methods, relevant for pharmaceutical research;
- the main groups of pharmaceuticals, their chemical and physical properties and their mechanism of action at the molecular and cellular level;
- the processes and theories that play a role in the metabolism, pharmacokinetics and pharmacodynamics of pharmaceuticals and other xenobiotics;
- routes of administration of medicines, and the influence of chemical and physical properties of pharmaceuticals on their storage condition and expiration date;
- social and ethical issues of pharmaceutical research, such as medical ethics (medical ethical committee, animal ethical committee);
- the safety issues of pharmaceutical research, such as legislation and regulation, relevant quality standards and quality models and the careful use of biological and chemical materials.

Skills

The graduate is able to:

- form an opinion and develop a viewpoint on pharmaceutical questions, thereby taking into account relevant scientific, social or ethical issues;
- find and analyse relevant data (literature, research data) in the pharmaceutical and (bio)medical field, critically judge these data and use them for research, to formulate a theory, and for the preparation and quality control of medicines;
- translate a clinical or fundamental pharmaceutical problem into a research question and subsequently, under supervision, design a (simple) experimental or compounding protocol, execute this and report about the results in a manner that fulfils scientifically accepted criteria;
- apply pharmaceutical laboratory techniques and skills under supervision, including pharmaceutical calculations and maintaining a laboratory notebook;
- report orally and in writing, present to, and communicate with a diversity of target groups (other academics, healthcare professionals and laypeople);
- discuss, reason, collaborate, and to give and receive feedback;
- reflect on his/her own development and (study)career, make conscious choices and commit to a further (study)career;
- perform pharmaceutical research both independently as well as in a team.

Attitudes

The graduate demonstrates:

- an respectful and constructive-critical attitude towards own and other people's plans, quality care systems, visions and research results;
- a social and ethical attitude towards science, society and social problems that affect the profession of researchers or pharmacists;
- a respectful and responsible attitude towards fellow students and other professional contacts;
- the ability to independently obtain relevant knowledge and skills and to maintain them lifelong.

Attachment 3 – Examples of Publications and research projects

Examples of Publications by CPS students

Boere, K. W. M., Soliman, B. G., Rijkers, D. T. S., Hennink, W. E., & Vermonden, T. (2014). Thermoresponsive injectable hydrogels cross-linked by native chemical ligation. Macromolecules, 47(7), 2430-2438.

De Vooght, K. M. K., Lau, C., De Laat, P. P. M., Wijk, R. V., Van Solinge, W. W., & Schiffelers, R. M. (2013). Extracellular vesicles in the circulation: Are erythrocyte microvesicles a confounder in the plasma haemoglobin assay? Biochemical Society Transactions, 41(1), 288-292.

Jordan, N. Y., Mimpen, J. Y., van den Bogaard, W. J. M., Flesch, F. M., van de Meent, M. H. M., & Torano, J. S. (2015). Analysis of caffeine and paraxanthine in human saliva with ultra-high-performance liquid chromatography for CYP1A2 phenotyping. Journal of Chromatography B: Analytical Technologies in the Biomedical and Life Sciences, 995-996, 70-73.

Koopmans, T., Wood, T. M., t Hart, P., Kleijn, L. H. J., Hendrickx, A. P. A., Willems, R. J. L., Martin, N. I. (2015). Semisynthetic lipopeptides derived from nisin display antibacterial activity and lipid II binding on par with that of the parent compound. Journal of the American Chemical Society, 137(29), 9382-9389.

Lau, C., Mooiman, K. D., Maas-Bakker, R. F., Beijnen, J. H., Schellens, J. H. M., & Meijerman, I. (2013). Effect of chinese herbs on CYP3A4 activity and expression in vitro. Journal of Ethnopharmacology, 149(2), 543-549.

Roda, M. A., Fernstrand, A. M., Redegeld, F. A., Blalock, J. E., Gaggar, A., & Folkerts, G. (2015). The matrikine PGP as a potential biomarker in COPD. American Journal of Physiology - Lung Cellular and Molecular Physiology, 308(11), L1095-L1101.

Examples of Research Projects by CPS students (overview is not complete)

Year	Student	Research Project
2011	D.J. Doorduijn	The effect of anxiolytic drugs on ultrasonic distress vocalizations in mouse pups with CRF-overexpression (extra project)
2012	D.J. Doorduijn	The functionality of TLR4 in murine fetal enteric neurons
	E. van Leeuwen	The endocannabinoid receptor 1 and dopamine Val158Met polymorphisms interaction in the learning of extinction during a fear conditioning task
2013	N. van Andel	Ritalin abuse
	T.H. Cheung	How much stress is needed to develop PTSD in rodents
	A.T. Droujinine	Immunoliposomes for identification and sorting of extracellular vesicles
	A.M. Fernstrand	Early life stress enhances susceptibility and intensity of cow's milk allergy in mice
	C.A.G.H. van Gelder	Determination of the antidepressant effects of vasopressin 1b receptor antagonists in olfactory bulbectomized rats.
	J. Jansen	Ritalin abuse
	F. Kassim	Design and synthesis of alfa-helix mimetics of asttressin

	J.W. Lefferts	Specific targeting of atherosclerotic plaques
	R. J. Mulders	Examining the onset of depression in the brain
	J. Titulaer	Sexual side effects of vilazodone
	R.E. Verdonschot	Sexual side effects of vilazodone
	T.M. Wood	New antibiotics derived from nisin
2014	L. Beroske	Synthesis of vancomycin mimics by incorporating a third covalent constraint by ring-closing metathesis
	K. Chahal	Occupational exposure to multi-walled carbon nanotubes and its effect on lung health in factory workers
	A.M. van Genderen	The effect of intrauterine infection on the development of the intestinal tract and how this correlates with brain development and behaviour
	S.C. de Graaf	Convenient synthesis of an entrobactin derived siderophore suitable for conjugation by CuAAC
	E. van Groesen	Optimization of new semisynthetic lipopeptide antibiotics based on nisin
	P.N. Phan	The role of neuroimmune interactions in the development of anhedonia (i.e. pleasure deafness)
	M.J.L. Scholma	The influence of diabetes type II on the metabolism of proteins, fat and carbohydrates
	L. E. Swart	Stapled peptides as novel approach for cancer therapy
	N.Y. Jordan	Physicochemical and biological evaluation of liposomes for targeting atherosclerosis
	J.H.K. Man	Optimization of new semisynthetic lipopeptide antibiotics based on nisin
	J.Y. Mimpen	The effect of branched-chain fatty acids on epithelial integrity and function using organoids

Attachment 4 – Publications

Irma Meijerman, Berend Olivier, Andries Koster (2014) The College of Pharmaceutical Sciences. An Inquiry-Based Undergraduate Honours Programme for the training of Pharmaceutical Scientists
From: Marca V.C. Wolfensberger, Lyndsay Drayer, Judith J.M. Volker (Eds.). Pursuit of Excellence in a Networked Society. Theoretical and Practical Approaches Coming from the Conference Evoking Excellence in Higher Education and Beyond. Waxmann, Münster/New York 2014, pp.51-56.

Irma Meijerman, Jan Nab, Andries Koster. Designing and implementing an inquiry based undergraduate curriculum in pharmaceutical sciences. Submitted to International Journal of Science Education