The role of guidance in student engagement with chemistry studies

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During recent years, the Department of Chemistry at the University of Jyväskylä has made an extensive effort to support chemistry students' first study year. The first-year curriculum includes enhanced study counselling course, intensive orientation course and support for academic study skills via a specific course. In this study, the effects of the revisions were studied by exploring the chemistry students study continuation and what factors contributed to it. In 2015 to 2017, data were collected from first-year chemistry students (n = 106), who completed a questionnaire at the beginning and at the end of their first semester. The results show that the percentage of dropout rates after the first year decreased. Students' current challenges are different than they have been previously, thus putting new demands on their guidance. The results of the study indicate that students value guidance and study counselling especially at the beginning of their studies.

Keywords: first year model, study experience, chemistry studies, dropout, study counselling

Article Details

LUMAT General Issue
Vol 7 No 1 (2019), 165–182

Received 29 April 2019
Accepted 1 November 2019
Published 7 November 2019

Pages: 18
References: 36

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https://doi.org/10.31129/LUMAT.7.1.402

1 Introduction

The significance of the first year of study for student dropout in university has been extensively studied (e.g. Heublein et al., 2003; Richardson & Coates, 2010; Thomas, 2002). Among the most common reasons for dropping out are students' lack of integration into formal and informal parts of the university, and difficulty in maintaining the motivation to study (Heublein et al., 2010; Rautopuro & Väisänen, 2001; Richardson & Coates, 2010; Tinto, 1975; 1997). High dropout rates in higher education may also be motivated by personal, economic or social factors (Villwock, Appio & Andreta, 2015). According to Crisp, Palmer, Turnbull, Nettelbeck and Ward (2009) first-year students' the most important challenges are that they necessarily always do not understand the difference between studying at an upper secondary school and at a university or they do not understand the demands of the university-level teaching-learning environment. Overall, the first year of college often is the most difficult for many undergraduate students (Yan & Sendall, 2016).

The dropout rates among science studies, especially in chemistry, have generally been high compared to other study programs (Hailikari & Nevgi, 2010). In Europe, as

much as one third of students has dropped out of their science studies (Ulriksen, Møller Madsen & Holmegaard, 2010). For example, the dropout rate among German bachelor students in chemistry has been up to 43% (Heublein, Richter, Schmelzer & Sommer., 2012).

First-year teachers and courses have an important role in students' motivation and continuity regarding their science studies, particularly those in chemistry (Hailikari & Nevgi, 2010; Havia, 2013; Johnstone, 2000; Ronkainen, 2015). The students' false expectations of the studies, the lack of a collaborative environment and study conditions affect students' motivation to continue their studies (Havia, 2013; Heublein, Spangenberg & Sommer, 2003; Workman & Bodner, 1996). Teaching and learning chemistry is commonly considered to be challenging (Bertels & Bolte, 2015; Johnstone, 2000; Ronkainen, 2015). The chemistry field is at risk of losing future scientists. The high dropout rates and prolonged study times suggest that procedures must be promoted at the institutional level in order to prevent or at least diminish this phenomenon. It is important to assure that the students complete their studies, not just attract more students to science, technology, engineering and mathematics (STEM) programs (Ulriksen, Møller Madsen & Holmegaard, 2015). The students who might be at risk of dropping out or who have a reduced ability to study successfully should be supported as early as possible (Lewis & Lewis, 2007).

The role of students' first year of study has become an important key in order to reduce dropout rates, especially in science education. In Finland, many of students in chemistry study programs have also applied to study medicine, pharmacy or veterinary medicine before starting studies in chemistry, physics or biology (Hailikari & Nevgi, 2010). In particular, the number of applicants for medical school has grown. For example, in 2013 at the University of Helsinki only 7% to 9% of applicants were accepted as students to the school's medical faculty (Räisänen, Kuitunen, Partanen & Österlund, 2014). The Department of Chemistry at the University of Jyväskylä has made extensive improvements to support chemistry students during their first year of study and to influence their commitment to their studies. This study presents those improvements and their effects on students' experience of first-year chemistry studies.

2 First year model in Department of Chemistry

The Department of Chemistry has made several improvements regarding the first year of studies. The students' engagement and study motivation have been increased by enhanced study counselling, collaborative interaction between students and personnel, integrated study programs and a compulsory orientation course for the new chemistry students. The first year of study in the department includes several courses and other supporting actions through which chemistry students' engagement with their studies and the department is increased. Figure 1 presents the most important of these courses.

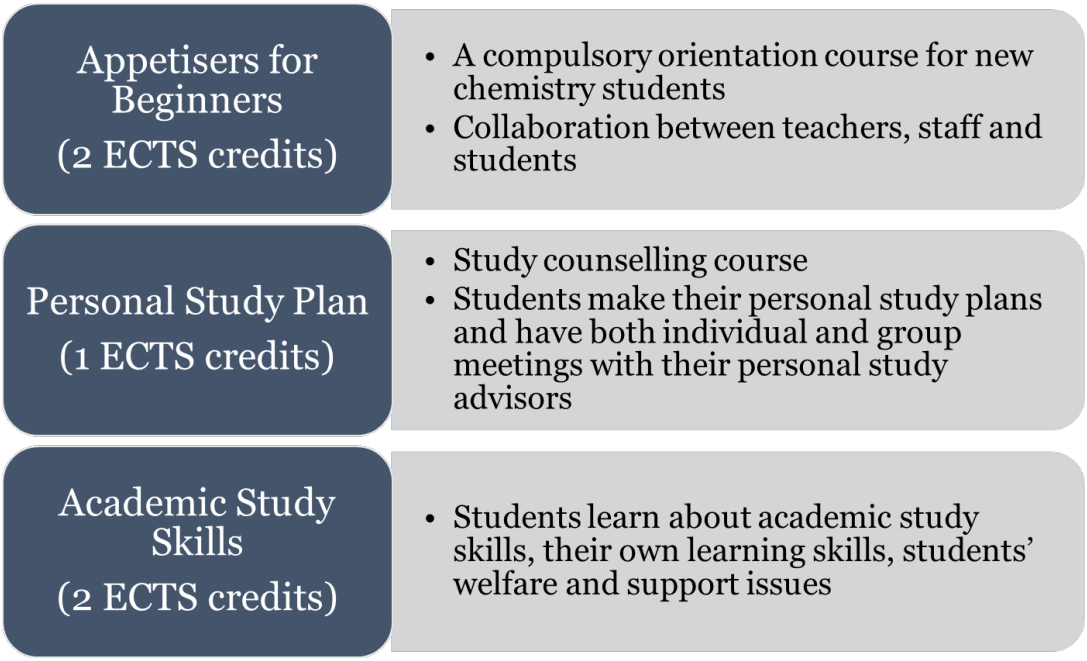

Figure 1. Courses supporting students' integration into the Department of Chemistry.

The department has developed a course entitled "Personal Study Plan" which continues throughout the first three years of chemistry studies until the bachelor's degree is complete (Valto & Lundell, 2015). In this course students make their personal study plans and have both individual and group meetings with their personal study advisors. The group meetings are held in small, familiar tutor groups to help students discuss more comfortably and ensure the opportunity to ask about all issues concerning life and studying. The main goal of this course is to help students approach their personal study advisors whenever they have questions or difficulties in their studies. The bachelor's studies also include a course called "Academic Study Skills" in which students learn about academic study skills, their own learning skills, students'

welfare and support issues. Our goal is to support our students in all areas of studying as well as in their life outside university. The "Academic Study Skills" course is a part of the Student Life and Goodie operating models, which the University of Jyväskylä started to develop in 2009. These models offer easily accessible help for every issue concerning life and studying.

"Appetisers for Beginners" is a compulsory orientation course for new chemistry students (Kiviniemi, 2013; Valtonen, 2008). It is carried out in collaboration between teachers, staff and students in the department. The main purpose of this course is to help the new students in their transition to university and to enhance their engagement with chemistry studies. It is conducted in the first few weeks of studies as an intensive introduction to the department, chemistry studies and different research areas. Figure 2 presents the general structure of the course.

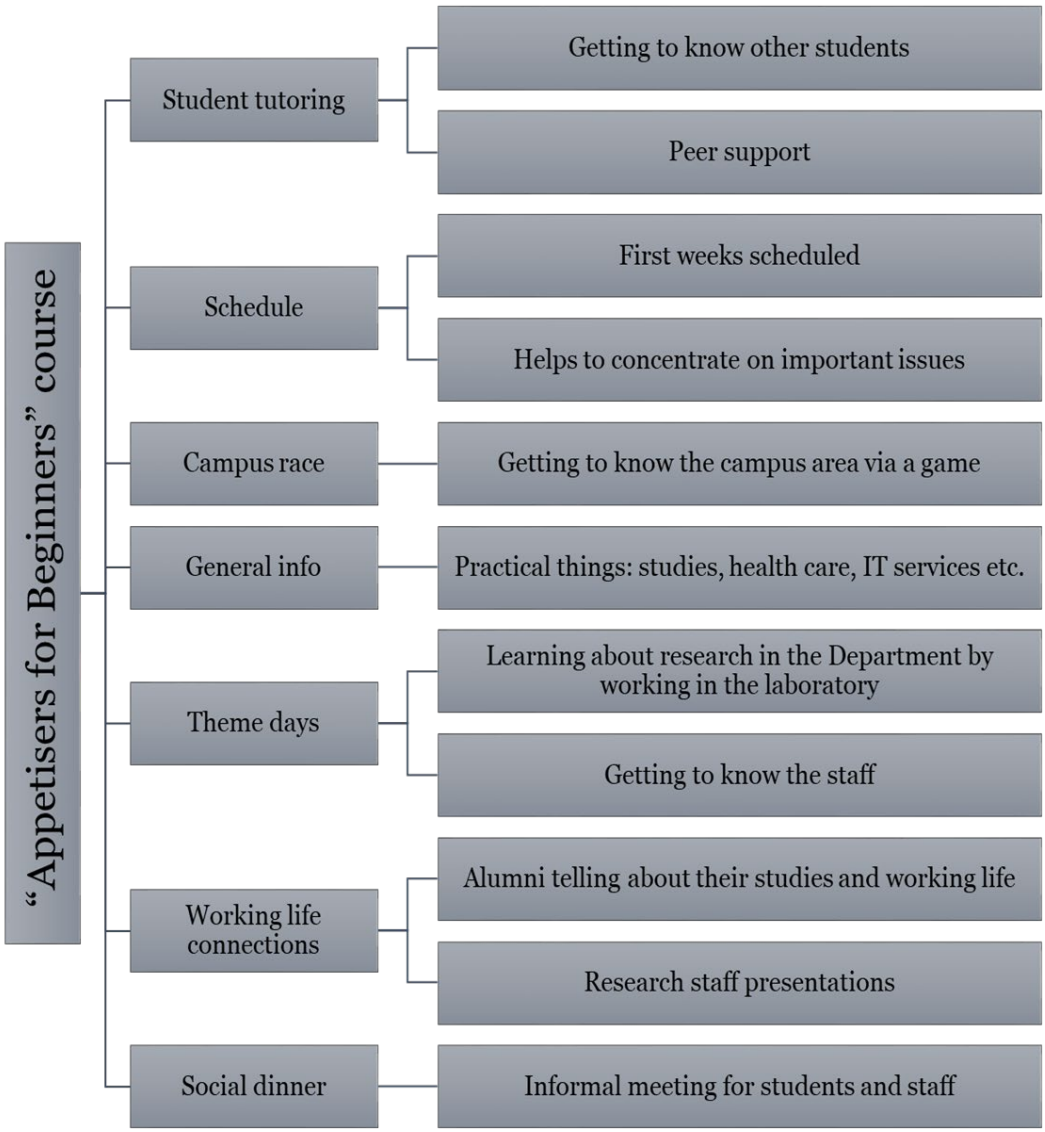

Figure 2. The structure of the "Appetisers for Beginners" course.

After this orientation course, students continue in the "Personal Study Plan" course in the same small groups with their assigned personal study advisors (Valto & Lundell, 2015). Small groups are also used in lecture and laboratory courses in chemistry. The collaborative group learning model continues throughout the bachelor's degree studies. In the "Appetisers for Beginners" course students complete a questionnaire (referred to as Q1 in this study) which asks about their study history and special study interests. This form provides important information concerning students' thoughts and main interests. The information collected with these forms is used as a basis for personal discussions with students, tutors and personal study advisors. The effect and meaning of the "Appetisers for Beginners" course have been studied previously (see Valtonen, 2008). Assessments of the course by teachers and students have been mainly positive and it seems that the course helps to create closer student–teacher relations, especially during the first year of study. These assessments have helped to further develop the orientation course together with staff and students.

3 Aims of the study

The aims of the present study are twofold. The first is to explore the continuation rate of students' chemistry studies: what were the students' first and other studying choices as well as dropout rates after first year of study. The student dropout rate and study success have already been assessed in a follow-up study (Valto & Lundell, 2015). The assessment of the first-year model with information gained from first-year students at the beginning and end of the first semester still in progress (for the period 2015 to 2017). The second aim is to analyze what factors contributed to the continuation of chemistry studies. The focus is on the role of study success (ECTS credits) and the ways the first-year model is reflected in the students' answers.

4 Methods

4.1 Data and participants

This research used questionnaires that students completed during their first days of studying in the department. The "Appetisers for Beginners" course questionnaire (Q1) was given at the beginning of the studies. It took about 20-minutes to complete the questionnaire. Between 2015 and 2017, the response rate was between 94% and 96%. Table 1 presents detailed data of the questionnaires. The results are based on

responses to the existing forms and the amount of collected forms varied depending on the year. The first-year students completed questionnaires (Q2) after the first semester during a compulsory inorganic chemistry laboratory course. It took around 10 to 15 minutes to complete the Q2 questionnaire. Table 1 shows the number of students who completed both questionnaires. Only those students (n = 106) who have completed both questionnaires have been included in this study.

Table 1. Detailed data from the research material.

Year	2015	2016	2017
Starting students [amount]	62	42	53
Questionnaire form Q1 [amount (% from starting students)]	58 (94%)	40 (95%)	51 (96%)
Questionnaire form Q2 [amount (% from starting students)]	43 (74%)	32 (76%)	36 (68%)

4.2 Data analysis and research quality

Both quantitative and qualitative analysis were used in the analysis phase. Quantitative data were analyzed by SPSS Statistics Version 24. Students responded to each statement using a 5-point Likert scale, with 1 indicating strong disagreement and 5 strong agreement. The Likert scale was chosen to allow objective quantification of the data. The qualitative data were analyzed by content analysis. Both researchers categorized the responses thematically and independently. After this phase, researchers discussed the results. They resolved the few disagreements through discussion and arrived at a consensus (Patton, 2015).

Students answered the questionnaires with their names because we wanted to combine questionnaires Q1 and Q2 with each other. All the names were coded at the end of the academic year. After the data were entered and coded on a computer, all the names were removed from the file. All the students in this study appear anonymously. The data analysis used the following codes: Student, number 1, 2, 3 etc. and year. Year refers to the year the questionnaire was completed. So, the codes are: Student 1, 2015, Student 2, 2015, Student 3, 2015 etc.

To determine the quality of the present study, the following analyses were conducted. Cronbach's alpha coefficient indicates scale reliability, and for this study the scales displayed satisfactory internal consistency. In the content analysis, two researchers made independent analyses and common conclusions were then reached after discussions, a process that adds reliability to the analysis. In a consensus-based theory of truth people can create truth by arriving at a consensus (Patton, 2015). The use of multiple coders in the analysis phase can be seen as a form of triangulation. The use of different kinds of analysis methods also adds triangulation.

5 Results

The results are summarized in the following sections. During research time, the basis of the chemistry courses curriculum and study application process was kept the same. However, some small changes were made in the contents of the study counselling course.

5.1 Students' primary studying choice and other studying choices

Chemistry students' main interests (primary study subject) after the first year of study have been compared. The questions in the questionnaire forms were as follows: *"Was chemistry your primary / only studying choice? If not, what was the primary one?"* During the period under study, chemistry was the primary choice for 34% to 40% of new chemistry students, and 59% to 66% of students applied to study a subject other than chemistry as a primary choice. Most of the chemistry students have been interested in applying to study medicine, pharmacy, dental medicine or veterinary medicine. These figures varied between 43% and 45%, depending on the year (see Figure 3). In comparison), the Department of Chemistry at the University of Turku lost 10 to 15 students annually to the Faculty of Medicine after the first year of study, according to a study by Lastusaari and Murtonen (2013). The same study found that those students (from chemistry or physics) have roughly a 30% higher chance of being admitted to the Faculty of Medicine than other students do.

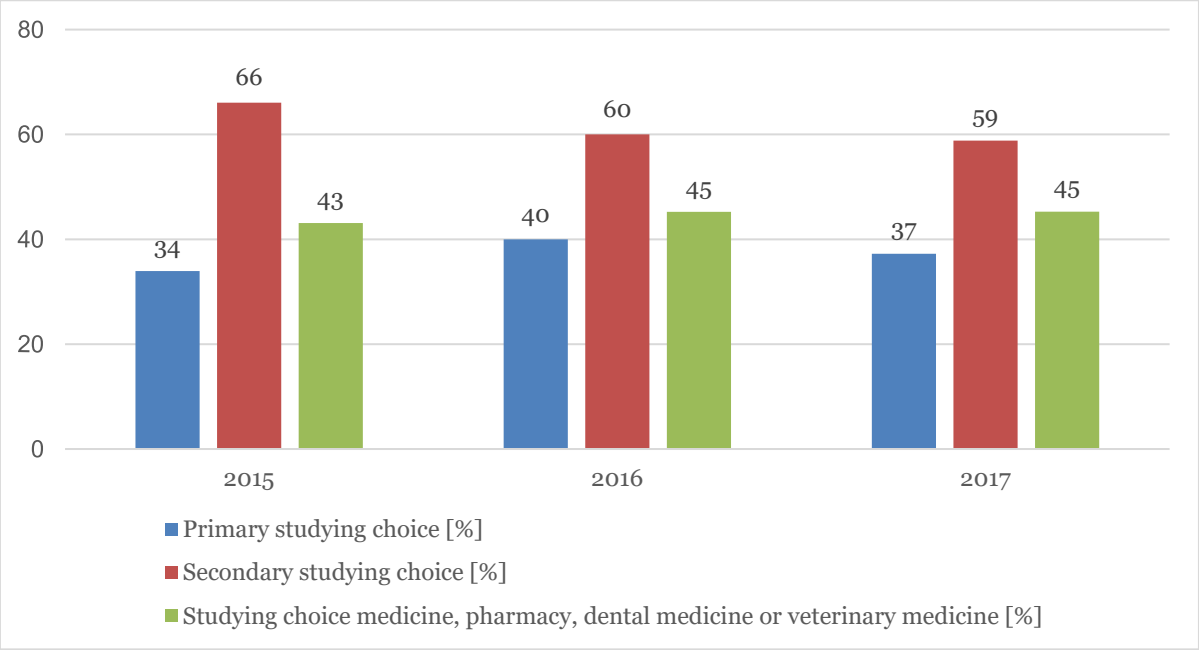

Figure 3. Chemistry students' studying choices based on an evaluation from students' answers to questionnaire Q1 (see Table 1).

5.2 Study continuity

First-year students' studying choices and continuation rate for the years 2015 to 2017 were compared. In each year, the majority of all chemistry students (68% (2015); 88% (2016); 79% (2017)) whose primary studying choice was chemistry also continued their studies in the department (Figure 4). Even though chemistry studies were the second choice for between 59% (2017) and 66% (2015) of the students (Figure 3), 57% (2017) to 71% (2016) of these students have continued their studies in the department (Figure 4). This might be due to the changes in Finnish educational applying system in which the first-time applicants are given priority.

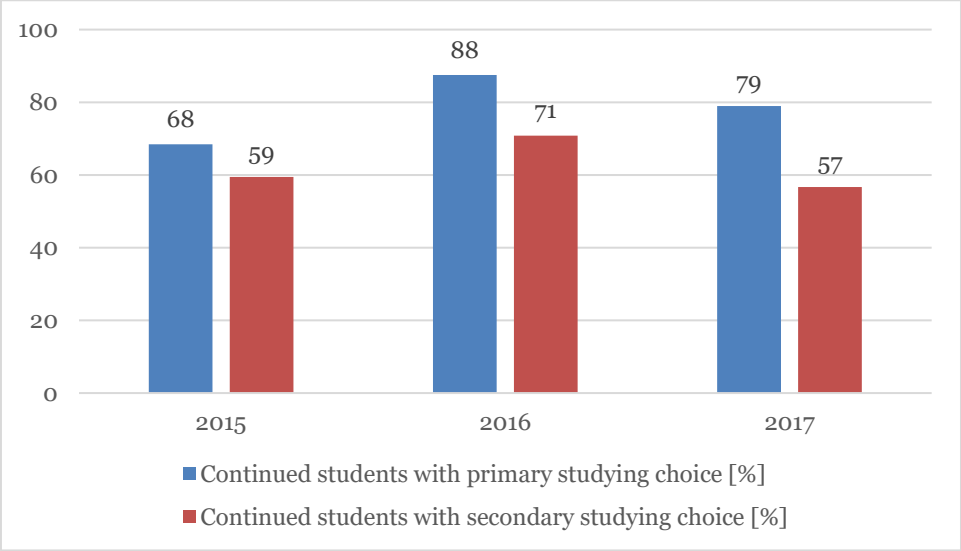

Figure 4. The students' continuation rate, 2015–2017.

The students were asked to answer the following open question: "*Is it possible that you will still change your studying* field*? Please justify your answer.*" We calculated the percentage of the answer that was *"maybe"*. Approximately a third of the students (34%, 2015 to 2017) commented that they were not sure if they want to apply again to their other studying choice. Here are a few students' answers:

> *"My primary studying choice was medicine but returning to it depends entirely on how I'm enjoying the first year here."* (Student 2, 2015)
>
> *"Medicine was my primary choice and chemistry was my secondary one. I will probably not pursue medicine anymore."* (Student 8, 2015)
>
> *"Chemistry was my secondary option. My primary choice was medicine. I still cannot say whether I'm looking for another field."* (Student 103, 2017)
>
> *"It was not, I primarily applied to the Medicine. This is probably just an intermediate stop."* (Student 78, 2017)
>
> *"All the subjects I applied to were related to chemistry. If studying chemistry feels right, I can hardly change."* (Student 85, 2017)

5.3 Dropout rate after the first year of study

Previously, the dropout rates in chemistry have been near 50% after the first year of study (Valto & Lundell, 2015). Nowadays, the dropout rate is about 26%. The data show the quantity of dropouts in the chemistry major at the University of Jyväskylä for the last three years. The number of dropouts in chemistry in recent years is as follows: in 2015 the dropout rate was 28%, and in 2016 and 2017 the dropout rate was 26%. On the other hand, there is some variation yearly in the number of new students. Despite the changes in number of starting students, there is no significant changes in the yearly dropout rates.

5.4 Factors that contributed to the continuation of the studies

5.4.1 The role of study success (ECTS credits)

A previous study has examined students' dropout rates after the first year of study along with their study motivation (Valto & Lundell, 2015). The students' study success and motivation were evaluated by measuring their overall ECTS credits during their first year of study. The number of students completing 55 ECTS credits during their first year has been increasing in recent years. Between 2015 and 2017, only 24% to 57% of the starting students earned 55 ECTS credits (see Table 2, Table 1 shows the number of starting students). In 2017, up to 69% of the students who continued to the second study year earned 55 ECTS credits. This amount is more than twice as high as it was in 2015.

Table 2. Students earning 55 ECTS credits among all the students who completed questionnaire Q1 in 2015 – 2017.

Year	2015	2016	2017
Students earning 55 ECTS in the first year of study [% of starting students]	24%	50%	57%
Students continued to second year and earning 55 ECTS [% of continuing students]	31%	61%	69%

5.4.2 Impact of the first-year model on student answers

The enhanced first-year study model aims to offer an inspiring study environment in which students want to continue their studies even though chemistry wasn't their first choice. The first-year model was also evaluated via questionnaires Q1 and Q2. Regarding to this Q2 questionnaire, the first-year students highly valued their first year of study experience in the department.

Table 3 presents sample items, means, standard deviations and Cronbach's alpha for the statements presented to chemistry students in the period from 2015 to 2017. The focus of the analysis was the following instruction: "Please respond to the following statements according to your own opinion on a scale of 1 to 5".

Table 3. Sample items, means, standard deviations and number of the students, 2015–2017.

#	Sample items	M (SD)	n
1.	The relationship between students and teachers is good in the department	4.28 (.62)	103
2.	Student tutoring helped me to become acquainted with student life	4.13 (.90)	103
3.	Studying chemistry has been meaningful	4.10 (.77)	105
4.	The "Appetisers for Beginners" course provided a good foundation for chemistry studies	4.10 (.90)	105
5.	Chemistry courses have been inspirational	3.83 (.83)	105
6.	The Department of Chemistry seeks to help me in my studies holistically	3.79 (.78)	103
7.	I feel I am part of a community of students in the field	3.79 (.93)	103

The Cronbach's alpha coefficient was 0.73, meaning the scales displayed good internal consistency. As can be seen from Table 3, students' perceptions of the claims were overall positive. Means ranged from 3.79 to 4.28 on a 5-point Likert scale. Students highly valued the relationship between students and teachers in the department. According to Krause, Hartley, James and McInnis (2005), academic staff has a key role in contributing to students' engagement with their study. Academic support is another important factor during the critical first year of college or university. During that time student success is in question. (Tinto, 2012). Table 3 shows that students felt student tutoring helped them become acquainted with student life. Students liked chemistry as a subject of studying. They felt studying

chemistry was meaningful and saw the courses as inspirational. The "Appetisers for Beginners" course offered a good foundation for later studies.

Table 4 shows how the students valued the different forms of support for studying. The focus of the analysis was the question "Please indicate your opinion about the following activities on a scale of 1 to 5". The reliability of questionnaire Q2 was high ($\alpha = 0.72$).

Table 4. Sample items, means, standard deviations and number of students, 2015–2017.

#	Sample Items	M (SD)	n
1.	"Appetizers for Beginners" course	4.28 (.75)	106
2.	The general atmosphere in the department	4.22 (.63)	106
3.	The expertise of teachers	4.21 (.77)	104
4.	Student tutoring	4.20 (.86)	106
5.	Student services	3.88 (.73)	104
6.	General image of the Department	3.89 (.74)	105
7.	Student counselling	3.81 (.85)	106
8.	Course offering	3.70 (.75)	104
9.	Information	3.56 (.82)	104
10.	Learning spaces	3.56 (.85)	105
11.	Study guide	3.52 (.76)	104
12.	Websites	3.41 (.87)	105
13.	Student wellbeing advisors	3.36 (.65)	105
14.	Student Life program	3.15 (.48)	104

As for the previous question, the students' perceptions of the all claims in this question were overall positive. Means ranged from 3.15 to 4.28 on a 5-point Likert scale. The "Appetisers for Beginners" course, a general atmosphere in the department, the expertise of the teachers and student tutoring all had averages over four.

Students also value student tutoring at a high level. When student tutoring was analyzed further, the annual differences were considered. Table 5 presents the years, means, standard deviations and number of students. Means ranged from 4.09 to 4.29. There was no significant change in students' answers: students valued the student tutoring at the same level every year.

Table 5. Student tutoring: years, means, standard deviations and number of students.

Year	M	SD	n
2015	4.09	1.00	43
2016	4.24	.87	29
2017	4.29	.63	34
Total	4.20	.86	106

6 Discussion and conclusions

This study had two aims. The first was to determine the continuation rate of students in chemistry studies. The second was to explore the factors that contributed to the continuation of the chemistry studies. Current study highlights development work in the Department of Chemistry at the University of Jyväskylä. During recent years we are especially focused on the first-year studies in chemistry and study success.

By improving the atmosphere of the entire learning environment and increasing the sense of communality in the department, we can also have an impact on the students' study success and the continuity in their chemistry studies. It is crucial for first-year students to have a positive experience because it is in first year of studies that universities either retain or lose the students (Bowles, Dobson, Fisher & McPheil, 2011; Lekena & Bayaga, 2018). Tinto (2012) observed that student success is directly influenced by the clarity and consistency of expectations and by their level. He adds that high expectations are a condition for student success.

The continuity of chemistry studies after the first year of study has been increasing in recent years. The results showed that a majority of the chemistry students whose primary studying choice was chemistry continued their studies after the first year of study (see Figure 4). The study continuity of the students whose primary studying choice was something else than chemistry has been at the same level. The values of these students who have changed their opinion and continued to study chemistry

instead of changing their major subject varied somewhat (see Figure 4). Previously, the dropout rates in chemistry have been approximately 50% (Valto & Lundell, 2015). Based on the current research, the dropout rate after the first year of study has fallen from 28% in 2015 to 26% in 2017 (e.g. Heublein et al., 2012; Ulriksen et al., 2015). This is a good result because the first year of college is difficult for many new students (Yan & Sendall, 2016; e.g. Crisp et al., 2009). However, chemistry, physics and mathematics are major subjects that suffer highest major changing rate in Finland. Also, these are the subjects which have highest dropout rates. In Finnish universities chemistry will lose on average 36.5 % of the total students annually (Lastusaari, 2018).

In order to complete a bachelor's degree (180 ECTS credits) in time in Finland, students should earn over 55 ECTS credits per year. This has affected students' achievements in their studies. However, the supporting study and counselling model, especially in chemistry students first year of study, seems to be essential. The study counselling model was improved and enhanced in 2012 (Valto & Lundell, 2015). The department's development work continues together with staff and students in order to maintain an inspiring study environment, support chemistry students in their pursuit of a bachelor's degree, enhance further cooperation with the students and develop meaningful study paths at the beginning of their chemistry studies. According to Lastusaari (2018) there is some kind of a possibility for the educators to have an impact towards persistence. Nelson (2014) states that a good first-year experience (FYE) is central for student engagement (e.g. Kantanis, 2000). Chen (2014) has made the same conclusions: the first year of college represents a critical juncture in STEM education. Chen (2014) also points out that retention is strongly influenced by students' experiences in their first college courses. Lastusaari and Murtonen (2013) highlight that more emphasis should be placed on the chemistry introductory courses to make them more interesting. For example, teachers could show how the course contents relate to the future careers of the chemistry students.

First-year university students need guidance and counselling especially at the beginning of studies. An orientation course such as "Appetisers for Beginners" developed by the department demonstrated a positive effect in the results, showing that the course provided a good foundation for chemistry studies. "Appetisers for Beginners" course contains interactive teaching by using student tutors (e.g. Lastusaari & Murtonen, 2013). According to Yan and Sendall (2016), many American universities and colleges have also begun to provide FYE programs for their first-year

students. FYE programs help students adjust to the university environment. These programs prepare students to be more successful in their university life.

The results of different counselling measures, such as student tutoring and student counselling, play an important role and are valued in the students' first year experience. The role of student tutoring was high because it helped students to become acquainted with student life. It is noteworthy that social and academic integration plays a significant role in first-year studies (e.g. Byl et al., 2016). According to García-Ros, Pérez-González, Cavas-Martínez and Tomás (2018), it is very important for universities to strengthen the support services and actions such as tutoring for first-year students (e.g. Cambridge-Williams, Winsler, Kitsantas & Bernand, 2013). It prevents any social, emotional or academic difficulties students may have in their first-year studies at university (García-Ros et al., 2018).

Between 2015 and 2017, the relations between teaching staff and students were valued as good or excellent. In contrast, the students' impression of the supporting Student Life model offered by the University of Jyväskylä remained uncertain in the first year of study. This result may be because they did not need these supporting services during their first year of study. For this reason, it can be seen as a positive result.

7 Implications

The results of the research also showed that student tutoring is highly valued. Researchers are currently examining the tutors' thoughts about paired peer tutoring in chemistry education. The development work of the tutoring system has shown that tutoring in pairs is a useful and efficient working method.

The Department of Chemistry has also started to use personal portfolios with starting chemistry students. Since the fall of 2018, students have started to make a portfolio in the study counselling course and it is used in discussions with personal study advisors. The main idea of the portfolio is to teach students to reflect on their ideas regarding studying and developing working skills during the studies.

More in-depth studies of our quantitative and qualitative data are in progress, with an emphasis on students' expectations of chemistry studies and their experiences from the first year of study. Additional survey questions posed to first-year chemistry students provide further understanding of students' attitudes toward chemistry

studies. Additionally, the department has begun to study its second-year chemistry students and their motivation to continue studying chemistry.

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