# Identifying Dropout Factors in Information Technology Education: A Case Study

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***Abstract*—Educators and researchers have been working to understand the reasons that may be contributing to high dropout rates, and low rates of participation, by females in the computer and information sciences discipline. Along the same lines, and propelled by the increased need for information technology (IT) professionals worldwide, we implemented a students' survey during the fall of 2015 in Norway's primary university for technological education. In this initiative we aim to identify reasons that may be contributing to high dropout rates, low rates of participation by females and aspects important for the efficient preparation of young people for careers in computer science and information technology. The results provide valuable insights and allow us to take appropriate measures for enhancing students' learning experience in the computer and information sciences.**

***Keywords— Retention; IT Education; Computer Science Education; Higher Education; Dropout.***

## I. INTRODUCTION

In recent years the problem of preparing young people for careers in information technology (IT) has attracted considerable attention, as the number of IT related degrees began to decline about 10 years ago and has only recently begun to recover [1].

As a result, many studies have been working to identify the factors related to IT enrollment, retention, and career choice. Xenos et al [2] identified five categories for drop out reasons in IT studies: professional (62.1% of respondents mentioned this), academic (46%), family (17.8%), health-related (9.5%), and personal (8.9%). Students were allowed to select more than one reason for dropping out. Academic reasons included beliefs such as that the student did not feel confident that he/she would be qualified enough to pursue university-level studies and a lack of assistance from the instructors.

Research in IT education indicates that the largest dropout point occurs in the first two years of their studies [3]. Approximately 40% of those who embark on a IT degree eventually leave without a degree, although this varies from about 30% to 60% depending on the institution [4]. Seymour and Hewitt [5] found that most of the students in their study who started in a science related discipline and switched to a different major made the change because they encountered poor teaching and advising, harsh grading, and heavy demands, that are quite common in these disciplines.

In this study we first briefly reviewed factors known to influence interest in IT education and career choice and then selected the appropriate measures based on the literature [2, 6-10]. Students were asked to use the offered survey as a constructive way to provide feedback about their teaching and course development.

The rest of the paper is organized into six sections. In the next section, the research questions are outlined. The third section describes the methodology employed to investigate dropout factors. The fourth section outlines both the qualitative and quantitative results of the empirical study; and the final section concludes the article with a summary of its contribution.

## II. RESEARCH QUESTIONS

The literature provides insights into a range of factors, such as students' performance or different learning styles, that may impact retention in STEM-related studies [11]. In particular, for IT studies, several negative beliefs and stereotypes exist related to the nature of the IT profession. These beliefs often prevent young people from seeking IT education and careers, or even leading them to drop-out from IT (or majoring in IT) [10]. A disinclination towards studying IT disciplines implies that more research is needed to investigate how students could be retained [12, 13].

Many believe that IT education is just like any other STEM field with certain recruitment and retainment difficulties; however, it seems that the situation in IT education differs from other STEM fields and needs special attention [14]. This is of particular importance, since IT competences are vital skills for the 21st century. IT skills and competences allow students to "construct" and "create" meaningful artifacts using computers [15]. In particular, skills such as computational thinking, which include problem solving, complex systems design, and evaluation as well as human behavior understanding, are cornerstones of IT education.

Previous studies [6, 16, 17] have empirically investigated numerous issues related to students' perceptions, beliefs, and experiences regarding IT studies. Although past studies provide some understanding of IT retention, the need for further studies

comes from the lack of consistent research results, the changing nature of IT studies, as well as societal demands (e.g. industry demands). The factors that affect student decisions to complete their studies can be classified as broad (not specific to particular content) and content specific.

In this work, we followed this rationale and after reviewing the respective literature, we identified both the broad and the content specific factors. After that we designed a survey in order to measure those factors and distributed during the fall of 2015 in Norway's primary university for technological education. We then captured data from 435 IT students who responded to our survey. In this contribution we focus on exploring the most important reasons an IT student might dropout from his studies. Precisely, we address the following research questions:

**RQ1.** What are the main attitudinal differences between female and male IT students?

**RQ2.** What factors (generic to higher education) impact students' intention to complete their studies in IT?

**RQ3.** What reasons to leave your studies impact students' intention to complete their studies in IT?

## III. RESEARCH METHODOLOGY

### *A. Sample description*

The sample of participants in this study consisted of 435 IT students. Of the 435 participants, 353 (81.2%) were males and 82 females (18.9%); this corresponds to 41.19% response rate (given that the CS dept. has 1056 students total). Notable, females' participation was very high 57.34% (82 out of the 143 female students) compared to males 38.66% (353 out of 913 male students). All of the students that participated in the study were from 18 to 55 years old, with the mean age being 22.68 (S.D. 3.34). The study was conducted over a period of one month, from mid-March to mid-April. As is illustrated in Table I, some students did not indicate their study program; nevertheless, the number of responses can be considered representative since the response rate was greater than 30% in every study program.

TABLE I. RESPONSE RATE PER STUDY PROGRAM

| Study Program | Total registered students | Respondents | Respondents in % |
|---|---|---|---|
| Master in CS (5 years) | 525 | 205 | 39.04% |
| Bachelor in Informatics | 392 | 152 | 38.78% |
| Master in CS (2 years) | 44 | 18 | 40.91% |
| Master in Informatics | 88 | 28 | 31.82% |
| Master in Information Systems | 7 | 7 | 100% |
| Undefined | - | 25 | - |
| Total | 1056 | 435 | 41.19% |

Respondents are from all the five study programs of the CS dept. (see Table 1), in particular 50% of the respondents were from the 5-year integrated study program of Master in Computer Science, 37.1% from the 3-years Bachelor in Informatics, 6.8% from the 2-year Master in Information Systems, 4.4% from the 2-year study program Master in Computer Science and 1.7% from the international study program Master in Information Systems.

Students were also asked about the importance of social media in learning. Seventy percent of the students mentioned that YouTube videos should be connected with the coursework, other social media like Wikis (54.5%) and Facebook (43.6%) were also found to be helpful for students. Students also endorsed the use of other social media such as Twitter (6.4%), Google Plus+ (7.5%), Blogs (20.9%) and Reddit (20.4%) to mention few. Figure 1 exhibits the responses of students regarding the potential of social media their work.

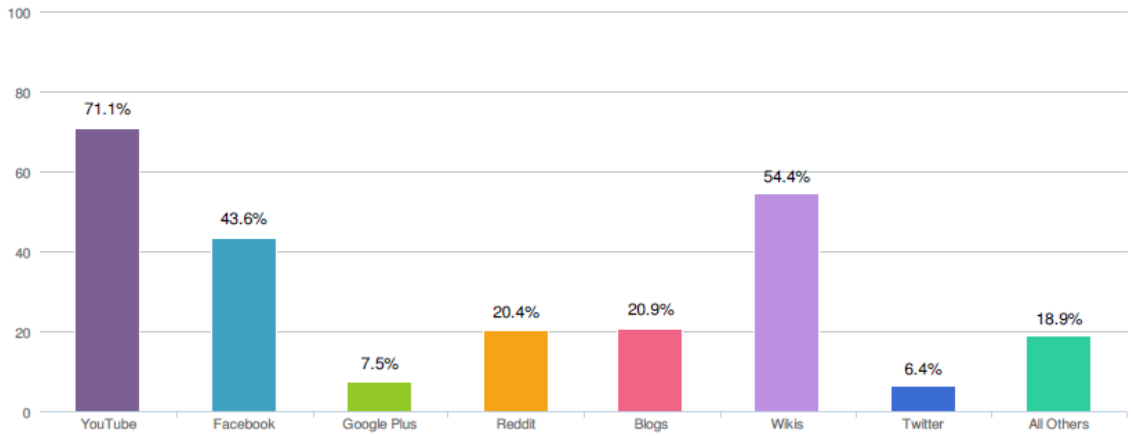


Fig. 1. *Presentence of student mentions regarding what social media should be connected to the course work*

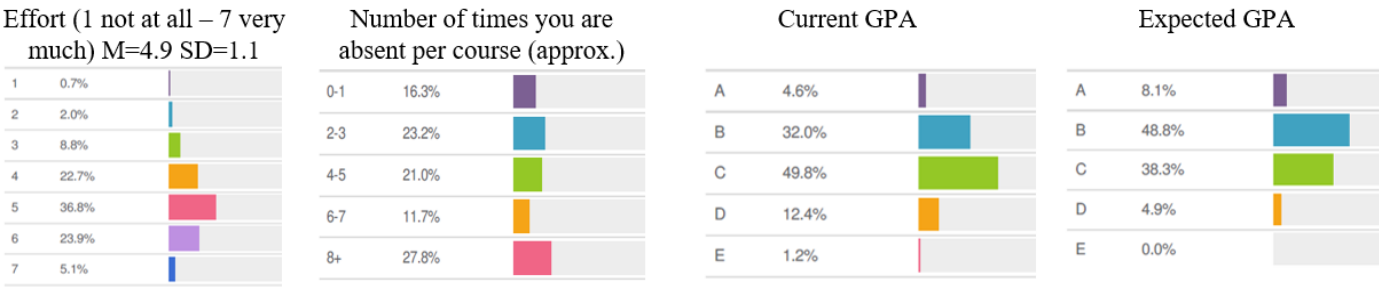


Fig. 2. *Percentage of respondents per effort, absence, current GPA and expected GPA*

As per students' effort, very few believe that they put very little or very much effort on their studies. Regarding students' attendance in the lectures, almost 40% of the students are absent less than three times per course, however another 40% of the students is absent more than six times. As per their Grade Point Average (GPA), almost half of the students have a C and one third B; many of them hope to be able to increase their GPA for at least 1 grading scale (see Figure 2).

As we mentioned before, respondents were distributed among the five year of studies; in Figure 3 you can see the percentage of the respondents per year of studies (left) and per study program (right).

As per students' dropout, figure 4 shows the dropout rates for the previous years at the department. This information was gathered in the fall of 2016, so it includes students from all study programs, including the five-year study program. The dates presented in the figure, are the dates that the students started their studies (2009-2014). The data are divided based on gender, into male and female dropout. For both genders, we present dropout and early dropout rates. Early dropout describes the students that dropout in the first or second year of studies (depending on length of the study program). Dropout describes the students that dropout later in their studies. Thus, students that entered in 2014 may decide to dropout later leading to an increase on the dropout percentage. Also, N represents the actual number of students that started their studies in that year. For example, in 2009, 302 males and 32 females started studying at the department. Out of the 302 males, 24,5% dropped out if their studies and 0,3% dropped out early. Similarly, out of the 32 females, 21,9% dropped out of their studies, and none dropped out early.

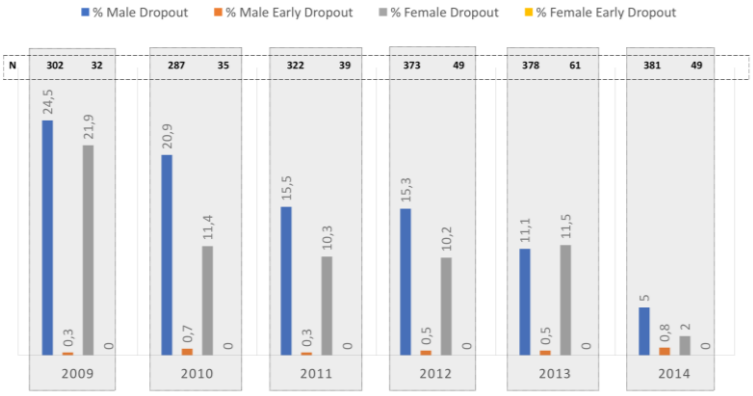


Fig. 4. *Students' general factors per gender*

## B. *Measures*

The survey of the study consists of four different parts.

1. Questions on the demographics of the students (age, gender) as well as information related to their study program, the year of their studies and questions related the overall teaching and content of the subjects.

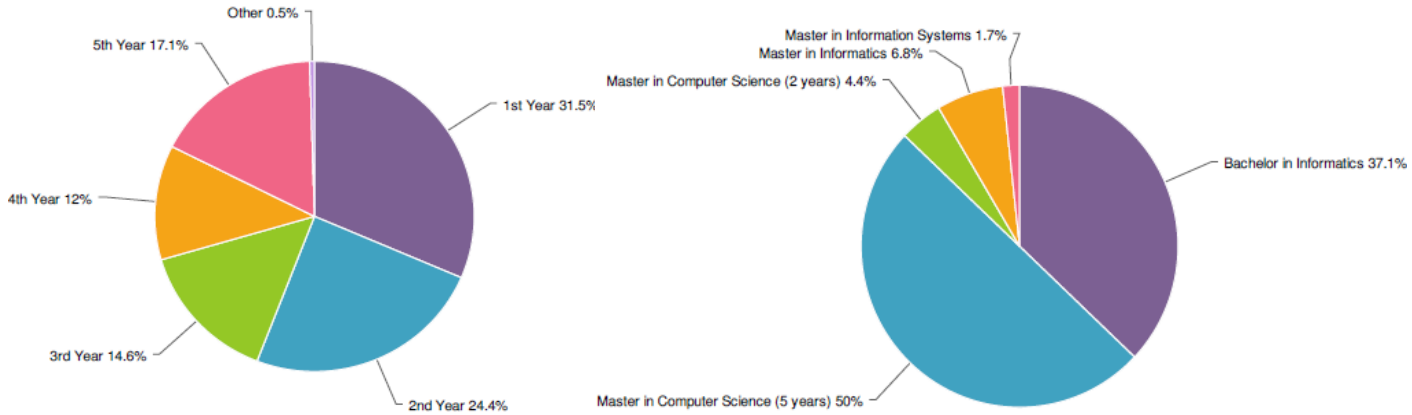


Fig. 3. *Percentage of respondents per year of studies (left) and per study program (right)*

2. Measures/questions of the various factors identified in the literature from previous studies as important (during studies in higher education – general studies). Table 2 (next page) lists the operational definitions and the number of items/questions used for each of the factors. In addition, we provide the literature reference (source) of each factor. In every question, we used a 7-point Likert scale anchored from 1 marked as 'strongly disagree' to 7 marked as 'strongly agree'.

3. Measures/questions of the various factors identified in the literature that might impact students' decision to leave IT studies. Table 3 lists the operational definitions and literature reference (source) of each factor; single question/item was used to measure each factor, with a 7-point Likert scale, anchored from 1 marked as 'not at all' to 7 marked as 'very much'. Students' were asked to indicate the degree to which these factors might impact their decision to leave their studies.

TABLE II. IMPORTANT FACTORS FOR STUDIES IN HIGHER EDUCATION, OPERATIONAL DEFINITIONS

| Operational Definition | Acronym | # of questions (items) | Source |
|---|---|---|---|
| Gains cognitive learning and development | Cognitive | 6 | [18] |
| Gains in non-cognitive learning and development | NonCognitive | 3 | [18] |
| Academic challenge | Challenge | 6 | [8] |
| Active and collaborative learning | Collaborative | 5 | [8] |
| Student–Faculty Interaction | SFInteraction | 5 | [8] |
| Enriching Educational Experiences | Enriching | 6 | [8] |
| Supportive Campus Environment | SupportiveCampus | 6 | [19] |
| Degree's usefulness | Usefulness | 3 | [19] |
| Intention to complete your studies | Not2Dropout | 3 | [20] |
| Intention to continue (or reenroll) your studies in IT | ReAttend | 4 | [20] |

TABLE III. MAIN REASONS TO LEAVE YOUR STUDIES, OPERATIONAL DEFINITIONS

| Operational Definition | Acronym | Source |
|---|---|---|
| Various reasons (not related to the studies) | ExternalFacrors | [2] |
| Quality of the studies offered | QofStudies | [22] |
| Focusing to students that are already related in some way to the subject of the studies | HighPerformersFocus | [2] |
| Bad estimation of the time required | TimeRequired | [2] |
| I am not sure I am able to pursue university-level studies in IT | Unconfident | [10] |
| Negative opinion about the education offered at IDI | NegativeExperience | [10] |
| I do not feel as if I belonged in IT | Belongingness | [21] |
| I am unhappy with my grades | Grades | [2] |
| Excessive workload | Workload | [2] |
| The curriculum does not provide enough flexibility | Flexibility | [22] |
| A non-computer science career would be more fulfilling to me | Fulfilling | [21] |
| Classes were unfriendly | Unfriendliness | [2] |
| Overall curriculum was too difficult or too lengthy | Difficulty | [2] |
| Poor teaching by IT faculty or teaching assistants | PoorTeaching | [22] |
| Classes were boring | Boring | [21] |
| The curriculum is too narrow and could not bring together my interests outside of IT | Narrowness | [2] |
| The classes are too big | BigClasses | [10] |
| Few of my friends are studying IT | SocialNorm | [10] |

4. Open-ended questions that look for feedback about (a) student experiences, (b) specific activities and attributes that help them improve their learning and complete their studies, and (c) additional over-all comments on the IT studies in the CS department.

### C. Data Analysis

In order to examine possible attitudinal differences between female and male CS students (RQ1), the analysis of variance (ANOVA) test was used, which is one of the most widely accepted methods in educational research [23]. ANOVA was performed for both the factors for studies in higher education and the main reasons to leave your studies.

In sequence, to examine possible predictors of students' intention to complete their IT studies, a series of multiple regression equations were calculated using factors identified as important for studies in higher education as well as students' age and gender (RQ2).

Next, we wanted to examine possible predictors of students' intention to complete their studies, based on the main reasons students leave their studies (RQ3). To do so, a second series of multiple regression equations were calculated using factors identified as main reasons to leave studies.

As for the data collected via the open-ended questions, the text corpus were 28 pages. In order to be able to complement our quantitative findings for RQ1,2,3; we used qualitative analysis to provide concrete recommendations. In particular, after all the responses were collected, we proceeded with a content analysis. Two researchers (coders) read all responses first, coding important keywords until categories emerged from similar codes. The results then discussed with a second researcher and reached consensus in the final categories; we followed the method described by Glaser and Strauss [24].

## IV. FINDINGS

### A. Descriptive Result and Gender Differences (RQ1)

In our effort to investigate students' learning experience, we measured factors identified in the literature as important in promoting students' learning in higher education. Respondents expressed a very high intention to complete their studies (Not2Dropout), as well as the usefulness of their studies (Usefulness), the cognitive gains (Cognitive) and their intention to continue their studies (ReAttend) in the CS dept. Additionally, they expressed slightly lower gains in non-cognitive learning and development (NonCognitive), academic challenge (Challenge), active and collaborative learning, enriching educational experiences (Enriching) and supportive campus environment (SupportiveCampus). Finally, they rated student-faculty interaction a bit low (especially the female students), in that phase we did not identify any significant differences between female and male students; figure 5 exhibits the detailed results.

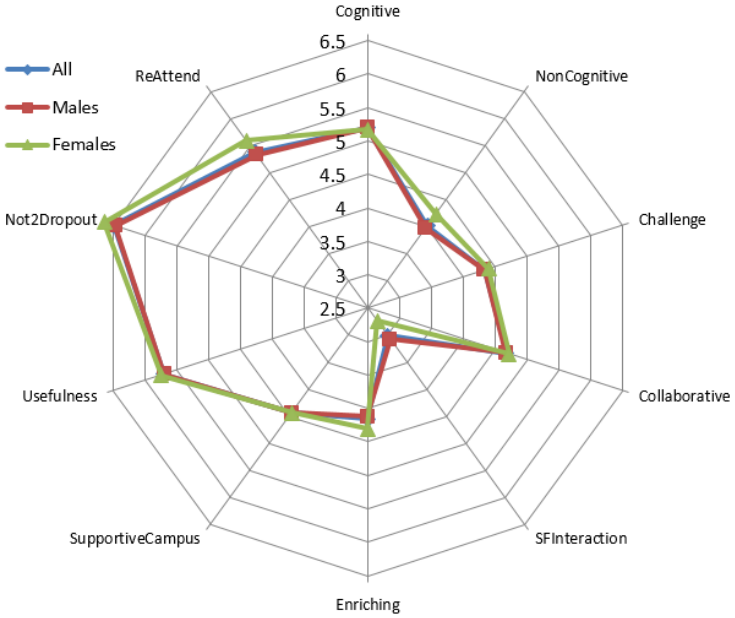


Fig. 5. *Students' general factors per gender*

After investigating students' learning experience on the basis of factors related to tertiary (general) studies. We attempted to measure and investigate factors related to tertiary IT studies with the aim to understand if and how they impact students' decision to leave their degree. Hence, in this section a high score of a factor means that this factor impacts' a student's decision to leave their studies. Respondents expressed that, poor teaching, external factors, workload, quality of the studies, time required, grades, boring courses, and focus on high performers might somehow impact their decision to leave their studies (see figure 6). In our analysis several differences were identified between female and male students. Females were found to be impacted more from poor teaching, difficulty of the subject, excessive workload, low grades and focus in high performers. The detailed results can be seen in figure 6 (next page); where * indicates a significant difference ($p < 0.05$).

### B. Quantitative Findings to Predict Students' Intention to Complete their Studies (RQ2 and RQ3)

A number of studies have predicted that certain factors may be associated with career orientation and decisions. For instance, [10] note that the study program, social support, self-efficacy and playfulness are associated with IT career orientation. To examine possible predictors of students' intention to complete their studies, a series of multiple regression analyses were calculated using scores 1) on factors generic to studies in higher education (RQ2) and 2) on factors related to IT education (RQ3).

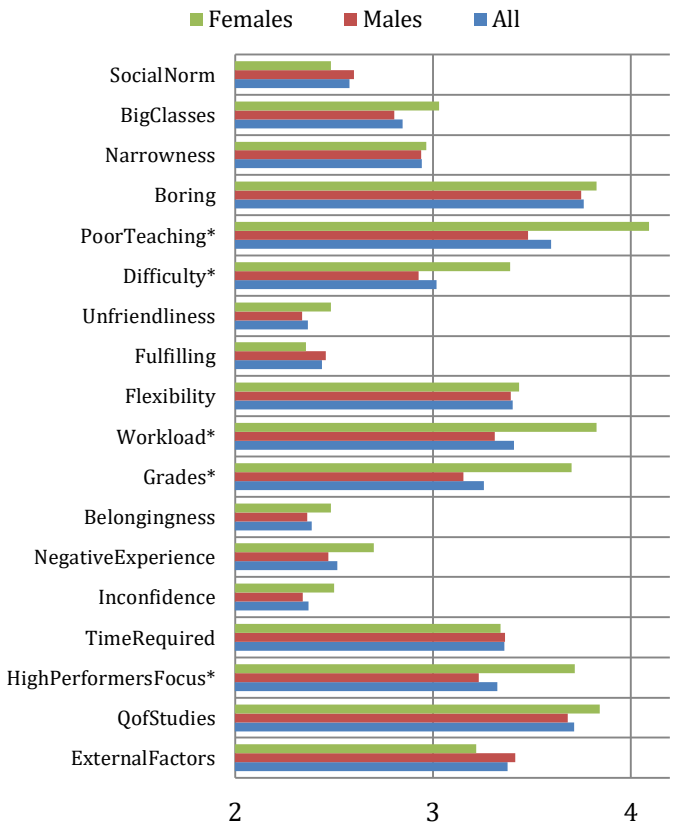


Fig. 6. *Students' responses related to different factors on IT education, per gender*

The results of the regression analysis to predict students' intention to complete their studies based on factors generic to studies in higher education are shown in Table 4 (next page). The overall model was significant (F (11, 264) = 11.814, p=0.000, $R^2$ = .330). The eleven-predictor model accounts for 33% of explained variance in students' intention complete their studies. In particular, the regression equations show a differential pattern of factors generic to studies in higher education predicting students' intention to complete their degree. Age (Older students are less likely to dropout) and scores on the 'Collaborative', 'student-faculty-interaction', 'degree's usefulness' and 'follow up with IT postgraduate in IT studies (reAttend)' factors predict students' intention to complete their studies.

TABLE IV. PREDICTING STUDENTS' INTENTION TO COMPLETE THEIR STUDIES (NOT2DROPOUT) BASED ON FACTORS GENERIC TO HIGHER EDUCATION

| Variable | β | t | Sig |
|---|---|---|---|
| Gender | 0.015 | 0.284 | 0.777 |
| Age | 0.165 | 3.136 | **0.002** |
| Cognitive | 0.014 | 0.206 | 0.837 |
| NonCognitive | 0.043 | 0.639 | 0.523 |
| Challenge | 0.020 | 0.321 | 0.749 |
| Collaborative | 0.126 | 1.985 | **0.048** |
| SFInteraction | 0.383 | 5.345 | **0.000** |
| Enriching | 0.198 | 2.952 | **0.003** |
| SupportiveCampus | 0.067 | -.940 | 0.348 |
| Usefulness | 0.322 | 4.706 | **0.000** |
| ReAttend | 0.228 | 4.095 | **0.000** |

The results of the regression analysis to predict students' intention to complete their studies based on factors related to IT education are shown in Table 5. The overall model was significant (F (18, 316) = 6.613, p=0.000, $R^2$ = .274). The predictor model accounts for 27.4% of explained variance in students' intention complete their studies. In particular, the regression equations show a differential pattern of factors related to IT education predicting students' intention to complete their degree (Not2Dropout). Based on the results from table 5, 'Negative experience', 'Flexibility', 'Fulfilling' and 'Narrowness' factors predict students' intention to complete their studies.

TABLE V. PREDICTING STUDENTS' INTENTION TO COMPLETE THEIR STUDIES (NOT2DROPOUT) BASED ON MAIN REASONS TO LEAVE YOUR STUDIES

| Variable | β | t | Sig |
|---|---|---|---|
| ExternalFacrors | 0.054 | 0.993 | 0.322 |
| QofStudies | 0.120 | 1.732 | 0.084 |
| HighPerformersFocus | -0.096 | -1.417 | 0.158 |
| TimeRequired | 0.002 | 0.0342 | 0.973 |
| Unconfident | -0.259 | 3.441 | 6.576 |
| NegativeExperience | 0.160 | 2.237 | **0.026** |
| Belongingness | -0.119 | -1.404 | 0.161 |
| Grades | 0.112 | 1.707 | 0.089 |
| Workload | 0.019 | 0.232 | 0.817 |
| Flexibility | 0.142 | 2.035 | **0.043** |
| Fulfilling | 0.203 | 2.491 | **0.013** |
| Unfriendliness | -0.019 | -0.275 | 0.784 |
| Difficulty | 0.144 | 1.585 | 0.114 |
| PoorTeaching | 0.080 | 1.082 | 0.280 |
| Boring | -0.042 | -0.570 | 0.569 |
| Narrowness | -0.170 | -2.342 | **0.020** |
| BigClasses | 0.043 | 0.660 | 0.510 |
| SocialNorm | 0.109 | -1.827 | 0.069 |

### C. Qualitative Findings

In addition to the standardized questions, we used three free-entry questions to capture any additional information and suggestions from IT students. The responses from the free-entry questions of the qualitative part of this study were utilized. After collecting the responses, we proceeded with a content-based grouping, as described in the data analysis section. Following, we summarized the emerged categories/recommendations, alongside with some exemplar student responses (italicized) from students.

- **Create the right environment to support students' learning, based on accessible/learnable materials**

  *I learn best by watching short (5 min) and on point learning videos. Put the content online, and focus on creating the right environment for practice.*

  *My IT studies would have gone slightly easier if there were conceptual videos (available in different video qualities) available along with lecture slides, a need usually covered in most TDT subjects.*

  *Relevant assignments and YouTube-tutorials. Reading and doing task by my own and discussions with friends also help a lot!*

  *In courses with just textbook and lectures I spend the double amount of work each week, get easily tired and learn less.*

  *My way of leaning is to initially scroll through recap notes and/or lecture notes of the curriculum before putting it to use in an assignment, or an exercise in the textbook, given that I have bought it beforehand. I also tend to watch recitation videos, which summarizes the core concepts of different parts of the curriculum that I particularly struggle with. If needed, I also search for different exercise videos, which show me how tasks directly relevant to my subject's exams are carried out.*

- **Intensify practical hands on learning experiences, group projects and practical/regular assignments**

  *Regular assignments with work and required understanding/need to research topic out of class.*

  *In my experience side projects is my best way of learning. Each time we learn something new I try to expand my project so I can use what I learned in the project. With own projects comes also a lot of errors you have to figure out yourself which I learned a lot from.*

  *Interesting assignments is the most important. Programming exercises and projects are a great motivation…*

  *Regular exercises every two/three weeks, is the best. With typically six out of eight that needs to be accepted.*

- **Use learning/supportive technologies consistently between courses**

  *Some courses use it's learning (the LMS of the university), other courses use their own wikis. Would be easier if everyone used the same pages*

  *Try to hold all information about the course in one place. It's learning or any other system work fine.*

- **Link project/assignment work with grades**.

  *Assignments projects etc. linked with grades/exams.*

  *Don't make written theoretical exams count 100%, as this is so much less relevant than actual practical work*

  *Interesting assignments that contribute a lot to your overall grade*

  *More courses should integrate assignments that count as part of the final grade, instead of the grade being decided solely by one exam.*

- **Maintain/increase flexible study options**

  *Divide the studies into smaller modules with more freedom for the students.*

  *It's very important to be able to select my own courses. I have been able to do this a lot at my study program (informatics), which has been very motivating. This practice should continue.*

  *I would have liked to have a more research oriented option towards the end of the studies*.

- **Instruct in layman's terms, pay particular emphasis in beginners**

  *A little too difficult to follow the instructors in lesson for new beginners at IT. They speak as if I have been into the subject for years, like themselves.*

  *In larger lectures it can be embarrassing to ask a question about something elementary which was mentioned several minutes ago. As such not many do so.*

## V. Discussion and Conclusion

This study presents a survey study conducted at the CS dept. in Norway's primary university for technological education (i.e. NTNU). This study focused on identifying reasons that may contribute to students' learning experience and retention. We presented an exploratory analysis in relation to gender differences (RQ1) and the relationships among factors identified in the literature as important and students' intention to complete their studies in IT (RQ2 and RQ3). Our data confirm some general findings (e.g., gender differences and the important role of the first year), and also identify factors that can predict students' intention to complete their studies. In addition, to the differences and predictors emerged from the quantitative analysis; an analysis of the qualitative data depicted additions considered highly important from IT students.

Last but not least, although the respondents' rate was high and we tried our best to have valid and reliable measures and results, the report is exploratory and has certain limitations. It is important to emphasize that these analyses are based on one set of data collected from a single survey study; this places significant limitations on how strongly we can interpret and generalize the reported patterns. Future research is needed not only to replicate and verify the patterns we have reported, but also to determine whether these results characterize students

who have left their studies (dropout) or others who have graduated and now work in the industry (e.g., via an alumni survey).

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## REFERENCES

[1] Zwedin, S. 2014. Computing Degrees and Enrollment Trends: From the 2012-2014 CRA Talbee Survey. Computing Research Association, Washington D.C.

[2] Xenos, M., Pierrakeas, C., & Pintelas, P. (2002). A survey on student dropout rates and dropout causes concerning the students in the Course of Informatics of the Hellenic Open University. Computers & Education, 39(4), 361-377.

[3] Huang, P., & Brainard, S. G. (2001). Identifying determinants of academic self-confidence among science, math, engineering and technology students. Journal of Women and Minorities in Science and Engineering, 7(4), 315–337.

[4] Ohland, M., Sheppard, S., Lichtenstein, G., Eris, O., Chachra, D., & Layton, R. (2008). Persistence, engagement, and migration in engineering programs. Journal of Engineering Education, 97(3), 259–278.

[5] Seymour, E., & Hewitt, N. (1997). Talking about leaving: Why undergraduates leave the sciences. Boulder, CO: Westview Press.

[6] Biggers, M., Brauer, A., & Yilmaz, T. (2008). Student perceptions of computer science: a retention study comparing graduating seniors with cs leavers. In ACM SIGCSE Bulletin (Vol. 40, No. 1, pp. 402-406). ACM.

[7] Joo, Y. J., Lim, K. Y., & Kim, J. (2013). Locus of control, self-efficacy, and task value as predictors of learning outcome in an online university context. Computers & Education, 62, 149-158.

[8] Pirker, J., Riffnaller-Schiefer, M., & Gütl, C. (2014). Motivational active learning: engaging university students in computer science education. In Proceedings of the 2014 conference on Innovation & technology in computer science education (pp. 297-302). ACM.

[9] Pike, G. R., Kuh, G. D., McCormick, A. C., Ethington, C. A., & Smart, J. C. (2011). If and when moneymatters: The relationships among educational expenditures, student engagement and students' learning outcomes. Research in Higher Education, 52(1), 81–106.

[10] Rosson, M. B., Carroll, J. M., & Sinha, H. (2011). Orientation of undergraduates toward careers in the Computer and Information Sciences: Gender, self-efficacy and social support. ACM Transactions on Computing Education (TOCE), 11(3), 14.

[11] Marra, R. M., Rodgers, K. A., Shen, D., & Bogue, B. (2012). Leaving engineering: A multi-year single institution study. Journal of Engineering Education, 101(1), 6–27.

[12] Giannakos, M. N., Pappas, I. O., Jaccheri, L., & Sampson, D. G. (2016). Understanding student retention in computer science education: The role of environment, gains, barriers and usefulness. Education and Information Technologies, 1-18. doi:10.1007/s10639-016-9538-1

[13] Pappas, I., Giannakos, M., & Jaccheri, L. (2016). Investigating Factors Influencing Students' Intention to Dropout Computer Science Studies. In Proceedings of the 2016 ACM Conference on Innovation and Technology in Computer Science Education (ITiCSE '16). ACM, New York, NY, USA, 198-203.

[14] Guzdial, M. (2015). Top 10 Myths about Teaching Computer Science, in Communications of the ACM, http://cacm.acm.org/blogs/blog-cacm/189498-top-10-myths-about-teaching-computer-science/fulltext

[15] ACM/IEEE Computer Engineering Curricula, (2016). Curriculum Guidelines for Undergraduate Degree Programs in Computer Engineering. Technical report, Association for Computing Machinery (ACM) IEEE Computer Society.

[16] Barker, L., Hovey, C. L., & Thompson, L. D. (2014). Results of a large-scale, multi-institutional study of undergraduate retention in computing. In Frontiers in Education Conference (FIE) (pp. 1–8). IEEE.

[17] Barker, L.J., McDowell, C., and Kalahar, K. (2009). Exploring factors that influence computer science introductory course students to persist in the major, SIGCSE Bull., 41(1), 153–157.

[18] Toutkoushian, R. K., & Smart, J. C. (2001). Do institutional characteristics affect student gains from college? The Review of Higher Education, 25 (1), 39–61.

[19] Joo, Y. J., Lim, K. Y., & Kim, E. K. (2011). Online university students' satisfaction and persistence: Examiningperceived level of presence, usefulness and ease of use as predictors in a structural model.Computers &Education, 57(2), 1654–1664.

[20] Litzler, E., & Young, J. (2012). Understanding the risk of attrition in undergraduate engineering: Results fromthe project to assess climate in engineering.Journal of Engineering Education, 101(2), 319–345.

[21] Rountree, N., Rountree, J., Robins, A., & Hannah, R. (2004). Interacting factors that predict success and failure in a CS1 course. In ACM SIGCSE Bulletin (Vol. 36, No. 4, pp. 101-104). ACM.

[22] Petersen, A., Craig, M., Campbell, J., & Tafliovich, A. (2016, November). Revisiting why students drop CS1. In Proceedings of the 16th Koli Calling International Conference on Computing Education Research (pp. 71-80). ACM.

[23] Zientek, L. R. & Thompson, B. (2009). Matrix summaries improve research reports: secondary analyses using published literature. Educational Researcher, 38, 5, 343–352. doi:10.3102/0013189X09339056.

[24] Glaser, B., & Strauss, A. (1967). The discovery ofgrounded theory. London: Weidenfeld and Nicholson, 24(25), 288-304.