Formative Tutoring: A Program for the Empowerment of Engineering Students

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***Abstract*—*Contribution:* A model of tutoring program for the empowerment of engineering students in the information and communication technologies (ICT) area is proposed, as a mean to improve academic performance.**

***Background:* ICT students failing to proceed smoothly along their study path, and possibly abandoning university before graduating, is becoming a significant phenomenon in many countries. This is an important issue both from the student side and from the university side: the former is facing social and economic consequences, while the latter may be hindered in the ranking systems.**

***Intended Outcomes:* Design and application of tutoring actions that can lead students to empower themselves, develop several soft skills, and eventually improve personal and academic success.**

***Application Design:* Starting from the literature on tutoring, the approach of the "Tutorìa formativa de carrera" has been selected, because it considers students as the center of the learning model. The tutoring interventions have been then redesigned and tailored to the specific context of ICT courses.**

***Findings:* The effectiveness of the proposed program has been assessed by means of different indicators: self-perception of the participating students (based on Cawi surveys), success rate at the first mathematical exams as a short-term qualitative indicator, and long-term figures of merits of the students' career. In the latter case, proper techniques are used in order to create a quasi-experiment context. A significant impact of the proposed program is found for both students with high and low *a-priori* propensity to academic failure.**

***Index Terms*—Active learning, drop-out, empowerment, self-efficacy, soft skills, tutoring, vocational guidance.**

I. Introduction

SUPPORTING the academic success of students, and preventing university drop-out before graduation, are becoming urgent issues for any Higher Education institution [1], [2]. These issues are addressed also in the Bologna Process (1999–2010) [3], [4].

In the Higher Education context, significantly increasing the time to graduation, or being unable to get the final degree, are important failures both from the student side and from the university side [5], [6]. The student may completely lose self-esteem in his or her own capabilities, and hence give up forever the chance to improve his or her education level. Furthermore, such a situation may be lived as a waste of the efforts and resources that families are providing to give access to university to their young members, resulting in a series of social and psychological consequences. Universities are generally hindered in national evaluations or in international ranking systems due to the failure rate of their students. More importantly, universities are failing their basic educational mission and for the cases in which higher studies are funded by national governments, this is also a social issue and a waste of public resources.

Engineering courses of study in the area of interest of the IEEE, i.e., in the information and communication technologies (ICT) area, are also affected by the above-mentioned dynamics [2], [5]. Education institutions in this area are urged to implement proper strategies to improve the academic performance of each student. A quite common and straightforward action to address this issue is to increase the interventions by teaching assistants and to provide supporting resources, such as exercises, homework, laboratory activities, and massive online courses (MOOCs); new teaching methodologies (such as problem-based learning, team-based learning, flipped classroom, and so forth) are often proposed [7], [8], [9], [10], [11], [12]. However, the assumption underlying this kind of approach is that students are facing obstacles due to personal weaknesses just related to the scientific disciplines that characterize the ICT area. It is therefore assumed that the main reason why students fail the first exams (typically mathematical analysis, basic physics, and sometimes basic computer programming) is a general lack in mathematical and logical background [1], [13]. Actually, a wider perspective is needed, understanding that students may experience difficulties along their study path also due to the lacking of some soft skills [14]: whenever they experience an educational transition (from high school to university, from undergraduate to graduate studies, etc.), they may not be able to adapt themselves to the new context, to quickly understand how the new and complex institution works, to modify their approach to study, to integrate with a new (and often larger) group of mates, just to quote some examples. A potentially more effective approach could be to consider each student as the center of the educational process and addressing him or her in a more holistic way. This helps giving attention to both academic and personal issues. Unfortunately, these are the skills that students often struggle to master, hence designing a series of educational interventions to empower them should be an issue of broad interest within the community of engineering education.

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The design of an articulated set of tutoring interventions, to stimulate the development of soft skills by the students and to foster academic success and student retention, is presented in this article. Starting from the wide literature on tutoring (see Section II), especially in the university context, a reference model is singled out (*Tutorìa Formativa de Carrera),* and then a redesign is proposed to adapt the program to the specific context of ICT engineering courses (formative tutoring (FT) program) (see Section III). The expected result by applying the FT model is that each student is enabled to empower him or herself, developing some soft skills and also making the approach to study scientific subjects more effective. This is actually the most relevant expected outcome of the whole FT model, but an improvement of academic performance and hence a reduction of potential university drop-out may also take place as a consequence of the students' empowerment. In order to verify such a claim with objective data, a detailed evaluation process of the proposed tutoring program has been also designed, and some results are presented in Section IV.

II. Background and Tutoring State-of-the-Art

Tutoring is a complex and articulated phenomenon, and its application involves different dynamics and strategies [15], [16]. In the educational field, the term is now generally associated with actions and functions related to support and enhancement dynamics and to facilitation dynamics, such as facilitation of learning, communication, and relationships [17], [18]. The literature proposes the tutorship as a complex action, held in an interactive, purposeful, and systematic way by trained people, the tutors, who play a specific role, which is different from the "professional teacher" role [16]. A tutor can express his/her function not only as a supporter and a facilitator but also with other impactful roles, such as, among others, as an inspirer, a motivator, a counsellor, a communicator, and a problem solver [19], [20]. Since tutorial dynamics can take on different forms and objectives, we could find in the literature multiple tutoring practices: peer tutoring or tutoring led by an expert figure; e-tutoring or face-to-face tutoring, 1:1 tutoring relationships or activities with different tutors, and so on [21], [22]. The focus of this article is on tutoring in the university context: university tutoring can play a substantial role in the educational pathway of university students [23], by responding to their needs through multiple activities and dynamics that support the university experience [24].

The need to enhance university tutoring is connected to the necessity to respond to the new education and training needs of the "knowledge-based society," as focused in the Bologna process (1999–2010), which later resulted in the creation of the European Higher Education Area (EHEA) [3]. Tutors are identified as one of the essential "human" elements that could meet students' needs, by proposing a model of student-centered learning, implemented with flexible learning and teaching methods [25]. Tutoring actions in university help to promote conditions of real equity among students, and are, in fact, powerful strategies to contrast dropout, foster student retention [6], [26], and support the whole educational pathway [21], [27], [28], [29], in a perspective of holistic enhancement of the person and promotion of autonomy and academic success [23].

In the light of the many national and international experiences on this topic, the *Tutorìa formativa de carrera* [30] has been identified as a model of particular interest. The model is based on the social cognitive approach [31], [33] in terms of self-efficacy, responsibility, and academic commitment, and operates according to a preventive and proactive logic. The choice of the *Tutorìa formativa de carrera* as a reference model stems also from the pedagogical completeness of the proposed program, in terms of reflection on soft skills, developed according to a multilevel tutoring action: teachers, students, services, and experts, in a synergic perspective, act as a training action to support the students' academic careers.

The program presented in this article is called "Formative Tutoring"[1] (FT) and it is the result of the customization of the original Spanish proposal for the Italian context, with a particular focus on the application in the ICT area, at the University of Padua. It can be synthetically defined as the synergic contribution of different actions, carried out by several kinds of tutors, to promote the holistic development of a group of students, throughout their university career. The tutor facilitates the autonomous learning of students from a personal, academic, and professional point of views. The FT is a tutoring action because every activity proposed to the students is led and mediated by tutors with specific roles, that always differentiate between the typical roles of teachers, students, or administrative officers. It is formative because it leads the students in the process of developing and strengthening their personal and professional skills.

III. Application Design and Methodology

The FT model is the result of a long process of research and experimentation, carried out by a multidisciplinary team (engineers, pedagogics, and statistical scientists). The current methodological framework stems from 1) the analysis of the literature regarding student retention and the identification of the specific needs of the context; 2) the identification of the Spanish *Tutorìa Formativa de Carrera* model as a valuable resource to address the issues identified; and 3) the customization of the Spanish proposal to be effective in the University of Padua context and, more specifically, for an application in the ICT area. In this article, we focus specifically on points 2) and 3), by presenting the methodological choices that led to the development and customization of the FT.

The FT [25], [28] and the original *Tutorìa Formativa de Carrera* are both centered on the student and on his educational success. In summary, the implemented methods and the practices are connected to the research hypothesis that the tutoring actions, carried out by different tutors, are effective tools to prevent and address students' drop-out, in particular through the strengthening of important soft skills. The authors recognize in this approach an effective way to answer to some students' needs, filling a gap in the university supporting actions, usually concentrated of disciplinary skills. The experiment described in this article aims to demonstrate the

[1] tutorato formativo (TF) in Italian.

validity of these initial assumptions and the effectiveness of the proposed activities.

The FT is designed as a formative path consisting of a series of activities offered to university students of different degree courses in the ICT area. These students, who are usually at their first year, are arranged in groups and meet different tutors who propose ad hoc activities, following a scheduled calendar (usually, 12–14 meetings are proposed in a year). This multilevel tutoring structure was already present in the Spanish model, and it has been recognized as a strength of the original model, and thus transposed and extended to the Italian FT. Therefore, the FT includes, like the Spanish model, the contribution of teachers (tutoring actions) and "veteran" students (Peer Tutoring actions), who have both a strategic role in the proposed activities, as it will be described with more details in Section III-A. There are however some differences in the Italian model regarding the tutoring figures, such as, for instance, the involvement in plenary sessions of the staff of some university services [Service Tutoring (ST)] (e.g., libraries, Erasmus office, economic office, didactic and administrative office, etc.) and of Experts leading specific laboratories (Expert Tutoring) (e.g., about study methods). The choice to involve these additional tutoring figures is connected to the specific needs of our context, according to the context analysis [28].

The objectives of FT can be summarized as follows.

1) To facilitate students to become familiar with the new university context and to be at ease with it.
2) To enhance students' participation in the university life and context.
3) To improve students' personal knowledge and facilitate their learning process.
4) To develop strategies for academic and professional decision making.

These goals are graphically summarized in Fig. 1, where they are also associated with the soft skills that TF aims to enhance as a mean to reach each specific goal. These connections will be deepened in Section III-C.

The process that led from the Spanish model to the current FT for the Italian context (represented by the University of Padua—UNIPD), can be better understood by highlighting some phases related to its practical implementation, which are explored in Sections III-A–III-E.

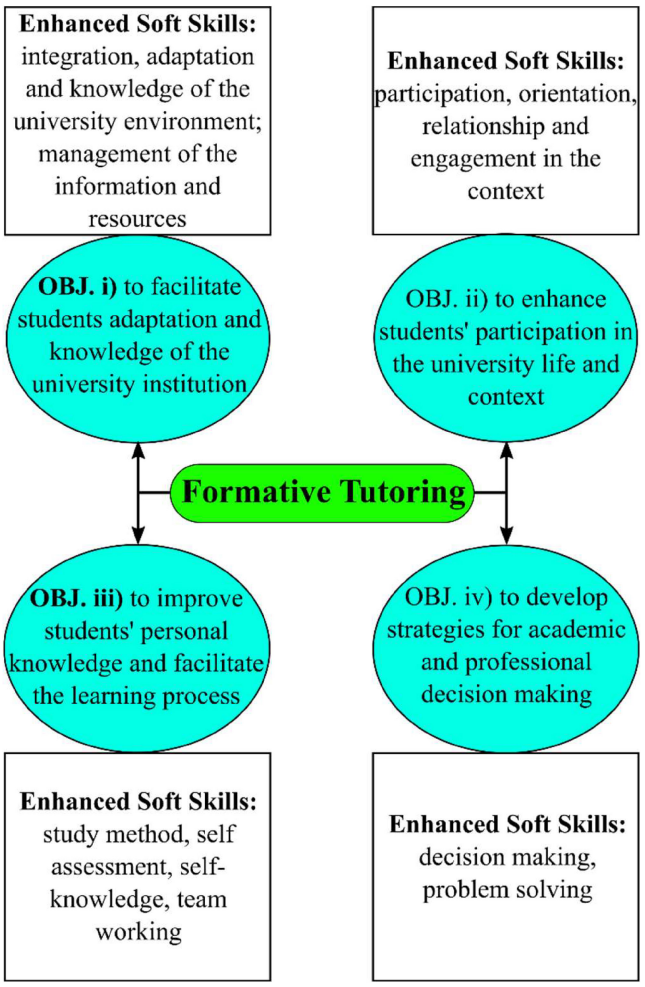

Fig. 1. Main objectives of the FT and corresponding skills which are enhanced through the proposed activities.

A. Tutors Involved

The FT model involves different tutors and tutees, as presented later in this section, selected when a new TF edition starts.

Teacher Tutors (TTs): Similar to the Spanish model, TTs are professors who are responsible of some classes of the study course. They must have a good confidence with the main educational goals and with the basic architecture of the study course.

Peer Tutors (PTs): PTs are singled out on a voluntary basis, and they are chosen among students of the same study course of the tutees, and are enrolled in the second or later years. The Italian education system does not allow for formal recognition of this service in terms of credits. Nevertheless, the participation of PTs is awarded with an "Open Badge" [34], which states the competencies developed during the activities.

Service Tutoring: According to some analysis carried out in the previous years [28], it is apparent that getting familiar with the complex structure of a large university is particularly difficult for Italian students. Therefore, the role of ST is empowered with respect to the original Spanish model. Service Tutors propose informative activities in which they present the competences and the procedures of their office. They must have a solid knowledge of all the characteristics and the administrative procedures of their service and also hold some communication skills.

Expert Tutors (ETs): Similarly, engineering students manifested the need of specific actions devoted to develop a proper method of study: in the FT, these actions are implemented by the ETs (typically pedagogy or psychology professionals).

Coordination Tutors (CTs): Moreover, in the last two years, the FT has also introduced another "new" tutor, not present in the original Spanish model: the "CTs." They are PTs with a specific training who play supervisory and organizational actions, helping the tutors and the coordinators in the management and the planning of the activities.

TABLE I
LIST OF THE TRAINING SEMINARS ATTENDED BY TUTORS

Number	Title
1	The FT program: role and activities of the tutors
2	The method of study: being profitable in studying at university
3	Leading a group during FT activities: simulation of a FT session with a small group of tutees
4	Effective communication, active listening and public speaking
5	Leading small or medium groups
6	Soft skills for tutors: team building and problem solving

Tutees: The tutees are, in the FT, students enrolled in the first year of some UNIPD degree courses, invited to join voluntarily the FT at the beginning of the first semester.

B. Role Training

Tutor training plays a very important role in the FT model since its foundation. In the original Spanish model, there were already some training experiences, which in the FT have been systematized and extended. This choice to implement a solid training program stems from the recognition of the great impact that it could have on the success of the whole program: trained tutors have more tools, competences, and knowledge to better act their role.

All Peer and TTs receive an *ex ante* training about their specific role and the educational relationship: Table I lists the training seminars that the tutors had to attend before the beginning of the semester. Teacher and PTs also participate to periodic meetings with the FT team, to share the educational goals as well as the calendar of activities. In these occasions, the activities are defined, and plenty of supporting material is delivered to the tutors. The FT is based on a shared and collaborative approach, therefore during these periodical meetings, the team takes inspiration from the material prepared in the reference model but adapts the activities to be led in the class, according to the specificities of the context and the skills of the tutors.

C. Leading the Groups and Activities

As already said, FT is offered to all students enrolled in the first year, who voluntarily decide whether to participate to the program or not. Once the list of volunteer tutees (students) is defined, they are divided into groups. In the *Tutorìa formativa de Carrera,* these groups are of 10–15 students; however, this is hardly replicable in the University of Padua's context, due to the large number of tutees together with a limited availability in terms of resources (such as classrooms and tutors). A good tradeoff between these practical limitations and the efficacy of the tutoring actions has been singled out in groups of approximately 40 students.

The activities are proposed to groups of students enrolled in the same degree course (with TTs or PTs), or different groups are assembled for the activities with the Service and ETs. Sometimes, in this latter case, groups of students from different degree courses are assembled.

As far as the work in groups is concerned, each group of students is mediated by a couple of TTs or a couple of PTs. The activities are customized, according to the specific issues of the degree course. The use of active learning methodologies is preferred and supported: hence, the activities are not carried out in a traditional, *ex cathedra,* way, rather tutors try to involve the tutees using active, cooperative, innovative didactic techniques (e.g., role play, teamwork, case study, and discussions, with the support of paper and digital tools when needed).

The ST meetings in plenary sessions guide and direct students to take advantage of the various supports offered by the university. The tutoring sessions with experts are focused on specific issues of particular relevance and complexity (e.g., on the study method if the didactic path presents particular criticalities or obstacles that impair the regularity of careers).

As far as the proposed content is concerned, tutoring and Peer Tutoring activities are dedicated to the development of some soft skills. Soft skills (sometimes in the literature called "key competences," "life skills," or "transversal competences") have been the subject of the increasing interest in lifelong learning, since they are strongly associated with success in life and work [35]. Soft skills are competences needed for personal fulfillment and development, active citizenship, social inclusion, and employment. If possessed and properly managed, soft skills can determine interesting job performances and also contribute to the personal, relational, and work development of the individual [36]. These are not hard competences, linked to a specific job, role discipline, or situation: they are transversal as applicable to different contexts. These skills are recognized as useful in the academic context to foster integration and academic success, and in particular the FT activities try to enhance the following soft skills:

1) orientation, integration, and adaptation in the new university context [37], [38];
2) problem-solving process and decision-making processes [39], [40];
3) teamworking [41], [42];
4) study method (learning processes, study strategies, planning strategies, etc.) [43];
5) relationships, engagement in the context, and connections with others [39], [44];
6) self-assessment, self-knowledge, and self-development [41], [45].

These competences are fostered through specific activities, as summarized in Table II, where the numbers in the right column are based on the list above and indicate the main competence enhanced by that activity.

In the FT, meetings are held weekly, last about 1 h and are scheduled during the teaching hours, with the exception of holidays and exam periods. In the original model, the planned activities are more frequent. The choice to articulate the UNIPD calendar as described above is related to organizational needs and to make the program more sustainable for the students. The students who consistently participate obtain

TABLE II
LIST OF THE FT ACTIVITIES AND RELATED SOFT SKILLS

Tutor Role	Title	Main enhanced skill
ST	Presentation of rules and opportunities for university fees, fellowships and other subsidies.	1
ST	Presentation of student administrative office	1
TT	"Did I choose the proper course of study?": discussion on the course contents and perspective	1, 6
PT	"Let us know our context"	1, 5
ET	Introduction to the method of study at the univeristy	4
TT	Opportunities of the course of study: how to choose courses	1, 2, 6
TT	Studying at the university: how to prepare for exams	2, 4
ST	Presentation of the language study center, of library services and of international mobility programs	1
PT	How to prepare for exams: the student point of view	4, 5
TT	"Are you feeling ready for the exams?": introduction to self-evaluation	4, 6
TT	"How has it gone the first session of exams? How can we improve for the next one?"	4
PT	"Team working: why is it important at university and at work?"	3, 5
TT+PT	Problem solving	2
ST	Career service: support and opportunities to get in touch with world of work	1

a certificate of the developed competences through an Open Badge [46].

The FT differs significantly from other tutoring resources at the University of Padua. As mentioned in Section I, often the general assumption is that students' difficulties depend on just a poor level of mathematical and logical skills. Therefore, traditionally, a big effort has been put in organizing tutoring classes to propose additional exercise sessions or discussion and revision of the subjects explained by teachers during the normal classes. In some cases, these activities are organized in the form of study groups, which are led by a PT and hence a light potential of stimulating some of the soft skills discussed so far can be recognized. However, that is not an explicit task of the activities, nor the tutors are trained from that perspective, hence a significant soft skill enhancement cannot be expected. Moreover, in the past years, the need for administrative information and the value of support by peers have both been recognized, so some PTs are dedicated to informative and support practices. However, such a support is activated on the request of a single student and for the sake of that single student. The systematic proposal of different activities, which are planned and designed with a preventive and proactive logic to respond to some fundamental needs of a large part students (like in the TF proposal), is in this case completely lacking. Finally, in this case, just PTs are supporting the students, while in the FT, all the described different kinds of tutors are acting in synergy.

D. Evaluation

The Spanish *Tutorìa Formativa de carrera* proposes some experiences of process evaluation. The Italian model, starting from these reflections, has implemented a more articulated assessment model [25], which led to a proposal for a multilevel assessment. In fact, not only the processes but also satisfaction, propensity to participate, and effectiveness are assessed.

The assessment process developed for the FT can be summarized through the following four phases.

1) *Ex Ante Analysis:* A context analysis, based on administrative data, is always conducted before starting the program in a new context, to personalize the proposed activities. In particular, for the courses of study considered in this work, the dropout and delay rate were recognized as critical issues and the design of the FT activities always took these aspects into consideration. The *ex-ante* analysis also consists of collecting students' data from administrative databases and through specific survey proposed to the incoming students. This allows to assess the *ex-ante* level of some skills, which is instrumental to the measurement of the FT effectiveness, as better described at the end of this section and in Section IV-A.
2) *In Itinere Survey:* This analysis is conducted every year at the end of the first semester (February–March), involves participating and nonparticipating students, and aims at identifying the factors most influencing the choice to join the FT.
3) *Reports About Participatory Processes:* Attendance is collected during each activity, as those who attend at least 70% of the meetings receive a certificate of participation and an Open Badge.
4) *Ex Post Analysis:* At the end of the academic year, a specific Cawi survey is proposed to all the students that participated in the FT activities (students who drop-out before the end of the year are not involved, since they cannot receive the Survey in their institutional e-mail). The survey collects data of different aspects of the program, such as general satisfaction and self-perceived effectiveness of the FT in enhancing specific skills.

The main research assumption is that the TF program is an effective resource to prevent and counter the drop-out and foster academic success. Therefore, after the FT has been concluded for a given cohort, the students' career can be monitored, looking for evidence of some improvement. In particular, some figures of merit that are assumed to be significant with respect to the academic success of the students (i.e., regularity, drop-out rate, and the average number of collected credits), are going to be compared with the participation in the FT activities. In general, a self-selection effect cannot be excluded, i.e., students who were more self-motivated and competent may choose to participate in the program in the first place. In order to quantify this effect, using the data and

information from the *ex-ante* analysis, the *a-priori* propensity to academic success has been estimated, performing a sort of preinterventions assessment for students who participated to the FT and for those who did not (see Section IV-A). This method allows to compare the career data of the participants to the FT with the outcomes of a proper control group of students that are not participating to the FT but have a comparable propensity to academic success.

IV. Evaluation Results

Among the quite articulated evaluation process described in the previous section, this article focuses on the results of the *ex-post* analysis. These results are indeed more interesting from a research perspective, because they represent the mean to experimentally confirm the FT research hypothesis and to assess the effectiveness of the proposed program.

The results presented in this section refer to the four bachelor's ICT degrees offered at the Engineering School of the University of Padua (biomedical, information, electronic, and computer engineering). The results refer to the 2017/18 cohort (cohort A) and, when data is available, the 2018/19 cohort (cohort B) is considered too. The number of students enrolled in the above-mentioned degree programs has shown a steady increase in recent years, reaching a total of 1191 freshmen for the 2017/18 academic year, and a total of 847 for the 2018/19 academic year. Fluctuations in the number of enrollments usually occur from year to year in the considered ICT contexts. Nevertheless, it is worth noting that on average these values are approximately doubled in less than ten years. Such a large number of students represents itself a factor that makes the transition from secondary school to university more difficult for the students: there is a greater risk of not being able to integrate with fellow students and the relationship with teachers is more depersonalized.

Considering the 2017/18 cohort (A), 253 students participated to at least the 70% of the FT activities, 302 participated only to some of the proposed activities, and 636 did not participate at all (the FT is voluntary, so not all students participate). Considering the 2018/19 cohort (B), 374 students participated to at least the 70% of the FT activities, 184 participated to some of the proposed activities, and 289 did not participate at all.

A. Propensity Score

The *ex-post* evaluation that is going to be presented in this section is mainly based on associating with each student a propensity score (PS) [47]. The PS is calculated as the average of a numerical weight associated to a variety of factors that are usually considered to be significant with respect to the potential academic success of a student at the beginning of his or her university studies. Namely, the considered factors are: sex, age, final grade from the high school, grade at the university access test, enrollment at university just after the high school or later, kind of high school, working status, living or not near the campus, and cultural and professional level of the family. Additional factors are considered, on the basis of a survey that all the students fill in when enrolling (*ex-ante* analysis phase): personal effort they plan to dedicate to study, intention to apply for a Master degree after the Bachelor, awareness of employment outcomes of the chosen degree of study, the quantity of information collected in order to choose the course of study, personal sensitivity to gender issues, self-perception of Padua as a city suited for students; self-perception of the chosen course of study and of the University of Padua as instrumental for a good future.

TABLE III
Number of Students for Each Category in the Matching Procedure Cohort 2017/18—A

Category	# students
Total students enrolled in the cohort	1,191
Total students considered in the PS matching	661
Total students in the participating group	145
Total students in the non-participating group	516
Participating students properly matched	138

Theoretically, the PS can range between 100 (maximum propensity to success) and 0 (minimum propensity to success). For the considered population of students, it ranges from 0.4 to 75.4, with a mean value of 25.25 and a standard deviation of 17.8. If the calculation is limited to the students that chose to participate to the FT activities, the range restricts from 5.6 to 75.4, the mean value rises to 37.8, and the standard deviation is equal to 18.4. The population of participating students is representing different levels of self-motivation and initial competence. This observation excludes the case that the group of participants to the FT is mainly composed of students that are highly motivated and very familiar with scientific subjects, already at the beginning of the university.

A further step toward the minimization of any possible self-selection effect is to apply a PS matching approach [47], [48]: each student in the participating group is paired with a student in the nonparticipating group who has the same PS. After the PS matching, each "treated" (i.e., participating) student has a counterpart nontreated student with the same initial propensity to academic success [49]: differences in the effective academic success after one or two years of university are likely to be related to FT participation.

A main limitation of the PS matching technique is that it may significantly reduce the number of students to be evaluated: in the case of the 2017/2018 cohort (A), for instance, the 302 students partially participating to the FT activities have been excluded because it is questionable whether they belong to the treated or to the nontreated group; furthermore, for 228 students of cohort A, part of the information needed to calculate the PS is not available because they did not reply to the initial survey (that unfortunately is not mandatory). Consequently, the matching procedure can be applied to a sample of 661 students, 145 of which belong to the participating group, as summarized in Table III. A proper match for these students, i.e., a student in the nonparticipating group with the same PS, was found in 138 occurrences.

B. Self-Perceived Effectiveness

As explained in Section III-D, the *ex-post* analysis includes the measurement of the self-perception of the FT effectiveness,

TABLE IV
DISTRIBUTION OF REPLIES TO THE QUESTION "HOW MUCH DID THE FT CONTRIBUTE TO IMPROVE THE FOLLOWING ITEMS?"—COHORT A 2017/18

Item	# of replies in the range High or Medium
Knowledge of your course of study	73%
Knowledge of your university	73%
Your integration in the university life	59%
Your motivation to go on with and to conclude your study program	57%
The way you plan your academic and professional path	50%
Your method for studying and the way you organize it	41%
Your relationship with class mates	35%

TABLE V
SUCCESS RATE FOR THE MATHEMATICAL ANALYSIS EXAM AT THE FIRST YEAR COMPARED WITH THE PARTICIPATION AT THE FT (COHORT A 2017/18)

Result	Fully participating	Partially participating	Not participating
Passed	146 (58%)	144 (48%)	208 (33%)
Failed	77 (30%)	98 (32%)	219 (34%)
Not taken	30 (12%)	60 (20%)	209 (33%)
Total	253 (100%)	302 (100%)	636 (100%)

too. A total of 431 students (cohort A—2017/18) replied to the final survey, and Table IV summarizes the responses to some items, which intended to measure the self-perception with respect to what has been improved due to the FT. In the 2017/18 cohort (A), the knowledge of both the study course and the university are indicated as being improved by the FT, with a 73% of positive replies in both cases; an improvement of the method and way to study is reported, with 41% of positive replies; finally, only a 35% of positive replies refers to the relationship with classmates.

C. Success Rate at the Mathematical Analysis Exam

In this section, some descriptive results (referred to both 2017/18 and 2018/19 cohorts) are reported with respect to the first step in the career of students in the new university context, represented with good approximation by the results of the Mathematical Analysis 1 exam that is considered as one of the most challenging for first-year students. Data are collected from the administrative career data base of the university.

If the success rate for the Mathematical Analysis 1 exam is associated with the level of participation in the FT, some differences between the groups can be appreciated, as exemplified in Table V (referred to the 2017/18 cohort A) and Table VI (referred to the 2018/19 cohort B):

1) the number of students passing the Mathematical Analysis 1 exam is larger among the participants to the FT (58% of the participants versus 33% of the nonparticipants for the 2017/18 cohort A, and 66% versus 51% for 2018/19 cohort B);

TABLE VI
SUCCESS RATE FOR THE MATHEMATICAL ANALYSIS EXAM AT THE FIRST YEAR COMPARED WITH THE PARTICIPATION AT THE FT (COHORT B 2018/19)

Result	Fully participating	Partially participating	Not participating
Passed	246 (66%)	96 (52%)	146 (51%)
Failed	104 (28%)	54 (29%)	48 (16%)
Not taken	24 (6%)	34 (19%)	95 (33%)
Total	374 (100%)	184 (100%)	289 (100%)

2) there are fewer students who do not even attempt the Mathematical Analysis 1 exam among those participating in the FT than those who do not participate (12% versus 33% in 2017/18—A, and 6% versus 33% in 2018/19—B).

These descriptive results should be taken with some caution. First, the numerousness of the compared groups (fully, partially, or not participants) is quite different. Therefore, if the fraction of good performing students (with respect to the whole population of each group) is compared, there is a tendency in FT participants to attend and pass the Mathematical Analysis 1 exam more than students who do not participate. If the absolute numbers are considered, the nonparticipants groups are much larger than the other, hence even a moderate fraction of its students is larger if compared to the population of the other groups. Furthermore, the results may be biased by students' different mathematical skills, although the PS has similar distributions for the participating group and the nonparticipating one. The fact that some of the parameters used for the PS calculation are generally strictly related to mathematical skills (e.g., grade at the university access test), gives a certain degree of trust about the tendency of students who participate to the FT program to be generally more successful with the first mathematical exam.

D. Academic Success After One or Two Years

Some academic outcomes of students participating to the FT are compared with that of nonparticipating students. Such a comparison is performed on the basis of students coupled by means of the PS matching, as explained in Section IV-A. Therefore, the outcomes of students participating to the FT are compared with those of a control group with comparable initial skills and potentials.

Table VII compares the academic status of students of the 2017/18 cohort A, resulting from the administrative database, after one year and after two years from enrollment.

1) A student is considered "regular" or "on delay" at the end of the first year if he or she has collected at least 20 or less than 20 credits[2] out of 60, respectively. Similarly, the threshold between these two profiles at the end of the second year is set to 60 credits out of 120.

[2]This definition of "regularity" complies with the university's scholarship regulations, which define, for example, regular anyone who has obtained at least 20 ECTS at the end of the first year.

TABLE VII
ACADEMIC STATUS OF STUDENTS CONSIDERED IN THE PS MATCHING PROCEDURE; COHORT A—2017/18

Profile	Participating	Not Participating
AT THE END OF THE FIRST YEAR		
Regular	67%	49%
On delay	7%	10%
Changed Course	13%	13%
Abandoned	13%	28%
AT THE END OF THE SECOND YEAR		
Regular	64%	42%
On delay	8%	13%
Changed Course	13%	13%
Abandoned	15%	32%
DIFFERENCE (SECOND YEAR – FIRST YEAR)		
Regular	-3%	-7%
On delay	1%	3%
Changed Course	0%	0%
Abandoned	2%	4%

TABLE VIII
AVERAGE NUMBER OF COLLECTED CREDITS AT THE END OF FIRST AND SECOND YEAR (STUDENT OF THE 2017/18 COHORT)

# Credits	Participating	Not participating	Difference	p-value
First year	47	42	5	0.036
Second Year	95	83	12	0.02
Difference	48	41	7	0.033

2) A "changed course" profile refers to the fact that the student moved to a different course of study within Padua university or moved to a different university.
3) The "abandoned profile" identifies students that left academic studies voluntary or in force of exclusion due to academic rules.

The data of Table VII, referred to cohort A, confirm the results of previous works [25]: the highest percentages of regularity after one year characterize the FT participants (67% of the participating students are regular versus 49% of nonparticipants), while the highest dropout rates characterize nonparticipants (28% versus 13%). These propensities are confirmed even in the second year with a more reduced decrease in regularity among the participants compared to nonparticipants, and a growing dropout differential between the two groups, whose statistical significance has been assessed using the χ-squared test:[3] the differences are globally significant both at the end of the first year (sign $\chi^2 = 0.017$), and even more at the end of the second year (sign $\chi^2 = 0.004$).

Table VIII reports the average number of credits collected by the two groups (participating/not participating), at the end of the first and second year, respectively. At the end of the first year, the nonparticipants students obtained an average of 5 credits less than the participants, while at the end of the second year such a difference increases to 12 credits. The table reports the estimated statistical significance of the different performances, with respect to the participation to the FT. In this case, a *t*-test has been used and the corresponding *p*-values are reported in the table, too. Although the obtained *p*-values are not extremely low, they are always lower than 0.05, hence a correlation between the number of collected credits and the participation to the FT can be assumed.

[3]A statistical significance is assumed when χ^2 is less than 0.05.

TABLE IX
PERCENTAGES OF STUDENTS CAREER PROFILE AND COLLECTED CREDITS DIVIDED ACCORDING TO THE ADMISSION TEST SCORE QUARTILES—COHORT A 2017/18

	$<Q_1$	Q_1-Q_2	$>Q_3$	$<Q_1$	Q_1-Q_2	$>Q_3$
Career profile	Participating			Not Participating		
Regular	20%	65%	88%	0%	46%	65%
On delay	13%	5%	8%	16%	13%	12%
Changed Course	17%	20%	4%	21%	11%	12%
Abandoned	50%	9%	0%	63%	30%	12%
# Credits	78	93	101	60	90	78

Another interesting approach is to analyze the career status and the average number of collected credits separating the students of the two groups (participants and nonparticipants) into subsets, according to the entrance test grade, which largely aims to measure mathematical and logical skills. The first set includes students whose grade is below the first quartile of the grade distribution: these may be considered students with a significant disciplinary weakness. The second set includes all the students of the two central quartiles. Finally, the third set refers to the students with the highest grades: these are potentially the most promising students.

This analysis, as summarized in Table IX (referred to the 138 couples of matched students from cohort A), still highlights a general better performance of students participating to the FT. Furthermore, different levels of performance can be observed, depending on the initial skills.

1) Among students with a low level of mathematical skills, the career outcome obviously remains strongly influenced by disciplinary gaps; nevertheless, 20% of the participating students manage to remain regular, while none of the nonparticipating achieves such a result; similarly, the dropout rate, while remaining significant, is also lower in the case of the participants.
2) For "typical" students, the career outcome is significantly influenced by participation in the program.
3) The performance of the group of students with higher levels of entry skills is significantly influenced by participation in the program (sign $\chi^2 = 0.013$); in addition to the zeroing of the dropout percentage (which remains at 12% for the nonparticipating), there is also a significant increase in the collected credits.

V. DISCUSSION AND CONCLUSION

This article has presented the FT model, an articulated set of tutoring actions to support students at the beginning of their

ICT degree course to live more profitably the education transition from high school to university. Different kinds of tutors interact in a synergic way with the students, putting at the center the needs of each of them.

Although the direct goal of the FT is to empower students' skills, the underlying assumption is that its actions could be effective tools to prevent and counter drop-out and foster academic success. In order to verify this hypothesis, different evaluation analyses have been performed, as discussed in Section IV. The enforcement of soft skills is tested by the means of the self-perception of the students participating to the FT, while no specific evaluation activity is adopted to test directly the skills level in a more quantitative and objective way. Students report a satisfactory improvement for some aspects (e.g., knowledge of their university and course of study); conversely, they feel that the FT was poorly effective in improving the relations with their classmates: this is a quite surprising result, because, in most of the activities, the students are encouraged to work in groups and to relate with classmates. This issue needs further consideration in the future, also because the survey is not structured in a way to highlight whether they consider to already have a good relationship with their classmates or not.

The lack of a more specific evaluation for skills development may be a limitation of the proposed program, but encouraging students to take any additional evaluation test (in particular, at the end of the semesters, when they are already under the pressure of curricular exams) may discourage the participation to the FT. Nevertheless, the design of a more specific evaluation tool for the assessment of skills development, with objective and subjective parts, is under development, as a future improvement of the FT. As reported at the beginning of Section IV, about half of the enrolled students never participate in any FT activity, and this fraction further increases if we consider only the participation to most of the proposed activities. Student volunteer participation is therefore a point of attention for the program, and somehow one of its weaknesses. Part of the nonparticipating students accepted to fill a brief survey (evaluation phase 2 of Section III-D), and the main reasons for not participating are the idea of not having enough time and the belief they do not need such a kind of support. This suggests, for the future, to improve the initial presentation for the FT but also to carefully evaluate the time effort required to the students: from this perspective, increasing the evaluation pressure, by adding other tools, may not be a good idea, as stated previously.

A quick check for a qualitative short-term indicator of academic performance is the success rate at the first mathematical exam (most students try to face this exam at the end of the first semester). This is a descriptive analysis, but allowed to consider the outcomes of all the enrolled students.

On a longer term, the regularity of careers and the average number of collected credits have been monitored at the end of the first year and at the end of the second year. The *a-priori* propensity to academic success has been estimated for both participant and nonparticipant students. Furthermore, the outcomes of the participants have been compared with that of a control group of nonparticipants students with the same PS (see Section IV-A), to rule out significant bias of the discussed results, and creating a quasi-experiment context. In general, the students who participated in the FT activities outperform the nonparticipating ones with respect to all the considered parameters.

In the context of this final discussion, it is worth to focus the readers' attention on the data of Table IX, in which the students are also divided in accordance to the admission test score. Although participants always hold better figures of merit than nonparticipants, the largest gap is measured for the class of students with average admission test score. For instance, the drop out rate of nonparticipants is 30%, while participants drop only in the 9% of cases; similarly, 65% of the participants are regular, while the regularity rate is 46% for nonparticipants. Students with such a performance for the admission test hold, in theory, a disciplinary competence that should be strong enough to successfully engage in the first years of engineering studies. In these cases, an unsuccessful career is more likely due to a weakness in soft skills: they are, for example, students who had difficulties to orient and integrate themselves in the new context, or lacked of a proper approach to the university studies or of a personal strategy for success. It is, therefore, not surprising that the FT demonstrated to be most effective from this class of students, whose weaknesses are exactly the issues on which the FT concentrates on. Another interesting observation is that the FT was effective also for students with the highest admission test grade, although the gap between the two groups is less significant. Nevertheless, the 12% of nonparticipating students with the highest admission test grade abandoned the course of study, while none did so among the participating students. This contradicts the possible prejudice that this kind of tutoring actions are useful for "weak" students only. Conversely, any student can get its own advantages through the empowerment facilitated by the FT.

The experience documented in this article is confirming the positive role of tutoring, in accordance with prior findings as discussed in the initial literature review. In general, tutoring actions aimed to make the students develop and reinforce soft skills, are demonstrating to be complementary to disciplinary support. These findings are also in accordance with the theoretical framework and experimental results of the original Spanish model. Beyond the adaptations discussed in this article, a substantial improvement is introduced in terms of efficacy assessment, leading to a further practical validation of the theoretical model. A comparison with similar interventions in the context of engineering courses is less straightforward, because often the specialized literature focuses on strategies to make the teaching of disciplinary subjects (e.g., computer science, mathematics, electromagnetism, etc.) more effective. Even in those contributions where soft skills are considered a key factor, the development of such skills is based on disciplinary teaching units, for instance, exploiting a project-based learning approach or a computer-aided education. Therefore, up to the authors' knowledge, this contribution may be considered a novelty in the context of engineering studies, expanding the focus on soft skills within engineering education. From this perspective, this work suggests that soft skills are important not just for the future profession of students: conversely,

the development of these skills may be crucial for their academic success, as well. The evaluation approach, presented in Section IV, is worth to be connected to previous studies, since most contributions on relevant topics propose a way to assess the validity or the efficacy of their methods. Measuring the acquired level of competence in the case of soft skills is not a trivial task and as a matter of fact often the approach is to quantify the self-perception of the students by means of *ex-post* surveys [10], [11], similar to what is reported in Section IV-B. More objective approaches are based on the students' performance with respect to a specific exam [10], [11]. Such an assessment has been exploited for FT, too, as discussed in Section IV-C. However, the tutoring actions proposed by the FT are not specifically set up for enhancing the success at the considered mathematical exam, therefore this data is used as a qualitative measure of a short-term impact of the FT. Conversely, when the soft skills development is embedded in a specific class, the literature proposes much more refined statistical analysis [10], [12]. Nevertheless, in these cases, the *a-priori* level of competence of the students is rarely considered. The PS methodology proposed in this work addresses such an issue, with the aim to set up a more reliable control group, even though the groups are set up after the experiment. Surely there are still margins for improvement, but from this point of view, this work may contribute to expand prior findings. Finally, basing the assessment analysis on the long-term academic career performance may be an interesting suggestion for other researchers, since it holds the potential to demonstrate that once soft skills are acquired, they empower students for the rest of their careers.

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