

Factor Implicit Model of Machine Classification Learning Based on Factor Space Theory

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Abstract— This paper examines the trends in online programs and enrollment to support the argument that those attracted to full time online programs are place (and time) bound nontraditional students looking to continue their education (e.g., working professionals, stay at home parents, active duty military). The authors also survey the literature to explain the reasons why students choose online programs versus face-to-face education, concluding that the motivations for choosing online learning are unique and pose no threat to long term sustainability of physical universities. Online programs offer the opportunity for continuing the education of students who would otherwise be unable to attend college, while traditional students' first choice for education remains in-person programs.

Keywords— online, enrollment, higher education

I. INTRODUCTION

In the last two decades, higher education has seen a rapid growth of online learning with an increasing number of universities offering both online courses and fully online programs [1-8]. As more and more schools develop online programs, it is important to know how this change impacts higher education. Change for the sake of change is not necessarily progress. As such, we need to carefully investigate the impacts of moving away from traditional brick and mortar institutions towards online education. Is there a place for each method in the future of higher education?

Rather than focusing on a specific discipline, this paper focuses on examining the general trends in online education over the last seventeen years. Additionally, this work focuses on the student perspective by unpacking the reasons why students choose online versus in-person educational opportunities and what students value in each approach. This perspective defines the impact of online education in the where, when, and why of student engagement to determine the place of each method in the changing face of higher education..

II. TRENDS IN ONLINE EDUCATION

Since 2002, the Babson (College) Survey Group has created an annual report regarding the state and trends of online education. Data from these reports are summarized below. While there are varying definitions of an online course, the Babson Survey Group defines an online course as “one in which 80% or more of the course content is delivered online” [1]. All students who were enrolled in one or more online courses were included in this data.

Fig. 1 shows the overall enrollment trends in higher education since 2002. The visible drop in online enrollment in 2012 can be accounted for as in that year the Babson Group switched their data collection methods from surveying and projecting from individual institutions (which had resulted in slight overestimates for the number of distance courses offered) to using data from the United States Department of Education's National Center for Education Statistics' Integrated Postsecondary Education Data System (IPEDS) [2]. Despite these data collection issues, the trend remains clear. The amount of students pursuing their education online has increased. “Since 2012 distance growth has continued its steady increase in an environment that saw overall enrollments decline for four straight years” [3].

As of Fall of 2016, almost one-third of students were taking at least one course at a distance (online) [1]. Many public universities offer online instruction to cope with campus restrictions (e.g., classroom space, schedule conflicts). These programs are not fully online, but offer an occasional online course to address logistical bottlenecks. Of all students taking at least one online course during their studies, approximately two-thirds are students who live on campus and 83% of the students are undergraduate [1]. These classes could be considered a one-off in the educational experience of traditional undergraduates. There are, however, an increasing number of students who are enrolled in fully online educational programs

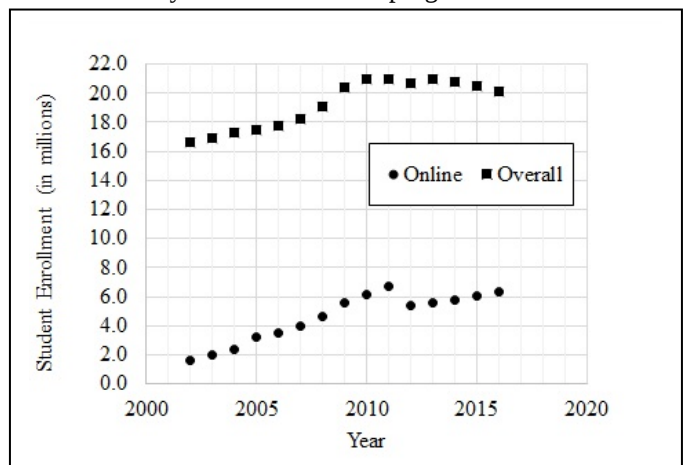


Fig. 1. Trends in Online Learning (adapted from Babson Survey Group Reports) [1, 4, 5]

In general, the number of students taking courses online are increasing for both students in one online course and those in

fully online programs [6-8]. A 2010 article posted in The Engineer reports that a survey of eleven universities which offer online engineering master's programs indicated program growth of 79% from 2005 to 2010 [9]. Online programs are more popular at the graduate level for a number of reasons. First, online graduate programs are more accessible and flexible for the needs of the audience [10]. Secondly, graduate courses typically are not as heavily laboratory-based as undergraduate programs, requiring less in-person education [11-12]. Third, while undergraduate education is typically accredited by organizations such as ABET, master's programs are typically not accredited, allowing universities more flexibility in offering some graduate courses online [12].

Additionally, looking at online enrollment by degree program reveals some interesting trends. A 2013 study by Pontes and Pontes indicated that students enrolled in engineering are significantly less likely to be enrolled in distance education than students in business, computer science, health, and education [13]. These trends are shown in Fig. 2. It would appear that business and computer science rely more heavily on online modes for course delivery whereas engineering, math, life sciences, and physical sciences are among the lesser adopters of online course delivery. Engineering courses in particular have fewer undergraduate online offerings due to significant laboratory requirements, heavy computational requirements, and emphasis on ABET accreditation [10, 12, 14].

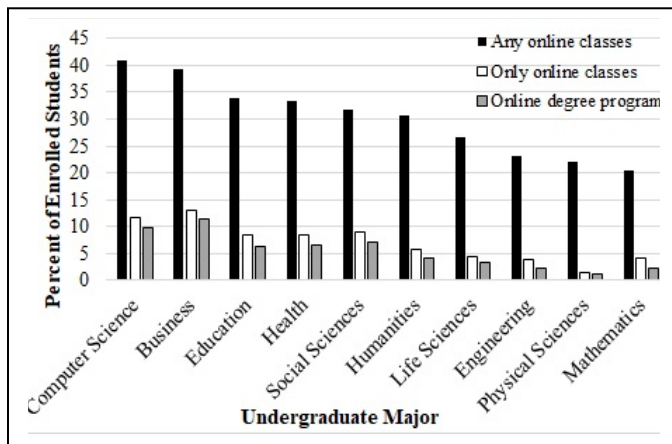


Fig. 2. Percentage of Undergraduate Students Participating in Distance Education (2011-2012) from the 2014 Digest of Education Statistics [6]

III. WHY STUDENT CHOOSE TO ENROLL IN ONLINE PROGRAMS

There is ample investigation as to why students enroll in online programs [10, 15-18]. However, none of these studies have specifically targeted the reasons why engineering students might seek online programs. Thus, the general online education literature was examined to discover the reasons why students seek online education. The reasons students choose to pursue higher education in fully online programs has remained remarkably consistent since the early years of online education through today - necessity and convenience [10, 15-18]. Learner preference among those who have previously had success with online learning can also be seen as another reason, but to a much lesser extent [19]. The literature regarding online learning choice is not discipline specific, but applies to the needs of

working parents, no matter their careers. However, it is reasonable to assume that engineers (who also have careers and families) pursue online learning for the same reasons as everyone else. Online learning continues to be primarily a vehicle for working adults to further their education while staying employed and/or raising a family. It broadens the educational possibilities of nontraditional students and makes furthering their education possible where it previously was not.

Research indicates that students who choose to pursue higher education courses online do so because they have a need to do so [15, 17, 19, 20]. In surveying the literature on this topic, the reasons students choose online learning has consistently been most often attributed to the following motivating factors:

- Necessity
 - including geographical distance from a face-to-face alternative [20]
 - demands of work and family life [9]
 - no face-to-face offering available that fits their current needs [16, 17]
- Convenience and Flexibility
 - including the ability to schedule course work around the demands of work [17] and family life [18]
 - the ability to pursue a degree while working full time [15]
 - avoiding the difficulty [17] and expense of commuting to campus [21]

The demands of work/family and distance from an appropriate face-to-face offering were the common root causes between students motivated by either necessity or convenience/flexibility. In essence, the students needed educational convenience and flexibility because of life circumstances. Dutton, Dutton, and Perry (2002), provide evidence of this in their study comparing online to on-campus students: "The two greatest responsibilities that [the online] students are likely to have outside of class are work and childcare" leading them to the conclusion that "on average, students taking the online section have greater outside responsibilities and that they live farther from campus" [20]. When discussing these very same needs driving choices among online learners, the 2014-15 National Online Learners Priorities Report summarized findings by stating "Convenience, flexible pacing, and work schedule are the consistent top three enrollment factors. Online learners clearly require their courses to fit into their lives and to allow them to participate when it is convenient for the student" [18].

Prior to an increasing availability of quality online higher education alternatives, nontraditional students were an underserved population who were often forced to choose not to pursue higher education. This very point was illustrated in a paper by Kinney, Liu, and Thorton (2012), which examined faculty and student perceptions of online learning in engineering education, stating "As student demographics have changed, many colleges and universities have employed various distance

education strategies to expand their offerings to ‘non-traditional’ markets, including students that are older, married or with families, or working part- or full-time. Due to these various demands, many of these students are not able to attend on-campus courses during regular course times. They require flexibility in time and place, and institutions are working to address these needs by offering courses online” [22].

It seems that nontraditional students at different life stages are drawn to online programs, as shown in Table I below. The age of the average online college student is quite unique when compared to the typical traditional undergraduate college student. Clinefelter and Aslanian revealed in the annual report Online College Students 2016: Comprehensive Data on Demands and Preferences that the average age of online undergraduate students in 2016 was 29 and in graduate courses was 33 [23].

TABLE I. AVERAGE AGE OF ONLINE STUDENTS BY YEAR [23]

Average Age by Year	Undergraduate	Graduate
2012	34	35
2013	35	37
2014	36	37
2015	32	35
2016	29	33

Older students are driven online due to work and family constraints that emerge as we age. Students are not choosing online education as a desired format out of anything more than necessity. In person programs are the default educational choice. Although many traditional undergraduates are taking a course or two online during their degrees, these are not fully online programs. Far more often not, traditional undergraduate students will choose to take higher education courses face-to-face in a classroom. The need to offer high quality face-to-face classroom instruction for traditional undergraduate students does and will remain strong even though formerly underserved populations are pursuing higher education via online learning in increasingly larger numbers every year. As Jaggers (2014) noted in Choosing Between Online and Face-to-Face Courses, a study in which college students discussed their experiences with online and face-to-face learning as well as their reasons for selecting online (rather than face-to-face) sections of specific courses: “To meet students’ needs then, colleges need to... continue to provide ample face-to-face sections of courses for those students who prefer them” [19].

A very recent analysis of Georgia Tech’s online master’s in computer science further illustrates this point. “People thought they were crazy...They thought that Georgia Tech was going to cannibalize its own revenue stream. But the profile of people applying online is so different, there’s virtually no overlap” [24, 25]. The study found that the school brought access to education to those who would otherwise be unable to attend graduate school, with no effects on traditional graduate enrollment. “Analyzing the first six cohorts of the online program, from spring 2014 to fall 2016, the report found that the typical

applicant to the online program was a 34-year-old midcareer American, while the typical applicant to the in-person degree was a 24-year-old recent graduate from India” [24, 25].

So as we can see those choosing to pursue higher education online are doing so due to their need for the convenience and flexibility the online format offers them. This need is driven by the demands that work and family place on them. They are a truly different subset of the potential higher education market formerly underserved by traditional face-to-face course offerings.

IV. WHY STUDENTS CHOOSE TO ENROLL IN FACE-TO-FACE PROGRAMS

It is clear that nontraditional students may choose online programs because of geographic or time constraints. However, traditional undergraduates do not carry the same life constraints that may drive nontraditional students into online programs. Traditional undergraduates are less likely to be burdened by careers and family and more likely to be free to seek out in-person programs almost anywhere. The decision factors for undergraduates selecting in-person programs are not at all based on convenience.

Buyer behavior models have been applied to potential undergraduate students selecting among college choices. Within consumer decision frameworks, potential students have a set of schools of which they are aware (awareness set) from which they determine some for consideration (consideration set) and ultimate college choice. The first-year student college choice literature surveyed specifically focused on in-person institutions [26-30]. In fact, the availability of online course offerings was notably absent as a selection criteria for first-year college students. Online programs are not mentioned as a part of the selection process because they are not in the consideration set. The lack of consideration of the availability of online course offerings during the college selection process of high school students confirms that traditional first year students are seeking an in-person experience. Overall, traditional undergraduate students are selecting from in-person programs based on the following factors [26-31]:

- cost
- availability
- school reputation
- influence and opinion of friends/family
- experience/impression of campuses

Like all economic decisions, cost is a major (if not the major) factor in college selection. In fact, the cost of a particular college has been shown to be a rising concern for first-year students [27]. As a result, more first-year students are attending colleges near their homes and almost one-fifth of incoming first-year students plan to live with relatives during the first year of college. The impact of cost on college decision is especially important for first-generation college students. Despite the fact that these students are accepted to their first choice institutions at similar rates as their peers, first generation students are less likely to attend a first choice institution [27]. In addition to

financial pressures, first generation college students have been found to have more limited college choice decisions due to complicated family relationships and less overall geographic mobility [29]. In fact, some families can place financial burdens on students. One national survey of first year college students revealed that 22.4% occasionally contribute money to support their families, with 6.5% frequent contributors [30]. However, race greatly determines whether a student is likely to be offering financial support to their family, with 48.2% of Hispanics, 44.3% of African Americans, 29.2% of Asians and 22.1% of Caucasians contributing financially to their families [30].

Although a 2012 national survey revealed that the top reasons first year undergraduate college students choose to attend college is to get a better job and make more money [26], data from the past year showed that undergraduate students were increasingly attending college to pursue interests and ideas [27]. Not only must a student be able to afford a school, but the school must also offer a major of interest to the student. Many colleges may be affordable, but if they don't have engineering majors, they will be of no interest to a future engineer. Thus, availability of a specific major has also been shown to be one of the major decision factors affecting in-person college choice for undergraduates [28]. But it is not enough to offer a major of interest, a future college must also have a good reputation, or positive perception of the school by both the student and their friends and family [28]. In fact, family and friends are key influencers in the college selection process.

Stephenson, Heckert and Yerger interviewed first year students at a mid-sized public university in the northeast U.S. to determine what factors influence the determination of a consideration set and ultimate university selection [28]. On average, students were choosing between three schools in their consideration set, usually a mix of public and private institutions of varying sizes. Students indicated that having family or friends who had attended the school positively affected their ultimate decision to attend, "allud(ing) to a level of comfort and familiarity with the school based on their friends' and family's experiences" [28]. Another study comparing SAT takers in 2004-2011 found that "many younger siblings apply to and enroll in the same college of their older siblings" [31]. This study also found that influence of sibling college choice was not found to vary much by race, income or proximity to public four-year colleges. Additionally, younger siblings who were more like their older siblings (with regards to gender, age and academic abilities) were more likely to follow their older siblings' college choices.

When it comes to actually selecting a school, campus visits play an increasing role in the selection process for first-year students [27, 28]. While on campus, student decisions are affected by the campus aesthetics and facilities, and whether the campus community feels welcoming and friendly [28]. One of the contributing factors to the lack of consideration of online schools may be that first-year undergraduate students cannot visit online schools in-person, resulting in less overall excitement about joining an online educational community

Although some populations of nontraditional undergraduates may need online education (due to being place bound by military service or life stage), traditional

undergraduates students are less likely to have the geographic and time restrictions (work and families) which attract students to online programs. These traditional students are selecting in-person programs based on cost, availability of majors, the reputation of a school, influence and opinion of friends and family, and their experience and impression of campuses, among other factors [26-30]. Online course offerings are not part of the decision factors for traditional undergraduate students. This is not surprising, considering the desire of young people to be among peers. The first-year college experience provides many with their first opportunity to be on their own in the world, making new friends and meeting potential life partners. Students encounter people from different geographies and world views. The online environment does not provide the same immersive cultural experience as in-person education.

V. WHAT STUDENTS VALUE ABOUT IN PERSON EDUCATION

Despite the growing number of online students, distance programs are not valued for the same reasons as traditional in-person education. Online students choose the format out of necessity for convenience, which is not only their main selection criteria, but also what they most highly value about online education. Traditional in-person undergraduates value very different things about their classroom experience, and convenience is not among them. Human interaction is one of the most highly valued aspects of in-person education, including interactions with the instructor and with peers.

A previous open-ended survey by one of the authors asked engineering technology students enrolled in an in-person undergraduate program what they value about both online and in-person education [17]. The top three things that the students valued about in-person education were: direct contact with the professor; classroom discussions and debates; and human interaction. Essentially, the students valued contact with their instructor and with their peers. The instructors themselves shepherd students through classroom interactions and set the tone for quality classroom interactions. As a result, the skills of the instructors themselves are often a major part of what students value about in-person education.

Hill, Lomas, and MacGregor (2003) conducted focus groups to ask students about what quality education means to them [32]. Several main themes emerged including (in order of importance): quality of the lecturer, student engagement with learning, and social/emotional support systems. With regards to lecturer quality, students desired lecturers who were knowledgeable about the subject, organized and interesting, as well as those who were "easy to be with and helped them to learn." Students also desired feedback from lecturers both on assignments and in the classroom. When it came to engaging student learning, students valued class materials which broadened their horizons, but were relatable to their chosen field. Finally, students valued support from their peers and university support systems. Ultimately, the authors' of this study concluded that "it is the quality of the interaction that leads to the quality of the learning experience where lecturer/student and student/student relationships are the key" [32].

As the main factor that students value about in-person education is contact with a quality instructor [17, 32], it is worth

examining exactly what students value about the instructors themselves. The ideal teacher possesses qualities which can be broken into two broad categories: the personality of the teacher and the professional knowledge of the teacher. A study by Arnon and Reichel (2007) asked education students open-ended questions regarding the ideal qualities of teachers [34]. Students valued personal qualities such as humor, kindness, calmness, fairness, and optimism. Students also valued teachers who were “empathetic and attentive to their pupils”, were authoritative leaders of their class, and seem to love teaching. Although empathy was a quality mentioned among students’ perceptions of ideal teachers, it may be of comparatively low importance to the other qualities, as indicated by the work of Trammell and Aldrich (2016) [33].

Trammell and Aldrich (2016) surveyed 132 students at a small midwestern university, asking them to rank essential (suggested) qualities in teachers on a Likert scale [33]. When it comes to professors themselves, students ranked all of the following qualities above a 4.3 on the scale (in decreasing order): approachability, strong teaching skills, knowledgeable about the course content, organized, positive outlook, consistent, enthusiastic, friendly, knowledgeable about technology, and quick responses to email/phone. Essentially, students valued instructor qualities which would improve their interactions with students. Students want instructors who are available, responsive, knowledgeable and pleasant in their interactions. Surprisingly, the quality “empathetic” only scored 2.64 on this scale [33].

Overall, students value contact with quality instructors and classroom interactions which promote learning. Although online instructors may possess the qualities that students seek in educators, some believe the instructors’ abilities to reach the students in a deep and meaningful way may be hampered by the distance format. Noonan and Coral (2013) assert that virtual environments work well for information transfer, but do not foster the in-depth human contact and social interaction required for quality education, arguing that “people respond differently... when they feel the presence of others” [35]. It is clear that students want to be engaged in their learning through quality instruction. Communication is richer in person, where individuals can hear each other’s tone, see gestures and respond in real time. Classroom debates can flourish and instructors can probe and respond with greater agility in person. Furthermore, in-person programs also provide students with complete immersion in the educational experience, surrounded by peers who are also learning, questioning, and growing daily. It should be no surprise that traditional undergraduate students seek in-person education as the default educational format.

Overall, when considering what students value about in person education, it is clear that students want to be engaged in their learning through quality instruction. Communication is richer in person, where individuals can hear each other’s tone, see gestures and respond in real time. Classroom debates can flourish and instructors can probe and respond with greater agility in person. Furthermore, in-person programs also provide students with complete immersion in the educational experience, surrounded by peers who are also learning, questioning, and growing daily. It should be no surprise that

traditional undergraduate students seek in-person education as the default educational format; with students being driven online out of necessity due to geographic and time restrictions such as those caused by work, families, or military service.

VI. CONCLUSIONS

Enrollment is increasing for online programs [3,6]. The demands of work and family create a need for the convenience and flexibility of online education and have consistently been shown to be the leading reasons why students choose online education [10, 15-21]. The older age of online students [23], when compared with traditional undergraduates, indicates that differences in life stage accounts for the needs of online students, who are more likely to have work and family obligations. In contrast, first year undergraduate students are comparatively more free to move geographies to obtain an education. In fact, when we examine the factors that influence school selection for traditional undergraduate students, they are motivated by cost, availability of majors, campus visits, size/location of schools, and sibling choices [27-29,31]. Convenience and flexibility (the main driving forces for those who choose to study online [26-31]) are not even mentioned among the college selection criteria of traditional first year undergraduates. For the institutions, as well as the students, it is clear that the default educational choice is in-person and the online format is chosen for necessity and convenience. Even in-person programs select online classes out of necessity and convenience when driven to do so by scheduling conflicts or limited space [31].

Traditional undergraduate students value contact with quality instructors and each other [17, 32-34]. Some also feel the best format for the in-depth challenging dialogue required of education is in-person classes [23]. Some academics fear the trend in growing online classes, but students use this format out of necessity, not preference. Because of the irreplaceable experience of direct human contact, the internet will not replace in-person education.

Growth in fully online engineering undergraduate programs has not occurred at the fast pace of other disciplines [6]. Undergraduate online engineering programs have several hurdles to overcome in their transition to online offerings, including significant laboratory requirements, heavy computational requirements, and emphasis on ABET accreditation [10-12, 14]. In addition, both faculty and students perceive online engineering courses as requiring more motivation and organization on behalf of the student to be successful academically [22]. Although we know that online graduate program enrollment is driven by necessity and convenience, the more mature graduate student population may have more developed motivation and self-discipline, necessary characteristics to be successful in the online learning environment.

There is a definite gap in the literature as to why students enroll in online engineering programs. We know in general, why students seek online programs (necessity and convenience), but assume that these same factors dominate why students study engineering online. Future research might explore whether there are different or additional motivating factors for enrollment in

fully online engineering programs. Future research might also address whether older, more mature students possess increased motivation and self-discipline required for success in online learning.

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