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Entrepreneurial Career Choice and Characteristics of Engineering and Business Students*

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This paper measures the entrepreneurial intent and related characteristics of engineering undergraduates, as compared with business students. The purpose of this study is to describe and test the difference on entrepreneurial intent and related characteristics for engineering and business students with different career goals for both genders. Data were collected through the Young Entrepreneurs Study (YES) survey, which included 518 engineering and 471 business undergraduates from multiple institutions. Analysis of Variance with Tukey-Kramer tests and independent samples t-tests with Bonferroni corrections were conducted to test for differences across groups. The results showed that starters (participants who stated starting an organization as their career goal) reported significantly higher scores than did joiners (participants who stated joining an organization as their career goal) in several entrepreneurship-related characteristics. Although business students were more likely to cite entrepreneurship as their career goal than were engineering students, engineering and business students who had the same career goals showed similar characteristics that were related to entrepreneurial intent. Women and men starters, regardless of discipline, have similar entrepreneurship-related characteristics; however, business men have higher entrepreneurial intent than do engineering women. With similar entrepreneurship-related characteristics among engineering and business starters, entrepreneurial courses and programs for engineering and business starters could be structured similarly. Perhaps these courses could be multidisciplinary, serving both engineering and business starters, although engineering students in these types of courses should be encouraged to have more confidence in communicating their ideas. Curricula might be designed such that some groups, such as engineering women, with less salient intentions, could easily access resources and tools to develop their ideas.

Keywords: entrepreneurship; innovation; gender

1. Introduction

Technology-based innovation and entrepreneurship contribute greatly to economic growth and job creation [1–3]. Because of this, technological innovation and entrepreneurship are highly promoted in higher education in the United States [4]. This change has brought an increasing demand for engineering graduates to be not only experts in their professional fields but also innovative and able to recognize opportunities [5, 6].

To educate engineers to succeed in this changing work environment, a variety of entrepreneurship courses and programs have been created for undergraduate engineering students [2, 7]. These courses and programs are often interdisciplinary in nature, regardless of whether they are designed primarily for engineering students [8, 9] or are open to

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students from multiple disciplines [10, 11]. As those courses and programs are in development, it is important for engineering educators to understand the career goals and characteristics that are associated with entrepreneurship among engineering students. In addition, from an interdisciplinary perspective, it is valuable to identify similarities and differences between engineering and business students on these same measures, as oftentimes business and engineering students are both included in these courses and programs. Yet, only a limited number of studies have probed engineering students' entrepreneurial intent or entrepreneurship related characteristics. In addition, gender issues are particularly relevant for engineering majors, where women make up less than 25% of the student body [12]. However, only a few studies [13, 14] have compared students from engineering and business disciplines, much less investigated the extent to which differences by discipline might vary by gender.

To fill this gap, the present study examines the career goals and characteristics that are related to entrepreneurial intent of engineering undergraduates as compared with business undergraduates; to do this, we draw from cross-institutional survey data (YES data) collected from both men and women. The findings of this present research will provide important references to the engineering education community in designing and creating entrepreneurial courses and programs. For example, with the knowledge of career goals and entrepreneurship related characteristics of engineering students, engineering educators can create more effective pedagogies in introducing business knowledge and concepts. For those classes and programs open to students from multiple disciplines, engineering educators can better structure the learning content and activities in light of the similarities and differences between engineers and their non-engineering peers.

2. Literature review

2.1 Theoretical framework

The framework that we used to guide this research is the Relational Developmental Systems Theories (RDST), which is a popular theory in developmental science [15, 16]. The theme of RDST is that human development happens in the dynamic, complex, and bidirectional relationships (←→) between individuals and their contexts (e.g., families, schools, peer groups, etc.) [17, 18]. Individuals' characteristics and behaviors can change their contexts while contexts can also influence and shape individuals. RDST has been widely used to explain the development of human beings [15, 16]. Positive developmental outcomes, such as successful life management and successful occupational and partnership functioning, are thought to occur when there are mutually beneficial bidirectional relationships between individuals and their contexts [19–21]. Entrepreneurship interests are theorized to be a positive developmental outcome in the framework of RDST [18, 22]. The reciprocal relationships between individuals and their contexts describe how people's entrepreneurial interests develop during their adolescent period and why some individuals are more entrepreneurial oriented than are others. We report students' personal characteristics that are related to the development of their entrepreneurial interests. At the same time, students' discipline of study is regarded as a contextual factor that can contribute to the development of entrepreneurial interests.

2.2 Factors related to entrepreneurial intent

A number of studies have explored which factors may affect individuals' entrepreneurial intent, which is the intention to start an organization. Consistent with the RDST framework, these factors generally fall into one of two groups: personal characteristics [23–26] and contextual factors [27–31]. Typically, the participants in these studies are business students or employees from large organizations.

Studies focused on personal characteristics attempt to distinguish entrepreneurs from the rest of the population on psychological measures such as Need for Achievement and Proactive Personality. McClelland [32] reported a correlation between 55 male graduates' Need for Achievement scores and their career status fourteen years after their college graduation. Participants who were engaged in entrepreneurial careers after graduation had significantly higher scores in Need for Achievement during their college years. Similarly, Crant [33] found that Proactive Personality, defined as the extent to which people are willing to "take action to influence their environments," was strongly and positively (r = 0.48) related to entrepreneurial intent, among a sample of 181 undergraduate and MBA students from a medium-sized Midwestern university in the United States. These studies suggest that certain personal characteristics are correlated with entrepreneurial outcomes.

The Big Five personality dimensions (Conscientiousness, Agreeableness, Neuroticism, Openness to Experience, Extraversion) [25, 26, 34] offer a systematic approach to examine the personal-psychological differences between entrepreneurs and non-entrepreneurs (usually managers). Through a meta-analysis approach, Zhao and colleagues [25, 26]

showed that the Big Five personality factors were moderately correlated with entrepreneurial career choice. Entrepreneurs scored higher than managers did on Conscientiousness and Openness to Experience, and lower on Neuroticism and Agreeableness. Entrepreneurs and managers did not differ on Extraversion. Other personal characteristics shown to be related to entrepreneurial intent include, for example, self-efficacy [24, 35–37], innovativeness [38, 39], and risk tolerance [40, 41]. People who had higher entrepreneurial intent were found to have higher self-efficacy, to be more innovation oriented, and to be more risk tolerant.

Some researchers have shown that not only personal characteristics, but also contextual factors, such as influence from family, can affect entrepreneurial intent and career choice [33]. For example, Carr and Sequeira [42] suggested that, among a sample of respondents from a large southwest city in the United States, the levels of exposure to a family business were significantly and positively related to entrepreneurial intent. Similarly, in a study of 89 business students at a large Midwestern university in the United States Matthews and Moser [43] reported that participants' entrepreneurial interest was closely associated with having an entrepreneurial parent. These studies suggest that both personal characteristics and contextual factors are related to the development of entrepreneurial intent.

2.3 Entrepreneurial intent of students from different disciplines

Studies indicate that business students tend to have higher entrepreneurial intent than do students from other disciplines [28, 44], although engineering is not commonly included in these studies. For example, Taatilla and Down [44] compared 277 undergraduates of different majors from a university in Finland on their entrepreneurial intent and innovativeness. Between-major differences were found in entrepreneurial desire but not in innovativeness. Students majoring in business ventures, service management, business information technology, and hotel and restaurant management showed more desire for entrepreneurial careers than did students majoring in nursing, information technology, security, and social work. Similar findings were reported by Franco, Haase, and Lautenschläger [28], in a study of 988 undergraduate and masters students selected from three European universities. They found that business students had higher intention to be self-employed compared with students from other disciplines (engineering, other social sciences, arts and humanities, design and mathematics) as a whole group. However, students' intention to be self-employed was not specified for each of these non-business disciplines.

Only a few studies have described the entrepreneurial intent of engineering students specifically. Nabi, Holden, and Walmsley [13] measured the entrepreneurial intent of undergraduates from England based on the Entrepreneurial Intention Survey (N = 8,456). They compared the entrepreneurial intent of students from six different disciplines: (1) medical and health, (2) science, (3) engineering and technology, (4) business, (5) social science, and (6) art and humanities. Business students showed the highest entrepreneurial intent, with half of respondents indicating that they "definitely" (10%) or "probably" (40%) wanted to start a business. Engineering and technology students had the second highest intent with about 45% of the respondents indicating that they "definitely" (8%) or "probably" (37%) wanted to start a business. The entrepreneurial intent of students from other disciplines was much lower than was that among business or engineering and technology students. Duval-Couetil, Reed-Rhoad, and Haghighi compared the entrepreneurial interests of two groups of senior engineering students registered at three large institutions. The first group (n = 354) had not attended any entrepreneurship courses and the second group (n = 147) had attended one or more entrepreneurship courses. Significant differences were found between the two groups. Fifty-nine percent of the students in the second group wanted to become entrepreneurs, whereas 34% of students in the first group wanted to become entrepreneurs. Lüthje and Franke [45] measured students' intention to be self-employed among 512 undergraduate and graduate students majoring in electrical engineering/computer science or mechanical engineering from Massachusetts Institute of Technology. Among these students, 10.6% indicated that they would "very probably" be "self-employed in the foreseeable future after graduation" whereas 44% of the participants indicated that they would "quite probably" be self-employed. Very few studies have systematically looked into not only the entrepreneurial interests or intentions of engineering and business students, but also the entrepreneurship-related characteristics of these students.

2.4 Gender and entrepreneurial intent

Studies suggest that women have lower entrepreneurial intent than do men, and women are less involved in entrepreneurial activities [27, 46–50]. It is reported that about 14% of men and 11% of women in the United States are early-stage entrepreneurs [51]. The gender gap in entrepreneurship intent is evident even among college students. For example, Sax [52] reported that 47.7% of men versus 37.9% of women entered college with career goals of starting their own businesses.

Some studies have also shown that women and men differ in personal characteristics and contexts that are related to the development of entrepreneurial intent. Wilson, Kickul, and Marlino [53] showed that, among 933 MBA students from seven graduate programs in the United States, women had lower entrepreneurial self-efficacy than did men, and self-efficacy was more strongly associated with entrepreneurial intent for women than for men. Thébaud [54] conducted similar analyses using a large-scale (N = 15,242) cross-national dataset collected through Global Entrepreneurship Monitor. Results showed that women tended to have lower self-assessments of their entrepreneurial ability than did men, and this difference in self-assessments contributed to the gender difference in entrepreneurial intent. Engle, Schlaegel, and Delanoe [27] suggested that entrepreneurial parents were more likely to positively influence men than women on their entrepreneurial intent. In contrast, BarNir, Watson, and Hutchins [49] suggested that role models had a stronger positive effect for women than for men on their entrepreneurial intent. Most of the participants in the studies mentioned above were business students or from a general population. Few studies have compared men and women in engineering majors on their entrepreneurial intent or related characteristics. In this current study, engineering men and women will be compared on the career goals and characteristics that are related to entrepreneurial intent.

2.5 *Our preliminary study*

This present study builds on preliminary research that we conducted [14]. Here, we provide a short summary of that preliminary study to provide context for the present analyses that are subsequently described. The aim of our preliminary study was to provide a comprehensive descriptive data analysis reviewing the personal characteristics and contexts of engineering undergraduates, as compared with business students, within the YES sample. The results indicated that engineering students had lower entrepreneurial intent than did business students. Men had higher entrepreneurial intent than did women for both engineering and business students. We also measured the career goals of engineering and business students, as shown in Fig. 1.

Business students (43.7%) were significantly more likely than engineering students (25.1%) to cite starting an organization (profit and non-profit) as their career goals. Meanwhile, engineering men (32.1%) were significantly more likely than engineering women (15.1%) to cite starting an organization as their career goals, and a significantly higher percentage of business men (54.7%) than business women (32.9%) wanted to start an organization. We also found that students' innovation orientation was strongly correlated (r = 0.46 for engineering students and r = 0.47 for business students) with their entrepreneurial intent. What remains to be explored is how students who wanted to pursue entrepreneurial careers (defined as "starters") differ from students who did not want to pursue entrepreneurial careers (defined as "joiners") among both engineering and business students, as well as how gender further differentiates starts and joiners for both disciplines. This paper will provide more data to address these gaps.

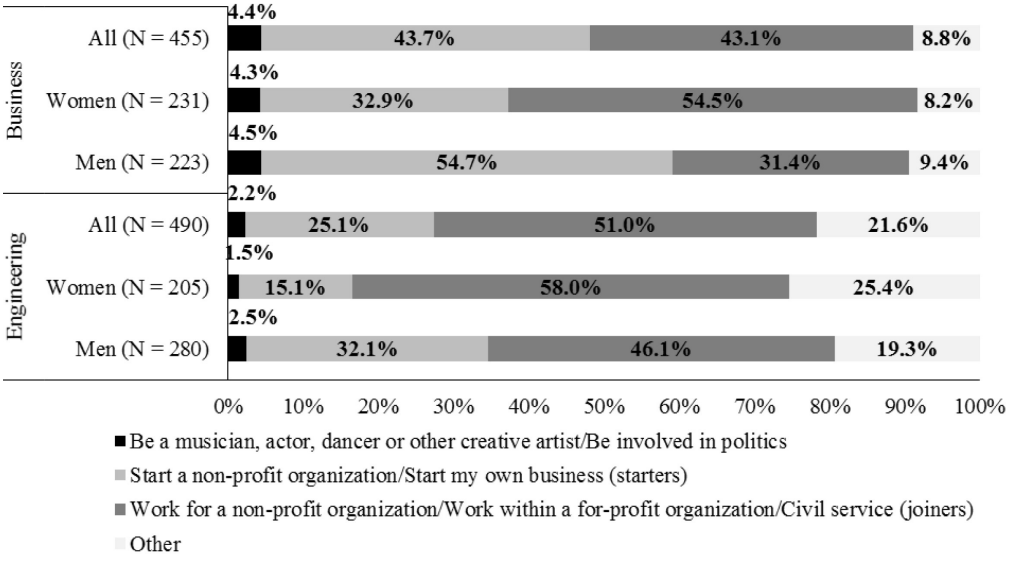

Fig. 1. Career goals of engineering and business undergraduates by gender (adapted from [14]). The Ns represent valid numbers of participants in the groups.

3. Research questions

Based on the literature review and our preliminary study, we identified three research questions to guide this study:

(1) How do engineering and business students with different career goals (to start an organization vs. to join an organization) compare on entrepreneurial intent and related measures?
(2) Among students who want to start an organization and among students who want to join an existing organization, separately, how do characteristics that are related to entrepreneurial intent vary by discipline and gender?
(3) To what extent are starters different from joiners for men and women in engineering and business disciplines?

4. Methods

4.1 Participants

The data for this study come from participants in YES. YES is a mixed-methods longitudinal study designed to explore the relationship between personal characteristics, contexts, and the development of youth entrepreneurship. The YES survey is based on the theoretical framework of RDST [22]. By the end of 2014, a total of three waves of survey data had been collected from students registered at 93 universities and colleges centered in three regions in the United States: New England, the West Coast, and the Midwest. Participants were either given course credits or were entered into a drawing for iPads as survey response incentives.

The present study draws from data collected in the first wave of data collection, which occurred between January and June 2012. The sample for our study includes only those survey participants in engineering and business fields (N = 989, 518 of whom were identified as engineering students and 471 of whom were identified as business students). Among the engineering students, 57.9% were men and 42.1% were women. Among the business students, 49.1% were men and 50.9% were women. The average age of the engineering students and business students was 20.7 (SD = 1.4) and 21.2 (SD = 1.4), respectively. More details of participants' self-reported demographics are summarized in Table 1.

Participants' discipline of study was determined based on their self-reported undergraduate majors, which were coded and then classified using a criteria similar to that used by Lichtenstein, McCormick, Sheppard, and Puma [55]. The 518 engineering students reported the following majors: aero/astronautical engineering, civil engineering, chemical engineering, electrical or electronic engineering, industrial engineering, materials engineering, mechanical engineering, computer science/engineering within an engineering school, and general/other engineering. The 471 business students had the following majors: accounting, business administration (general), finance, international business, marketing, management, entrepreneurship, and other business.

Table 2 summarizes the numbers and percentages of students from these engineering and business majors, as well as the numbers and percentages of starters and joiners by discipline. As indicated in Fig. 1, the total number of starters and joiners is smaller than the total number of participants, as a few participants chose to be artists, to be involved in politics, or ''other''. The students who majored in industrial, civil, mechanical, and computer engineering were more likely to identify themselves as

Table 1. Demographics of Participants

	Engineering		**Business**	
	n	**%**	**n**	**%**
Total Number of Respondents	518	100%	471	100%
Sex				
Male	297	57.9%	231	49.1%
Female	216	42.1%	239	50.9%
Valid Total	513	100%	470	100%
Race/Ethnicity				
American Indian or Alaska Native	0	0	1	0.2%
Asian or Asian American	148	28.6%	50	10.6%
African American	13	2.5%	18	3.8%
Hispanic or Latino	35	6.8%	19	4.0%
Native Hawaiian or Pacific Islander	2	0.4%	2	0.4%
White	269	52.0%	356	75.7%
Other	11	2.1%	5	1.1%
Multiracial	39	7.5%	19	4.0%
Valid Total	517	100%	470	100%

Table 2. Numbers and Percentages of Starters and Joiners for Engineering and Business Majors

	Total		Starters		Joiners	
	n	%	n	%	n	%
Engineering Majors						
Chemical	38	9.7%	4	10.5%	34	89.5%
Aero/Astronautical	4	1.0%	1	25.0%	3	75.0%
Materials	4	1.0%	1	25.0%	3	75.0%
Other	98	25.1%	25	25.5%	73	74.5%
Electrical/Electronic	17	4.4%	5	29.4%	12	70.6%
Industrial	12	3.1%	4	33.3%	8	66.7%
Civil	56	14.4%	19	33.9%	37	66.1%
Mechanical	66	16.9%	24	36.4%	42	63.6%
Computer	95	24.4%	43	45.3%	52	54.7%
Total	390	100.0%	126	32.3%	264	67.7%
Business Majors						
Accounting	88	21.6%	33	37.5%	55	62.5%
Other	37	9.1%	15	40.5%	22	59.5%
Finance	48	11.8%	22	45.8%	26	54.2%
Marketing	58	14.2%	28	48.3%	30	51.7%
Business Administration	80	19.6%	42	52.5%	38	47.5%
International Business	19	4.7%	11	57.9%	8	42.1%
Management	49	12.0%	30	61.2%	19	38.8%
Entrepreneurship	29	7.1%	26	89.7%	3	10.3%
Total	408	100.0%	207	50.7%	201	49.3%

Starters: students who wanted to start a non-profit organization or to start their own business.
Joiners: students who wanted to work for a non-profit organization, work for a for-profit organization, or work for civil service. Non-starters and non-joiners were excluded from the table.

starters compared with those from other engineering majors. A significant difference was observed in the percentages of starters and joiners among the engineering majors (χ^2 (8) = 18.44, p = 0.018). Similarly, for business majors, students from business administration, international business, management, and entrepreneurship majors were more likely to identify themselves as starters compared with those from other business majors. A significant difference was observed in the percentages of starters and joiners among the business majors (χ^2 (7) = 28.53, $p < 0.001$).

Among starters, 52.6% of the engineering students and 52.3% of the business students had at least one entrepreneurial parent. In contrast, only 37.6% of the engineering joiners and 43.0% of the business joiners had at least one entrepreneurial parent. A significant difference was observed among the four groups ($\chi^2 = 12.68$, $p = 0.005$) in the percentages of students who have entrepreneurial parents.

4.2 Measures

In this study, we used seven measures, described individually below. Two scales were used to represent career goals and entrepreneurial intent. In preliminary analyses described above [14], we identified five additional measures as moderately correlated with entrepreneurial intent for both engineering and business students: Career Values-Challenging, Innovation Orientation, Goal Selection-Novel, Goal Selection-Challenge, and Sense of Self-Movers and Shakers. Table 3 summarizes the items and Cronbach's alphas for each scale.

4.2.1 Career goals

Students' career goals were measured using a multiple-choice question scale that asked participants to select their most important career goal. Participants were given eight options, of which they could only choose one: (1) Be a musician, actor, dancer or other creative artist; (2) Be involved in politics; (3) Start a non-profit organization; (4) Start my own business; (5) Work for a non-profit organization; (6) Work within a for-profit organization/business; (7) Work in civil Service (e.g., education, government employee, etc.); and (8) Other. If participants selected "Other" as their most important career goal, a follow-up question asked them to specify their choice.

4.2.2 Entrepreneurial intent

For this study, entrepreneurial intent represents, as Bird describes [56], the "state of mind that directs attention, experience, and action toward a business concept," and entrepreneurial intent sets the "form and direction of organizations at their inception." The scale consists of four items [22] measuring the importance of starting/developing a new business in participants' lives. Students were asked to rate how important the items were in their lives. The items were measured on a five-point Likert scale with

Table 3. Description of the Measures

Measures	Cronbach's α	Items
Entrepreneurial Intent	0.89	(1) Start my own business. (2) Develop my own business. (3) Start a new organization. (4) Change the way a business or organization runs.
Career Values-Challenging	0.72	(1) A career where you make decisions. (2) A career where most problems are quite difficult and challenging. (3) A career that is interesting to do. (4) A career where you can see the payoff of what you create. (5) A career where you can have the chance to be creative. (6) A career that leaves you mostly free of supervision by others.
Innovation Orientation	0.84	(1) Search out new technologies, processes, techniques, and/or product ideas. (2) Promote and champion ideas to others. (3) Investigate and secure funds needed to implement new ideas. (4) Develop adequate plans and schedules for the implementation of new ideas. (5) Generate creative ideas. (6) Are innovative.
Goal Selection-Novel	0.78	(1) I like to pursue projects that others have not thought about pursuing. (2) I am interested in projects that involve new ideas. (3) I take on ventures that address unmet needs.
Goal Selection-Challenge	0.88	(1) I select challenging goals. (2) I prefer to take on challenging projects. (3) I enjoy challenging tasks.
Sense of Self-Movers and Shakers	0.76	(1) Willing to stand up for what I believe is right. (2) Involved in solving community problems. (3) Creative or imaginative. (4) Politically involved. (5) Compassionate, concerned about all kinds of people. (6) Unconventional, nonconformist. (7) Concerned about justice and human rights. (8) Outgoing, sociable. (9) Curious.

responses ranging from 1 (not at all important) to 5 (extremely important).

4.2.3 Career values-challenging

Career values are defined as the importance attached to various rewards of careers and are closely related to career choice [57]. The scale of Career Values was adapted from the Job Value Scales created by Johnson [58, 59]. Career Values-Challenging is a sub-scale in the scale of Career Values. It measures how much students value challenging careers. The items were measured on a five-point Likert scale with responses ranging from 1 (not important) to 5 (extremely important).

4.2.4 Innovation orientation

The scale of Innovation Orientation was adapted from Scott and Bruce's measures of individuals' innovative behavior [60]. The scale includes six items that ask participants to rate the extent to which they engage in a list of behaviors. The items were measured on a five-point Likert scale with responses ranging from 1 (almost never) to 5 (almost always).

4.2.5 Goal selection

Goal Selection was operationalized by two sub-scales from the Entrepreneurial Intentional Self-Regulation Questionnaire (EISR), which was developed specifically for the YES by the research team and asks participants to rate the way they approach and accomplish goals in their lives [61]. Goal Selection includes two sub-scales: Novel and Challenge. Selection of novel goals represents a preference for selecting goals others have not considered or that fulfill an unmet need. Selection of challenging goals represents a preference for selecting challenging goals, projects, and tasks. The items were measured on a five-point Likert scale with responses ranging from 1 (almost never) to 5 (almost always).

4.2.6 Sense of Self-Movers and Shakers

The scale of Sense of Self was adapted from the Stanford Youth Purpose Survey [62]. This scale measures characteristics that are relevant to participants' sense of whether they are powerful people who initiate events and influence people. Participants were asked to respond according to the

centrality of these qualities to their identity, rather than how desirable they think these characteristics are in general. The original scale contains several subscales, but we used only the Movers and Shakers subscale. The items were measured on a five-point Likert scale with responses ranging from 1 (not at all central to my sense of self) to 5 (very central to my sense of self).

4.3 Data analyses

We conducted one-way analysis of variance (ANOVA) with Tukey-Kramer tests to compare the means of different groups for each of the measures described above. In the first step, the means of the following four groups were compared: (1) engineering students who wanted to start an organization (ES), (2) business students who wanted to start an organization (BS), (3) engineering students who wanted to work for an organization (EW), and (4) business students who wanted to work for an organization (BW). In this step, Levene's tests for constant variance suggested that the assumption of constant variance was not violated except for Entrepreneurial Intent ($p < 0.001$). Thus, a Tukey-Kramer test was conducted to compare group means for the measures except for Entrepreneurial Intent. An alternative post-hoc test, the Games-Howell test, which is robust to unequal variance [63], was used on the scale of Entrepreneurial Intent. In order to have a better understanding on how engineering and business students compare in their innovation orientation, the four groups were further compared on the six items from the scale of Innovation Orientation. Levene's tests for homogeneity of variances suggested that the constant variance assumption was not violated except for Item 3 (''Investigate and secure funds needed to implement new ideas'') ($p = 0.004$) and Item 5 (''Generate creative ideas'') ($p = 0.02$). Thus, Games-Howell tests were conducted to compare the four groups on these two items. Tukey-Kramer tests were conducted to compare the group means on all other items. Eta-squared from ANOVA was summarized as effect size.

In the second step of data analyses, engineering and business students of both genders were compared within the starter group and the joiner groups separately. There are four groups in the starter group: (1) men engineering starters (ES-M), (2) women engineering starters (ES-W), (3) men business starters (BS-M), (4) women business starters (BS-W). There are four groups in the joiner group as well: (1) men engineering joiners (EJ-M), (2) women engineering joiners (EJ-W), (3) men business joiners (BJ-M), and (4) women business joiners (BJ-W). Levene's tests for homogeneity of variances suggested that the constant variance assumption was not violated for any of the scales. Thus, Tukey-Kramer tests were conducted to compare the group means in all the comparisons. Eta-squared was also calculated in this step.

In the third step, starters and joiners were further compared within these groups: engineering men, engineering women, business men, and business women. Here, *t*-tests with Bonferroni corrections were conducted to test the differences in the means and the associated p-values were reported in Results section. Based on the Bonferroni correction, a new significance level ($\alpha = 0.008$) was used in place of the original significance level of 0.05. Cohen's d was calculated and reported as effect size.

5. Results

5.1 How do engineering and business students with different career goals compare on entrepreneurial intent and related measures?

To address this research question, we compared four groups of students on both their entrepreneurial intent and measures that were identified as moderately correlated with entrepreneurial intent [14]. These four groups are: (1) engineering starters (ES), (2) business starters (BS), (3) engineering joiners (EJ), and (4) business joiners (BJ). Table 4 summarizes the means and standard deviations for these measures for each of the four groups. On four of the six scales (Career Value-Challenge, Innovation Orientation, Goal Selection-Novel, and Goal Selection-Challenging), starters (ES and BS) had significantly higher scores than did joiners (EJ and BJ), but engineering and business students were not significantly different within the starter or joiner groups. In order words, engineering and business starters are similar on these measures, and engineering and business joiners are similar on these measures.

On the scale of Entrepreneurial Intent, the four groups were significantly different from each other. Business starters had the highest mean score and engineering joiners had the lowest mean score on this measure. On the scale of Sense of Self-Movers and Shakers, business starters also had significantly higher scores than did the other three groups. Although the mean scores of business starters were not significantly different from the mean scores of engineering starters, the business starters' mean score was significantly higher than both engineering and business joiners. Large effect size was identified for Entrepreneurial Intent and small effect sizes were identified for the other measures.

Given the importance of technology innovation to the economic growth and job creation, we are

Table 4. Entrepreneurial Intent and Related Characteristics: Means and Standard Deviations (SD) for Starters and Joiners from Engineering and Business Disciplines

	Starters				Joiners				ANOVA					
	Engineering (ES)		Business (BS)		Engineering (EJ)		Business (BJ)				Post-Hoc Analysis[3]			
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	F^1	Eta-squared[2]	ES	BS	EJ	BJ
Entrepreneurial Intent	3.90	0.62	4.17	0.67	2.62	0.99	2.97	0.95	158.57***	0.38	b	a	d	c
Career Value-Challenging	4.11	0.52	4.10	0.57	3.81	0.53	3.82	0.58	17.81***	0.06	a	a	b	b
Innovation Orientation	3.56	0.65	3.71	0.74	3.21	0.74	3.28	0.73	22.18***	0.08	a	a	b	b
Goal Selection-Novel	3.97	0.71	3.99	0.74	3.68	0.69	3.60	0.69	14.67***	0.05	a	a	b	b
Goal Selection-Challenge	4.09	0.68	4.05	0.67	3.81	0.71	3.71	0.73	12.26***	0.04	a	a	b	b
Sense of Self-Movers and Shakers	3.55	0.59	3.69	0.55	3.32	0.60	3.48	0.63	14.85***	0.05	a b	a	c	b c

[1] *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.
[2] Eta-squared guidelines: small (0.02, 0.13), medium [0.13 – 0.26), and large 0.26 or higher [64].
[3] Groups with the same letter are not significantly different. Tukey-Kramer tests were used in the post-hoc analysis.

particularly keen to have a better understanding of the innovation-related characteristics for engineering and business students. Thus, we further investigated their scores on the scale of Innovation Orientation at the item level. As summarized in Table 5, the two groups of starters had significantly higher scores than did the two groups of joiners on three of the items: searching out new technologies, process techniques, and/or product ideas (Item 1), generating creative ideas (Item 5), and being innovative (Item 6). Again, however, the differences between engineering and business students on these three items within each career goal group were not statistically significant based on Tukey-Kramer tests. Business starters distinguished themselves from the other three groups (even engineering

Table 5. Items in the Innovation Orientation Scale: Means and Standard Deviations (SD) for Starters and Joiners from Engineering and Business Disciplines

	Starters				Joiners				ANOVA					
	Engineering (ES)		Business (BS)		Engineering (EJ)		Business (BJ)				Post-Hoc Analysis[3]			
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	F^1	Eta-squared[2]	ES	BS	EJ	BJ
Item 1. Search out new technologies, process techniques, and/or product ideas	3.78	0.90	3.71	1.03	3.32	1.03	3.11	1.00	18.12***	0.06	a	a	b	b
Item 2. Promote and champion ideas to others	3.52	0.91	3.80	0.91	3.28	0.94	3.46	0.92	12.62***	0.05	b	a	b	b
Item 3. Investigate and secure funds needed to implement new ideas	2.86	1.05	3.28	1.17	2.62	1.12	2.84	1.03	13.81***	0.05	b	a	b	b
Item 4. Develop adequate plans and schedules for the implementations	3.46	0.95	3.66	0.93	3.28	1.08	3.48	1.01	5.45**	0.02	a b	a	b	a b
Item 5. Generate creative ideas	3.85	0.79	3.95	0.89	3.40	0.89	3.44	0.95	20.31***	0.07	a	a	b	b
Item 6. Are innovative	3.85	0.82	3.86	0.92	3.38	0.81	3.37	0.88	19.65***	0.07	a	a	b	b

[1] *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$
[2] Eta-squared guidelines: small (0.02–0.13), medium (0.13–0.26), and large (0.26 or higher) [64].
[3] Groups with the same letter are not significantly different. Tukey-Kramer tests were used in the post-hoc analysis.

starters) on two of the measures: promoting and championing ideas to others (Item 2) and investigating and securing funds needed to implement new ideas (Item 3). No differences were found between engineering starters, engineering joiners, and business joiners on these two items. Business starters had significantly higher scores than did engineering joiners on Item 4 (developing adequate plans and schedules for the implementations) based on Tukey-Kramer tests; business starters and engineering joiners were at the extremes on this measure.

5.2 Among starters and among joiners, separately, how do characteristics that are related to entrepreneurial intent vary by discipline and gender?

We further investigated the characteristics of engineering and business students by gender. Among starters (as shown in Table 6a), four groups were compared: (1) engineering men, (2) engineering women, (3) business men, and (4) business women. These four groups were indistinguishable from each other on four scales: Career Value-Challenging, Innovation Orientation, Goal Selection-Novel, and Goal Selection-Challenge. On the scale of Entrepreneurial Intent, business men reported the highest scores and engineering women reported the lowest scores. In contrast, it is engineering men with the lowest mean score on the scale of Sense of Self-Movers and Shakers (and business men again with the highest).

Turning to joiners (as shown in Table 6b), four parallel groups were compared. These four groups were indistinguishable on all scales except for Entrepreneurial Intent. The results are similar to those for starters: business men had the highest mean score and engineering women had the lowest mean score

Table 6a. Entrepreneurial Intent and Related Characteristics: Means and Standard Deviations (SD) for Starters by Discipline and Gender

	Engineering				Business				ANOVA					
	Men (ES-M)		Women (ES-W)		Men (BS-M)		Women (BS-W)				Post-Hoc Analysis[3]			
Starters	Mean	SD	Mean	SD	Mean	SD	Mean	SD	F^1	Eta-squared[2]	ES-M	ES-W	BS-M	BS-W
Entrepreneurial Intent	3.94	0.59	3.74	0.66	4.21	0.67	4.12	0.66	6.20***	0.05	b c	c	a	a b
Career Value-Challenging	4.14	0.49	3.98	0.58	4.10	0.53	4.10	0.63	0.67	0.01	a	a	a	a
Innovation Orientation	3.58	0.64	3.47	0.69	3.81	0.68	3.55	0.80	3.63*	0.03	a	a	a	a
Goal Selection-Novel	3.99	0.70	3.88	0.75	4.07	0.69	3.86	0.81	1.56	0.01	a	a	a	a
Goal Selection-Challenge	4.11	0.67	3.96	0.72	4.09	0.65	3.99	0.70	0.78	0.01	a	a	a	a
Sense of Self-Movers and Shakers	3.51	0.58	3.64	0.59	3.74	0.54	3.60	0.57	3.08*	0.03	b	a b	a	a b

[1] *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$
[2] Eta-squared guidelines: small (0.02–0.13), medium (0.13–0.26), and large (0.26 or higher) [64].
[3] Groups with the same letter are not significantly different. Tukey-Kramer tests were used in the post-hoc analysis.

Table 6b. Entrepreneurial Intent and Related Characteristics: Means and Standard Deviations (SD) for Joiners by Discipline and Gender

	Engineering				Business				ANOVA					
	Men (EJ-M)		Women (EJ-W)		Men (BJ-M)		Women (BJ-W)				Post-Hoc Analysis[3]			
Joiners	Mean	SD	Mean	SD	Mean	SD	Mean	SD	F^1	Eta-squared[2]	EJ-M	EJ-W	BJ-M	BJ-W
Entrepreneurial Intent	2.72	0.97	2.50	1.00	3.14	0.95	2.88	0.95	7.16***	0.04	b c	c	a	a b
Career Value-Challenging	3.86	0.55	3.74	0.50	3.86	0.60	3.80	0.58	1.21	0.01	a	a	a	a
Innovation Orientation	3.19	0.75	3.25	0.72	3.43	0.73	3.20	0.72	2.00	0.01	a	a	a	a
Goal Selection-Novel	3.73	0.70	3.62	0.67	3.64	0.68	3.58	0.70	1.15	0.01	a	a	a	a
Goal Selection-Challenge	3.84	0.64	3.78	0.78	3.77	0.72	3.68	0.74	1.16	0.01	a	a	a	a
Sense of Self-Movers and Shakers	3.34	0.65	3.31	0.55	3.49	0.65	3.47	0.62	2.50	0.02	a	a	a	a

[1] *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.
[2] Eta-squared guidelines: small (0.02–0.13), medium (0.13–0.26), and large (0.26 or higher) [64].
[3] Groups with the same letter are not significantly different. Tukey-Kramer tests were used in the post-hoc analysis.

on the scale of Entrepreneurial Intent. This measure of intent, in other words, appears to have consistently differentiated between business men and engineering women regardless of primary career goal. Unlike findings for starters, however, engineering and business women and men who reported that their goal was to join an organization had comparable mean scores on Sense of Self-Movers and Shakers.

5.3 To what extent are starters different from joiners among men and women in engineering and business disciplines?

We then compared starters and joiners using independent samples *t*-tests with Bonferroni corrections within the following four groups: (1) engineering men, (2) engineering women, (3) business men, and (4) business women. Cohen's ds as effect sizes were also summarized. Table 7a summarizes the results for the engineering students and Table 7b summarizes the results for the business students. A new significance level (α = 0.008) was used to determine if the differences are significant or not, based on Bonferroni corrections. Business men starters had significantly higher mean scores than did business men joiners on all measures. Engineering men starters had significantly higher mean scores than did engineering men joiners on all measures except for Sense of Self-Movers and Shakers. This finding is consistent with the findings summarized in Table 4. However, the results were slightly different for women. Business women starters reported higher scores than did business women joiners on all measures except for Goal Selection-Novel and Sense of Self-Movers and Shakers. In contrast, compared with engineering women joiners, engineering women starters reported significantly higher scores on Entrepreneurial Intent and Sense of Self-Movers and Shakers only, but reported similar scores on Career Value-Challenge, Innovation Orientation, Goal Selection-Novel, and Goal Selection-Challenge. The patterns of effect sizes (Cohen's ds) shown in Table 7a and Table 7b were consistent with those from *t*-test results shown in the same tables.

6. Discussion

In this study, our research focus was to understand the similarities and differences between students who desired to start their own organization (starters) and those who desired to work for an existing organization (joiners), as well as to understand how students in different disciplines (engineering vs. business) compared on their entrepreneurial intent and related characteristics for both genders.

We found that students' major of study was related to whether they wanted to start a company/organization. Among engineering students, we found that students from certain majors, such as computer engineering, were more likely to choose

Table 7a. Results of *t*-tests between Starters and Joiners for Engineering Men and Women

	Engineering Men						Engineering Women					
	ES-M		EJ-M				ES-W		EJ-W			
Engineering	Mean	SD	Mean	SD	p-value[1]	Cohen's d[2]	Mean	SD	Mean	SD	p-value[1]	Cohen's d[2]
Entrepreneurial Intent	3.94	0.59	2.72	0.97	< 0.001	1.45	3.74	0.66	2.50	1.00	< 0.001	1.32
Career Value-Challenge	4.14	0.49	3.86	0.55	< 0.001	0.53	3.98	0.58	3.74	0.50	0.039	0.46
Innovation Orientation	3.58	0.64	3.19	0.75	< 0.001	0.55	3.47	0.69	3.25	0.72	0.112	0.32
Goal Selection-Novel	3.99	0.70	3.73	0.70	0.007	0.37	3.88	0.75	3.62	0.67	0.085	0.37
Goal Selection-Challenge	4.11	0.67	3.84	0.64	0.003	0.41	3.96	0.72	3.78	0.78	0.215	0.24
Sense of Self-Movers and Shakers	3.51	0.58	3.34	0.65	0.044	0.27	3.64	0.59	3.31	0.55	0.007	0.59

[1] The p-values were calculated from t-tests, with two tails. Bonferroni corrections were used to determine the significance level (α = 0.008).
[2] Cohen's d guidelines: small (0.2–0.5), medium (0.5–0.8), and large (0.8 or higher) [65].

Table 7b. Results of *t*-tests between Starters and Joiners for Business Men and Women

	Business Men						Business Women					
	BS-M		BJ-M				BS-W		BJ-W			
Business	Mean	SD	Mean	SD	p-value[1]	Cohen's d[2]	Mean	SD	Mean	SD	p-value[1]	Cohen's d[2]
Entrepreneurial Intent	4.21	0.67	3.14	0.95	< 0.001	1.38	4.12	0.66	2.88	0.95	< 0.001	1.46
Career Value-Challenge	4.10	0.53	3.86	0.60	0.005	0.44	4.10	0.63	3.80	0.58	0.001	0.51
Innovation Orientation	3.81	0.68	3.43	0.73	0.001	0.54	3.55	0.80	3.20	0.72	0.001	0.48
Goal Selection-Novel	4.07	0.69	3.64	0.68	< 0.001	0.62	3.86	0.81	3.58	0.70	0.013	0.37
Goal Selection-Challenge	4.09	0.65	3.77	0.72	0.002	0.48	3.99	0.70	3.68	0.74	0.003	0.43
Sense of Self-Movers and Shakers	3.74	0.54	3.49	0.65	0.008	0.42	3.60	0.57	3.47	0.62	0.132	0.21

[1] The p-values were calculated from *t*-tests, with two tails. Bonferroni corrections were used to determine the significance level (α = 0.008).
[2] Cohen's d guidelines: small (0.2–0.5), medium (0.5–0.8), and large (0.8 or higher) [65].

entrepreneurship as their career goal than students from some other majors, such as chemical engineering. This might be due to the larger amount of time and resources required to create new products in some traditional engineering (e.g., chemical engineering) industries compared to relatively younger industries. Among business students, those from majors such as entrepreneurship (as might be expected) and international business were more likely to be starters than those from other majors such as accounting, which is consistent with findings reported by Kolvereird and Moen [66]. Career choice may also be related to family background, as many more students who were interested in starting an organization or company had entrepreneurial family members than did joiners. This is consistent with findings reported by a few previous studies that students with entrepreneurial family members are more likely to pursue entrepreneurial career paths [42, 43] compared to students without entrepreneurial family members.

The results of our previous research showed that engineering students had lower entrepreneurial intent and lower scores on developmental correlates of intent than did business students [14]. This is consistent with findings reported by Nabi, Holden, and Walmsley [13]. However, the results of the current study indicate that among students with the same career goals, differences between engineering and business students mostly disappeared, with the exception of differences on the entrepreneurial intent measure itself. In other words, although business students may be more likely to select entrepreneurship as their career goal than are engineering students, both engineering and business students with entrepreneurial goals share many of the same characteristics. Why engineers reported lower entrepreneurial intent than did business students even among those who wanted to start an organization is a key question, possibly understood through the lens of disciplinary culture and environments.

Our results also suggest that starters in both disciplines were different from joiners in both disciplines in their entrepreneurial intent and related characteristics. There were clear differences between members of the two groups in terms of the value they placed on challenging careers, innovation orientation, and selection of novel and challenging goals. Starters were also more likely to see themselves as movers and shakers than were joiners (though the boundary between the two groups was less stark on this measure compared to the other measures). These results are consistent with other studies suggesting that certain personal characteristics (e.g., need for achievement and proactive personalities) may differentiate entrepreneurs from non-entrepreneurs [32, 33].

Gender differences in personal characteristics were observed in our previous study for both engineering and business students [14]. These findings were consistent with those reported in other studies, such that women tend to report lower entrepreneurial intent than do men [53]. In the current study, however, when we examined starters and joiners separately (Table 6a and 6b), women and men in the same discipline often did not differ on entrepreneurial intent and characteristics that are related to entrepreneurial intent (e.g., selection of future goals and innovation orientation). However, among both the starter and joiner groups, business men had the highest scores on the entrepreneurial intent measure and engineering women had the lowest.

Moreover, all measures differentiated men starters and joiners in both disciplines. Compared to men joiners, men starters have higher mean scores on personal measures related to challenges and novelty, as well as to affecting change. These differences were observed between business men (starters and joiners) and engineering men (starters and joiners). The picture was different for women. Engineering women starters were comparable to engineering women joiners in terms of innovation orientation and novelty, for example, but were different in terms of their sense of self as a ''mover and shaker.'' They evaluated themselves as more creative/imaginative and curious than did engineering women joiners. In turn, business women starters were different from business women joiners on all measures but selecting novel goals and their sense of self as a ''mover and shaker.'' At the very least, it may be that measures differentiating men starters and joiners are slightly different from those differentiating women starters and joiners. This finding also echoes previous studies indicating that certain factors may have differential effects on women's and men's entrepreneurial career decisions [49, 53]. However, the results of our study point to the potentially important role of discipline in these interaction effects.

Results of our analysis of Innovation Orientation carry potentially important pedagogical implications, to be discussed further below. There are two reasons why we wanted to make comparisons on the scale of Innovation Orientation at the item level. The first reason is that innovation is being highly promoted in the United States, in general, and in engineering education, in particular [6, 67]. It is of interest to see how engineering and business students compared explicitly on innovation orientation. The second reason was that people have different definitions of innovation [39, 67, 68]. Some of these definitions may favor engineering students and some may favor business students.

For example, Siguaw, Simpson, and Enz [39] introduced five different foci in the process of innovation: technological focus, market focus, resource allocation focus, operation focus, and employee focus. The items in Innovation Orientation loosely represent these different foci. Item 1 (search out new technologies, process techniques, and/or product ideas) is related to technological innovation. Item 2 (promote and champion ideas to others) and item 3 (investigate and secure funds needed to implement new ideas) are related to resource allocation. Item 4 (develop adequate plans and schedules for the implementations) is related to the operation in innovation. Item 5 (generate creative ideas) and item 6 (are innovative) are general measures of innovativeness.

The item-level results on the Innovation Orientation measure indicated that business starters rated themselves more highly in resource allocation than the other three groups. Engineering starters were more likely rate themselves as technologically innovative compared to the other groups, although the scores for engineering and business starters were not significantly different. Starters generally saw themselves as being more innovative than joiners. The results are reasonable based on Siguaw, Simpson, and Enz's [39] framework of innovation, as engineering students are more often trained to problem solve and create new technologies, process techniques, and products while business students are more often inspired to be innovative in resource allocation and operations. However, it is also somewhat disappointing to see that engineering starters were not differentiated from engineering joiners in their confidence to promote and champion ideas to others (Item 2), to investigate and secure funds needed to implement new ideas (Item 3), and to develop adequate plans and schedules for the implementations (Item 4). These items are essential elements in the process of entrepreneurship.

7. Implications and limitations

7.1 Educational implications

The results showed that although business students were more likely than engineering students to select entrepreneurship as their career goals, engineering and business starters were similar in the characteristics measured in this study. This finding suggests that when entrepreneurship courses and programs are electives for engineering students, those who are enrolled are likely to have similar characteristics (e.g., innovation orientation and selecting novel and challenging goals) as their business peers. This finding further suggests that some pedagogies used to teach entrepreneurship and to motivate business students may be also effective for engineering students who are interested in entrepreneurship. Moreover, educators could design interdisciplinary courses and programs for both engineering and business students without worrying too much about the different characteristics that are related to entrepreneurship of engineering and business participants.

In addition, we observed that engineering students may be slightly more oriented than business students to searching out new technologies, process techniques, and/or product ideas. Business students may be more oriented to resource allocation and operations. This finding suggests that engineering and business students have their own advantages and that collaborations between students from the two disciplines are highly desirable in the technological innovation process. Educators should promote this kind of collaboration between students from the two disciplines. For example, engineering and business students can be teamed up together to work on projects and inter-disciplinary seminars can be created for students from the two disciplines.

Our item-level analysis of Innovation Orientation showed that engineering students (both starters and joiners) were less likely than business starters to promote and champion their ideas to others. Does this indicate a gap in engineering students' education, regardless of career goals, to be more confident in promoting and implementing their ideas to other people? In general, we suggest that engineering courses and programs should include more design experiences, put more emphasis on communication skills, and introduce more basic business practices to engineering students, in order to help them to be more comfortable in promoting and implementing their ideas.

7.2 Limitations and future research

In this study, we found that several measures were able to differentiate students with different career goals (starters and joiners). However, the causal relationship between characteristics and career goals is not clear. Specifically, we do not know whether students chose their career goals because of their characteristics or whether their career goals gradually shaped their characteristics. Researchers should collect longitudinal survey data to explore the causal relationship between students' characteristics and their career goals.

Meanwhile, we identified a group of students who wanted to work for existing organizations (joiners), but the size or the phase of the organizations was not specified. Future studies could further differentiate students who want to work for small start-ups from those who want to work for large established organizations. The characteristics of these two groups are expected to be different. Furthermore,

in this study, we focused only on measuring the characteristics of students. In order to have a better understanding of engineering students' entrepreneurial profiles, future studies could develop tools and use the tools to measure the skills and knowledge needed for entrepreneurship. A better understanding of engineering students' entrepreneurial profiles will support educators to design more effective pedagogies/interventions to attract and engage engineering participants.

8. Conclusions

In this study, we investigated the entrepreneurial intent and related characteristics of engineering and business undergraduates for both genders, and to inform the creation and design of entrepreneurship courses and programs for engineering students. Key findings from this study include:

- Starters differentiate themselves from joiners in entrepreneurial intent, value towards challenging careers, innovation orientation, and goal selection.
- Engineering and business starters are similar in the entrepreneurship-related characteristics measured in this study. Engineering and business joiners are also similar in these entrepreneurship-related characteristics.
- The extent to which these characteristics affect entrepreneurial intent may be different for women and men.

To promote entrepreneurship among engineering students, we suggest that educators should encourage inter-disciplinary collaborations between engineering and business students, as well as train engineering students to be more confident in promoting and implementing their ideas.

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