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An Automated Entrepreneurial Team Selection Tool

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An Automated Entrepreneurial Team Selection Tool

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Abstract

This is a Work in Progress paper and will focus on the development and implementation of a software tool for engineering entrepreneurship team selection. Students working in teams is an integral part of today's engineering learning experience. Selection of students for team placement is often done manually or in some other ad hoc fashion. We present an automated software tool we call "TeamBuilder" for forming teams in the classroom, as well as for supporting forming entrepreneurial teams. Our tool incorporates factors such as the student's personality, experience, major, and gender. TeamBuilder uses the Teamology approach, which utilizes Carl Jung's personality formula, similar to the Myers-Briggs type indicator, to classify a student's primary cognitive mode. The TeamBuilder program also incorporates a student's demographic information, enabling users to better specify the team makeup. Instructors can select and prioritize the criteria for group composition and TeamBuilder automatically builds the teams.

This tool allows any instructor to quickly form teams that have diversity or similarities with respect to personality type, primary cognitive modes, academic major, specific experience or expertise, and gender. With TeamBuilder, instructors can prioritize which factors are most important for the particular team exercise. TeamBuilder also offers the ability to create completely randomized student teams. This tool can support and facilitate researchers studying the effect of team composition on student learning. Instructors can even use TeamBuilder to create randomized control teams to use as comparison to teams with specific compositions.

In this paper we discuss the evolution of the TeamBuilder software and its use in the entrepreneurship team formation. We provide illustrative examples of TeamBuilder in use within courses to study the effect on students' team formation preferences. Initial data is used to directionally assess the performance of teams formed ad hoc versus with TeamBuilder.

Introduction

Team based student exercises are a growing part of the engineering education landscape. Many professors assign team exercises where the group or team is assigned some type of problem to solve. There are many ways discussed in the literature about how to select team members for a successful engineering entrepreneur team experience. However, the authors are curious whether for the budding engineer/innovator/entrepreneur, it is possible that the composition of their team may require a set of skills and cognitive modes that uniquely support the engineering design process teams use to achieve success. As the instructors of the course entitled 'Design for Manufacturing' in which student teams are formed to solve problems and create design solutions to specific customer needs, not unlike how an entrepreneur would design a solution, we have designed an automated software tool for strategically forming teams.

To help study the effects of entrepreneurial team composition we have developed an automated

team selection tool that allows users to control specific team criteria, so as to study the differentiating effects of personality type, primary cognitive modes, academic major, specific experience or expertise, gender, and grade level. The software facilitates the creation of control groups as well as study groups. This functionality can extend to courses with multiple sections.

As a part of the tool, students take an online demographic questionnaire and personality quiz. The purpose of the personality quiz is to classify a student's cognitive mode similar to the Myers-Briggs type indicator. The tool also makes use of Dr. Douglass Wilde's Teamology approach, which utilizes Carl Jung's personality formula to determine primary cognitive modes, and ultimately, help form teams.

With the tool in place and functioning we have been able to collect preliminary data from our 'Design for Manufacturing' course that may not be conclusive to any one team composition approach, but none the less exhibits the research capabilities of the TeamBuilder tool. This tool is currently in its second revision and as minor bugs are worked out data collection continues. TeamBuilder is web-based and can be used by students, faculty, or entrepreneurship centers from either a computer or mobile platform. Upon further successful testing, TeamBuilder will be made available to the entrepreneurial educational research community for use in team composition/design research. TeamBuilder will allow users to regulate team composition for entrepreneurial courses and to study its effect in depth.

Relation to previous work

In today's competitive world, engineering firms have become leaner than ever. Besides technical roles, engineers now have to fulfill project management and team leadership roles to comply with the now complex and multidisciplinary culture in the workplace. Engineering education has evolved in the last decades with the intent of fulfilling this demand of teamwork skills in graduates. Among the five major breakthroughs in engineering education discussed by Froyd et al. [1] are the outcomes-based accreditation guidelines introduced by ABET (Accreditation Board of Engineering and Technology)in the late 1990s, a major emphasis on design, a greater application of education, learning and social-behavioral sciences influence engineering education; all leading engineering education to a higher emphasis of team-based learning. Team-based learning impacts the student's interaction in the engineering and entrepreneurship classrooms and teaching methods of engineering instructors.

Team-based learning experiences vary as the different methods of team formation are used. A few different team formation methods are used; self-selection, random assignment, and instructor-assignment and a relatively new method, computer-aided team formation are the most common ones, [2]. Self-selected teams are teams created by students themselves. These teams are typically created on the basis of existing social relationships usually offering higher initial cohesion; self-selected teams tend to be overly homogeneous which prevents spread of knowledge and ideas and may also isolate some of the students in the classroom setting [3]. Random team assignment is not likely associated with good experiences since it is not likely to generate teams with a balanced, or useful, combination of skills, diversity, and general ability [4]. On the other hand, instructor-assigned teams tend to create teams composed of, what the

instructor thinks are, well balanced teams; well-balanced teams in the eye of the instructor may differ on key criteria instructors think are important. This last method mentioned of team creation is usually time consuming and may be challenging for the instructor when it comes to logistics and criteria selection, therefore this method is infrequent [4]. Lastly, we will discuss the advantages and disadvantages of the relatively newly created computer-aided team creation approach. Previous literature has discussed the computer-aided approach as its own method [2] [5], but we would like to discuss it as an improved version of the instructor-assigned method. As a major improvement to the challenge of the instructor-selection method, the computer-aided approach has vastly reduced time consumption disadvantages and has also greatly improved in providing instructors with a large collection of the criteria selection options. Having the previous main disadvantages taken care of, we can see how computer-aided could be the presently preferred method and is the future of team creation in education and maybe eventually even in the workforce.

Different computer software has been made for computer-aided team creation. Bacon et al. developed a software program called "Team Maker" [6] which consists of a survey given to students in order to collect demographic data and roles that students prefer to hold in teams. Instructors then manually transcribe students' survey responses to a spreadsheet programmed to form teams that optimize the instructor's criteria. The "Team-Maker" software (with a hyphen connecting the two words) was developed by Cavanaugh et al. [7] developed this web-based system to assign student to teams using instructor-defined criteria, including instructor-modified surveys to obtain data for this criteria.

As previously discussed, computer-aided approaches have solved the challenges of time constraints of instructors and criteria selection involved in the formation of teams. The question now is - do these computer-aided systems create teams that are cohesive and efficient? The Team-Maker computer-aided approach uses their own numerical method for team formation, depending on the type of questions the students answered on their survey and the weight the instructor set on the specific criteria. Team-maker suggests a combined use of Team-Maker and the Comprehensive Assessment of Team-Member Effectiveness (CATME) peer evaluation instrument. CATME allows students to rate themselves and their teammates using a secure, web-based interface. The instrument has three main purposes, peer and self-evaluation of team members, teaching members how to effectively contribute to teams, and research on teamwork[8]. The TeamBuilder approach intends to provide, a different variation of the method used for creating effective teams – a team cohesion system inspired by Dr. Wilde's Teamology approach [9].

Although we use the terms *groups* and *teams* interchangeably, we would like to emphasize that we concur with Katzenback and Smith discussion in The Wisdom of Teams [10], teams have different levels of cohesiveness and effectiveness. Cohesiveness refers to the ratio of the number of existing positive relationships to the theoretically maximum number of positive relationships in a group [11]. Teamology is a methodology for assembling teams to maximize their creative

output, it works by balancing Carl Jung's cognitive modes [12] of team members, thereby enhancing the ability of the team to effectively collect information and make decisions. According to Dr. Douglass J. Wilde [9], there are four kinds of variety relevant to team performance –experiential, professional, sociological, and cognitive. The experiential variety occurs when the professional experience levels vary, such as freshmen vs senior college students. Then comes the professional variety, which involves a variety of professions or skills such as interdisciplinary majors. The sociological variety comprises non-traditional groups, these may involve gender or different cultures. The three aforementioned are the ones, according to Froyd et al., that are "easy" to arrange, leaving the fourth one, the cognitive variation as the one left for further manipulation. TeamBuilder focuses on "intelligent" instructor-assigned approach. It allows educators to create teams based on a variety of attributes. These varieties facilitate the ability of building a team according to the educator's preferred method of grouping teams based on the four kinds of variety based on the aforementioned Dr. Wilde's approach. Different attributes may be considered such as team size, whether the team is homogenous or heterogeneous (major, GPA, etc.), demographics, skills, tenure, and personality.

Wilde found that the careful arrangement of personality diversity on a team dramatically improves the output of a common pool of candidates, and can be used to quickly build teams that are considerably more innovative [9]. According to a study performed by Cobert and Bohn [13] through a joint transatlantic National Science Foundation Research Experiences for Undergraduates (REU) program in automotive technologies at Virginia Tech and Technische Universität Darmstadt (VT-TUD), there is a strong correlation between personality diversity and team performance and cohesion, consistent with Wilde's work. With the intent to add to the already existing literature, we are analyzing this Teamology-inspired approach of TeamBuilder in our Entrepreneurial learning environment.

"One of the great myths of entrepreneurship has been the notion of the entrepreneur as a lone here, battling against the storms of economic, government, social, and other environmental forces before anchoring in the harbor of success" [14]. TeamBuilder aids in exposing students to a good experience in team-based learning. It has enhanced the team-based activities in our engineering education, from the first year of engineering to our capstone and entrepreneurship courses.

We believe that a positive experience in team-based learning will enhance the student's ability to successfully work in a team in the workforce. Team composition in the workforce will vary from company to company, student by then would have identified their strengths and will have an additional tool to efficiently overcome his/her weaknesses. Team composition in the entrepreneurial world will also vary. According to Pitman" [15]. Early in the life of the venture, changes to team composition are most likely when new members are being hired to support growth. With maturity the pattern may change, with existing team members being replaced by others with different skill sets." The skills sets will vary depending on their project, environment, and teammates.

Team composition

Individual characteristics are important consideration when composing teams. Some literary work advocates for heterogeneous team members since they are often related to increased research productivity, as opposed to some that believe that productivity decreases if the area of research is too widely expanded in different disciplines.

Surface-level composition variables refer to obvious demographic characteristics that can be reasonably estimated after brief exposure, such as age, race, education level, and organizational tenure. Deep-level composition variables refer to underlying psychological characteristics such as personality factors, values, and attitudes. Personality is an important factor in team functioning and performance, patterns of thinking, feeling, and acting affect the team's interaction with one another interpersonally and interdependently [17]. Levels of conscientiousness, extraversion, agreeability, emotional stability, and creativity are factor of personality related to positive team performance. But, some of these personality traits (agreeability and creativity) are positive, depending on the team's performance.

Other factors that may affect teams are task orientation and vision. Team implementation is more like to occur if team objectives are clear and team member participate in decision making. A climate in which it is safe to speak up and take risks is suggested to complement the adaptation and implementation of team innovation [18]. Team composition, which represents individuals' qualities that add to a team's assets in a social interaction, may be crucial at the initial stage of team creativity in determining the richness and quality of ideas available to the team.

Teamology approach

The Teamology approach is used to help us form effective teams. Rather than take a subjective approach to forming teams, Teamology uses a student's personality type scores to classify their dominant cognitive mode(s), or dominant way of thinking. The personality type scores are drawn from a Myers-Briggs-like test that assesses the four areas below:

- How outwardly or inwardly focused a student is - Extraverted versus Introverted.
- How a student takes in information – Sensing versus Intuition.
- How a student makes decisions – Thinking versus Feeling.
- How a student makes sense of the world – Judging versus Perceiving

The personality type scores are inputs for the straight-forward mathematical model used in the Teamology approach. The results are scores that help define a student's dominant cognitive mode(s). The scores fall into four affinity groups: idea people, people people, action people, and organization people.

Idea people like to think about and generate ideas. People people typically work to influence how people on a team interact and work together. Action people are the experimenters and builders. Organization people are task focused and deadline driven. The theory behind Teamology states

there is a higher likelihood of conflict between people who have the same dominant cognitive mode. The highest level of conflict occurs between people who score high for being idea people. When students who score high as idea people are placed on the same team, the productivity can decrease significantly because the frequency of opposing ideas prevents the team from working on the realization of any one idea. The level of conflict decreases for people people, is even lower for action people, and is lowest for organization people. Conflict between people people can slow the team down because it's not clear how the team should be working together. Conflict between action people can reduce the amount of output because they are spending their time building and testing, which is not always necessary. Conflict between organization people is minimal because in the end, they want to make sure the team meets expectations on time. Those who do not score high in any one category are classified as wildcards. Wildcard people work well on most teams and are good at filling the cognitive mode voids [9].

To reduce conflict and increase team diversity, teams are formed based on the scores of all of the students in a class or those interested in joining a new venture. The steps below outline the process used to form teams based on the cognitive mode scores:

1. Using the number of students in a class, determine number of teams needed to have 3 to 5 students per team.

2. Start each team by placing the top scoring idea people in different teams.

3. Using the remaining students, place the top scoring people people in different teams.

4. Using the remaining students, place the top scoring action people in different teams.

5. Using the remaining students, place the top scoring organization people in different teams.

6. If there are remaining students, they are likely wildcards and can be placed on any team.

The objective is to separate similar cognitive modes by first prioritizing separation of idea people, then people people, then action people, and finally organization people. The process can be purely objective and relatively simple to implement. It reduces conflict and it creates diversity of thought within teams.

TeamBuilder in the classroom and entrepreneurship

The Teamology approach is helpful and fairly effective. However, it doesn't readily account for other variables that influence a team's performance, like specific skillsets, or variables that can affect a student's learning experience, like gender or academic major. TeamBuilder is an automated tool that allows instructors, or new venture accelerators, to form teams. TeamBuilder uses personality types and cognitive modes for its foundation, but adds important variables. It enables instructors to include specific skillsets associated with experience, academic major, gender, and grade level, as well as instructor generated categories. The instructor can prioritize any of the categories to shape the team composition. The flexibility combines informed

subjectivity with objective results to form the teams. In the classroom, TeamBuilder appears to be very effective at forming the teams.

TeamBuilder is being piloted in a 'Design for Manufacturing' course. The course consists of two hours of lecture and two-and-a-half hours of lab per week, with approximately 20-30 students enrolled each year. It is a project-based course where students work in teams to go through the engineering design process while developing a product for a specific customer. Students iterate between defining the customer's needs, idea generation, analysis, low-to-mid-resolution prototyping, material selection, cost analysis, and detailed CAD models.

The instructor used TeamBuilder to form the teams. The instructor formed the teams by prioritizing according to the variables listed below:

1. Idea people

2. Academic major (which typically consists of mechanical and electrical students)

3. People people

4. CAD experience (which is defined CAD courses and certifications acquired)

5. Action people

6. Organization people

7. Gender (to minimize number of teams with only one female on the team)

8. Wildcards

Although the cognitive modes were used, they weren't always the most important variables for prioritizing the team composition. A student's academic major was made a high priority because the class typically only has a few electrical engineering students and the instructor didn't want any of them on the same team. CAD experience was defined as a specific skill and made a high priority because each team would need to create professional quality CAD models and basic simulations. Having at least one person with strong CAD skills on each team is essential. Gender was factored in because the class was mostly male and the instructor wanted to avoid, if possible, having multiple teams with only one female on the team. TeamBuilder enabled the instructor to objectively form teams by subjectively choosing which factors were most important to his course.

Likewise, TeamBuilder can also be leveraged in entrepreneurship. In particular, by organizations that support team formation, like on-campus accelerators. Often times there are students (or people in the community) who want to be a part of a startup, but don't have an idea for a product or service. Likewise, there are many founders and new ventures that are seeking to hire/partner with others; often seeking specific skillsets and overlooking personality types. The tool can be used to help entrepreneurs form more effective teams, as well as help each team

member better understand how to work together.

How TeamBuilder is used

The initial motivation for TeamBuilder was to create an easy to use tool for instructors to aid in determining student assignments into entrepreneurial teams. To have the TeamBuilder tool available to all students and be as convenient as possible, a web based approach was adopted. This allowed the student to use either a standard computer web browser or a mobile device web browser to interface with the TeamBuilder tool.

The website approach also allows for back end processing of the data provided by the students. The back end data processing provides the TeamBuilder tool with the capabilities to offer multiple entrepreneurial team scenarios to the instructor. Instructors and students interface with the TeamBuilder website by entering required information into online forms. The TeamBuilder website sends instructor notifications, personality test results, and team assignments to the users via email.

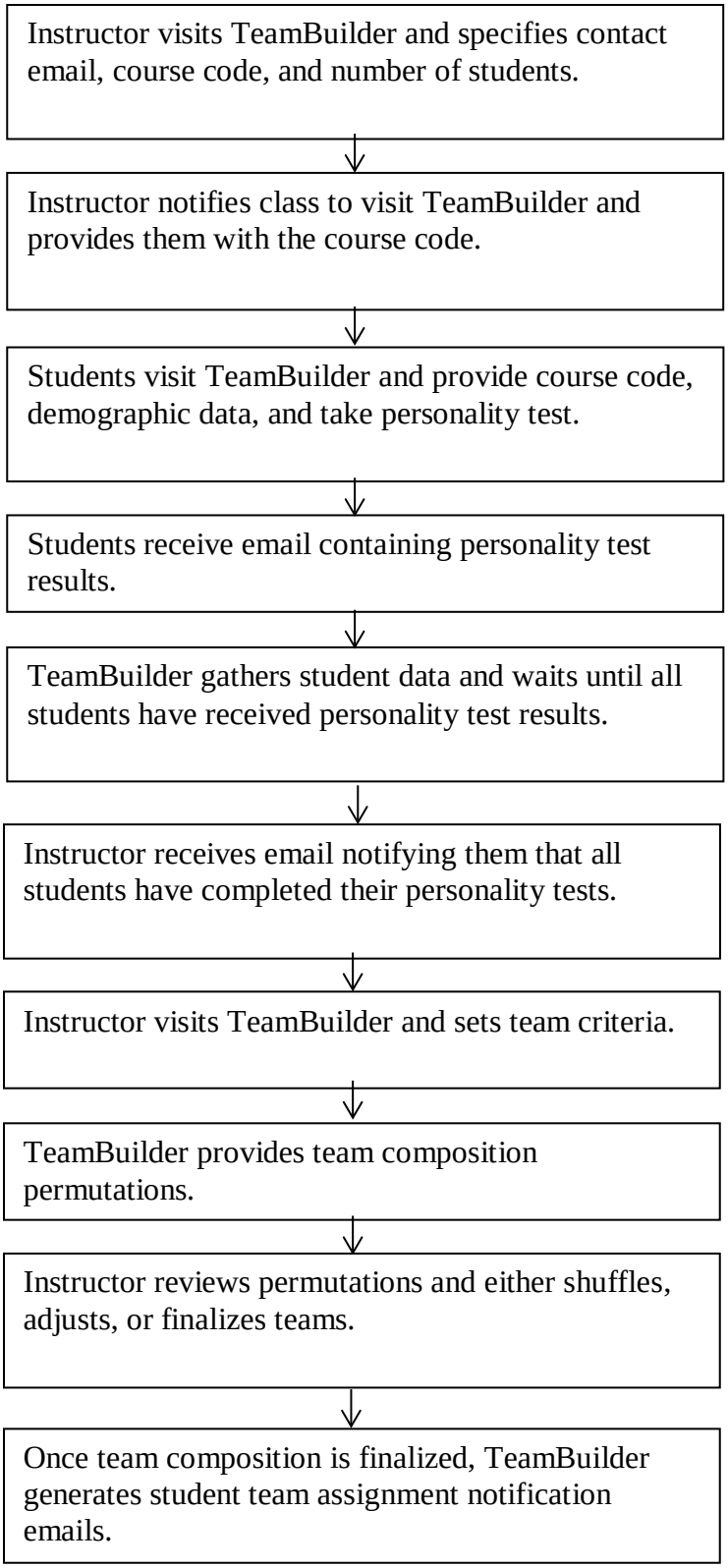

Figure 1. TeamBuilder flowchart.

Student interface

The student's role is primarily limited to a one time visit to the TeamBuilder website where they are asked several sets of questions. The first set of question is to retrieve the student's demographic information such as name, email address, gender, credit hours completed, and major. The next part of the questionnaire is the use of a personality quiz similar to the Myers-Briggs personality assessment. TeamBuilder personality test asks the student questions to determine their level of the four Myers-Briggs personality traits relating to extraversion, sensing, thinking, and perceiving. With the assessment of these four personality variables to choose from, the student's results are categorized into16 distinct personality groups. It is with these personality traits that instructors using TeamBuilder may prioritize students into their team assignments as needed.

After the student submits their information to TeamBuilder, they are notified by email of their personality test results. They are also provided with examples of well-known persons whose personality traits are similar to their own. However, they do not immediately receive their team assignments, the student team assignments will come later once all of the other students in the course have completed their TeamBuilder entries. TeamBuilder tracks the number of student entries for each particular course. Once the number of completed unique student entries matches the value specified by the instructor, the instructor is notified via email that the students have completed their entries. After the instructor has used TeamBuilder to create the team of their design, the students are again notified of their team name and their team partners.

Added to the team notification message is a list of the team members and email addresses to facilitate team member communications.

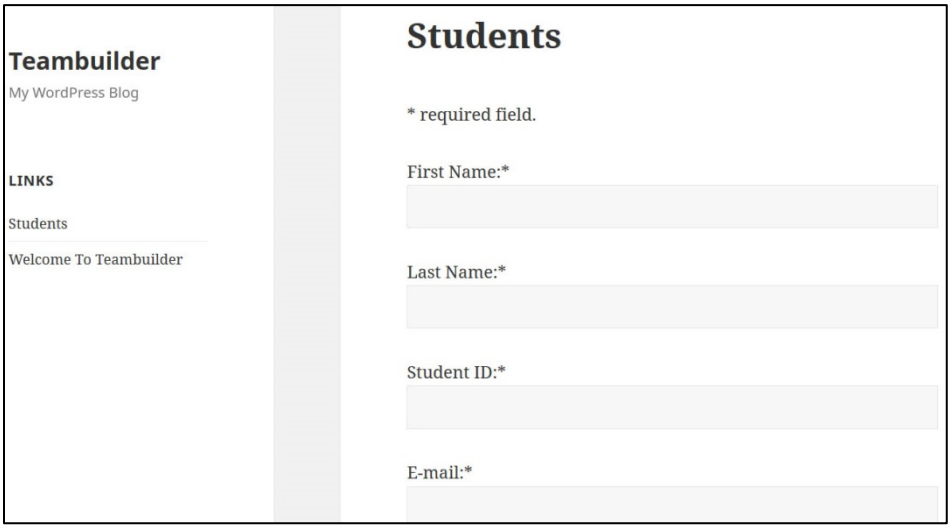

Figure 2. A portion of the student demographic interface.

Instructor interface

For instructors using TeamBuilder, the view is slightly different than from the student's perspective. The major aspect of TeamBuilder from the instructor's viewpoint is to easily create entrepreneurial teams that we believe will perform their best. The interface for the instructor is simple and straightforward. The instructor enters information such as the number of students, the desired team size, and which personalities and demographics should be prioritized for the entrepreneurial teams. Team assignments can also be completely random as well. This feature will allow for the easy creation of team teaching research control groups.

The team size is variable and can be set by the instructor. Depending on the class size and team size, there exists a possibility of solution sets that do not divide evenly and therefore will have one team or more teams that are undersized. TeamBuilder ensures that there is always more than one person on a team. If dividing up the total number of students into the team size specified by the instructor results in a non-zero remainder, then the final team will be the size of the remainder. If the remainder is one, then TeamBuilder will create two teams slightly smaller than requested to guarantee that there are no teams that consist of only one student.

Not only is the instructor allowed to create random team of students to size as previously discussed, but they are also given the option to specify several demographic features as priorities for each team to possess. These multiple priorities can be set to be met in a descending order of importance. An example may be of help here. Take for instance, an instructor that specifies in TeamBuilder to have a senior on each student team. TeamBuilder will then create the student team assignments and if there are a sufficient number of seniors available for the number of student teams required, then each senior will be assigned to the teams at random. TeamBuilder would then apply the same criteria for a secondary priority. TeamBuilder offers the ability to run multiple scenarios that do not notify the students until the plan is first formalized and executed by the instructor. Since in many cases there exist multiple solutions sets to the overall criteria, TeamBuilder has incorporated a shuffle feature that allows for shuffling team members through multiple permutations of the instructor's team composition requirements. These features can be used to get control groups for research into the effects of entrepreneurial team composition.

Once the instructor has viewed the multiple permutations made available by TeamBuilder and has come up with a set of teams they would like to implement, the last step for the instructor is to finalize the teams. Finalizing the teams initiates email notifications to all the students of their team name and their fellow team members. The instructor has the ability to download a spreadsheet of the data collected with the team names and student rosters.

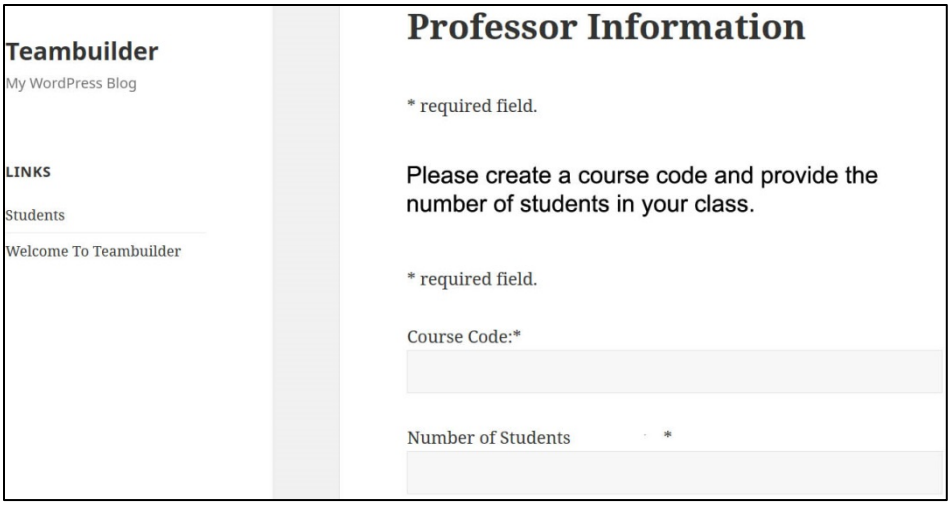

Figure 3. Screenshot of the instructor's course setup interface.

Limitations and refinements

Determining and categorizing a student's personality type to high degree of accuracy isn't very easy to do with a short 20 question quiz. There are many more accurate personality assessment tools that are available. The goal of TeamBuilder was to devise a quick and rudimentary personality assessment to apply the Teamology approach to team formation. For a more accurate assessment it would be beneficial to develop a more thorough personality assessment tool for TeamBuilder or to integrate an existing third party personality assessment.

TeamBuilder continues to be refined on a regular basis. There are plans to test TeamBuilder in our Introduction to Engineering course to select teams of engineering freshmen to complete entrepreneurial activities. As final testing continues, we are refining the TeamBuilder program for release into the entrepreneurial engineering education community for the purpose of creating a standardized method for assessing success with respect to entrepreneurial team composition.

Future features

Several additional features are under development and will be added in the future to help make TeamBuilder more robust and useful to instructors and students. TeamBuilder currently does not allow the instructor to assign students individually to teams. This feature would be helpful to the instructor by providing them the flexibility to fully customize teams. The website will eventually have added security features as well as a more robust authentication process. In the interest of additional security, there will be an option for instructors to delete their class information from the database. Load testing may be required to ensure that the web hosting service can handle a large number of TeamBuilder instances running concurrently. Additional demographic information will be added to the database that will allow an even more detailed study of team composition. Actual distribution of the team assignment through an instructor provided attachment will also be implemented. Another possible future improvement to TeamBuilder

would be to interface it with a more accurate personality test as previously discussed. This could be done by incorporating other third party testing technology into the tool, or simply formatting results of other tests to fit into the TeamBuilder database.

Preliminary results

The initial results are primarily qualitative and directional. The base size is too small for statistical significance. Also, the tool has yet to be studied across various courses and new ventures, as well as compared to control groups. Nevertheless, the initial results are promising.

The initial results from the 'Design for Manufacturing' course indicate TeamBuilder is an effective way of forming teams. Most students who were a part of the teams formed using TeamBuilder reported having a better overall experience than what they had while working on teams in previous courses. When comparing how to form teams at school, randomly assigned versus picking their own team versus being placed on teams according to their primary cognitive mode, students indicated they preferred to be placed on a team according to cognitive modes. However, many preferred selecting their own team. Students said they were very happy with their teammates and the results of their work. Often, many said the team just "clicked." Most students felt as though everyone contributed significantly to their project. Some said the team worked so well together that they worked extra to ensure they did not let their team down. In contrast, many students reported having very poor experiences with teams in the past. Some said the teams they were a part of were dysfunctional. Others said their previous teams were unproductive because "only one or two people would do all of the work."

When asked to rate how much they agree with the statement "*If I were to join or create a startup/new company, I would want to know the personality type and primary cognitive mode of my co-workers,"* 56% selected *Strongly Agree* and 44% selected *Somewhat Agree* – none were opposed or even neutral. This indicates that most (in this case all) see value in using a TeamBuilder-like approach.

The instructor who used TeamBuilder also reported having positive results. He noted all teams achieved strong results and conflict between team members was minimal. All of the teams exceeded their customer's expectations. The teams quickly developed methods of communication, as well as defined roles, responsibilities, and individual strengths. The instructor noted that inevitably there seems to be a few people who are unhappy with their team for one reason or another. The 'Design for Manufacturing' course had a couple of students who reported issues with their team. One was an issue with a student's motivation to contribute to the team. The other was the difficulty a student had with coordinating out-of-class meeting times. Both of these issues were regarded as minor by the instructor when compared to the challenges that can arise when working in a team. The instructor noted the issues weren't conflicts in opinions or personalities, and they weren't shortcomings in capability. The instructor felt the TeamBuilder tool was effective at forming teams and saved time by automating the process.

Assessment

TeamBuilder can be a useful tool for instructors who have team-based projects, as well as entrepreneurs and accelerator administrators who are seeking people to join their teams.

TeamBuilder empowers instructors to form teams based on the variables they feel are most important to their course. They can pick-and-choose which variables are most relevant course-by-course and project-by-project. Moreover, with ongoing use, instructors will develop a better understanding of how to form high-performing teams. Entrepreneurs and accelerator administrators can use the tool to better identify people to add to startups. Often there are people who want to be a part of startup, but don't have an idea of their own. TeamBuilder helps automate the process of finding the right people for a team.

Conclusions

Entrepreneurship education is a very interactive concept that requires the ability to interact with others in a productive manner. As educators that would like to offer our students realistic learning experiences, team assignments in entrepreneurship provide for genuine interactions between student team members that are very similar to those of actual entrepreneurial teams. Selecting students for individual assignment to teams can now be done in a more standardized way using TeamBuilder. With TeamBuilder personalities and other demographic information of each student is taken into account when team assignments are made. The instructor has the capability to create completely random team assignments or to create teams that are specialized in their personalities or demographics. TeamBuilder is a convenient tool for studying the differing compositions of successful entrepreneurial teams.

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