
Original Article

Building biotechnology teams: Personality does matter

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ABSTRACT Our study describes a naturally occurring experiment exploring linkages between interdisciplinary team outcomes and personality dimensions, general mental ability, and communication type and frequency. This research took place within the context of an NSF-sponsored bioscience entrepreneurship program that engaged science, health science, law and business students working in cross-disciplinary project teams in the technology commercialization process. Our results are consistent with research findings from the management literature. Deep-level diversity seems to increase conflict in teams and is quite difficult to overcome even over time; thus, finding ways to structure teams to minimize this type of diversity from the outset is desirable.

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INTRODUCTION

Translating bioscience research into a marketable product requires a complex set of cross-disciplinary knowledge, skills and talents, including the basics of intellectual property, early-stage technology finance, regulatory and reimbursement rules, and marketing.¹ Because

the biotechnology industry faces dynamic influences from diverse disciplines, a change in any one of these areas can impact other areas, which subsequently means the industry is in constant flux.² However, few people entering the biotechnology industry receive exposure to cross-disciplinary training.² Because of the crucial need to bring such disparate fields together to accomplish the commercialization task, Meyers and Hurley¹ suggest that teaching 'soft' skills such as communication, conflict

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resolution and team building is necessary in bioscience entrepreneurship training and education programs.¹

Yet, despite the obvious need for bioentrepreneurs to work together across disciplinary boundaries, the practitioner literature suggests that such teams often fail to fulfill their potential and are sometimes quite dysfunctional.^{3,4} Meyers and Hurley¹ offer that translating the complex body of skills and knowledge required to successfully commercialize technologies in the emerging and important field of bioscience entrepreneurship is a difficult task for which few are currently prepared either by experience or by education. General management research, which has focused more intensively on interdisciplinary team functioning, finds that managing diverse work groups is one of the most difficult challenges in today's organizations and that it is not going smoothly.⁵ Therefore, according to Freidman,² continuing education is a pressing need for bioscience and technology commercialization practitioners.

Perhaps this is why Meyers and Hurley¹ identify cross-disciplinary team training as a high educational priority for universities attempting to educate future bioentrepreneurs. Supporting this point of view, Fiore⁶ argues that the ability to work in teams across disciplines in the sciences is a process that must be learned rather than a product that naturally emerges. Incorporating relevant interdisciplinary teaming skills into science education could significantly enhance both bioscience research and commercialization success;⁷ yet to date, no roadmap exists to guide universities on how to accomplish this task.

In this paper, we describe a naturally occurring experiment that took place as part of an innovative new bioscience entrepreneurship program (BEP) at a Midwest university, which focused on incorporating cross-disciplinary teaming into its course of study. In following four teams comprised of law, science, health science and business students over the course of

two semesters, we gained insights into the reasons for success and failure in these teams and how adjustments can be made to improve team performance and satisfaction. These insights were gained in part because of turnover events that appeared to be correlated with changes in team performance. Interestingly, our findings do not involve disciplinary or demographic differences, which are 'surface-level' types of diversity, which tends to be high in interdisciplinary programs such as this one. Our findings, on the other hand, involved 'deep-level' diversity, such as the 'fit' among a variety of personality traits of the team members and a significant difference in general mental ability (GMA). These are typically stable traits that apply to all types of cross-disciplinary teams.

The paper proceeds as follows: first, there is a brief summary of the interdisciplinary teaming literature, which comes largely from the general management field, then, a description of the BEP and the teaming structure and process of the curriculum, this is followed by an analysis of the data collected over the course of the year and changes in the teams' performance and satisfaction outcomes are reported. Finally, there is a brief discussion, which includes the implications of this research for team formation in bioscience education.

TEAMING AND DIVERSITY

Team-based work is proliferating in today's organizations⁶ with research suggesting that 48 per cent of organizations use some type of team to accomplish their goals.⁴ Most managerial scholars agree that a team is defined as a collection of individuals who are interdependent in terms of their tasks, share responsibility for collective outcomes, and see themselves and are seen by others as a social entity.⁴

According to the management literature, the degree and type of diversity found within teams play a major role in team members' performance and satisfaction. Surface-level diversity generally involves easily observed differences among team members on demographic dimensions such as

age, race, gender, national culture and ethnicity,⁸ as well as differences along disciplinary or functional background.³ Most researchers agree that all other things being equal, demographically and functionally homogeneous work groups tend to result in relatively positive team outcomes, especially when routine problems are involved. Conversely, functionally diverse teams generally do not fare as well when it comes to team performance.³ While initial conflict tends to be higher in demographically and functionally diverse teams, over time and in certain contexts, these surface-level types of diversity may actually have a positive impact on a team's creativity and ability to tackle unique and complex problems.

Unlike the easily observable characteristics of surface-level diversity, deep-level diversity involves differences among team members' personalities, values and attitudes,⁹ as well as differences in their GMA. Personality diversity, which is often measured using Goldberg's¹⁰ five-factor model (extroversion, emotional stability, conscientiousness, agreeableness and openness), involves differences in personal preferences, which affect a team's ability to successfully organize and implement tasks. These measures, which are widely used in organizational research studies, are often correlated with team performance, satisfaction and turnover.¹¹ GMA, on the other hand, tends to predict the individuals' ability to process information and solve problems,¹² as well as their ability to prioritize between conflicting roles and adapt to new situations through learning quickly and better applying old learning.¹³ Meta-analytic findings indicate that GMA is a valid indicator of performance on essentially all jobs, including team-based activities.^{13,14}

Typically, differences in deep-level diversity dimensions are inferred over time through behaviors, communications and the disclosure of personal information as opposed to being immediately observable. Much like surface-level diversity, initial thinking about deep-level diversity and team performance suggests that people are

attracted to and prefer to be with others who have similar personalities and values.^{15,16} This belief then leads to the hypothesis that team members will not react positively to working with others who do not behave or believe like themselves.¹⁷ However, unlike surface-level diversity, the negative effects of deep-level diversity on team performance are more pervasive in that they tend to persist over time.

Most recently, several authors have reported an interactive relationship between surface-level and deep-level diversity.¹⁸ Elfenbein and O'Reilly,¹⁹ for example, found that for groups with higher levels of demographic diversity, similarities in personality tend to decrease turnover as well as improve satisfaction and performance. However, Phillips *et al*²⁰ reported that grouping teams with similar deep-level diversity characteristics does not result in high performance in teams with high surface-level diversity.

The team diversity findings in the management literature have direct implications for highly diverse teams such as those working in bioscience commercialization. As a result of the globalization of science, which allows for the rapid exchange of information anywhere in the world, as well as the ability to distribute work to the region where the best resources are located, teaming in the sciences increasingly has become a highly diverse activity when viewed from a demographic and disciplinary perspective. Because of the high level of functional experience diversity inherent in such teams, these recent findings suggest that creating teams with greater similarity in personality characteristics may improve team functioning. The following section describes a naturally occurring experiment that allowed us to test this theory.

METHODOLOGY

For this study, we used a method of data analysis called triangulation, which compares and seeks linkages between the quantitative personality dimensions, GMA, performance

data and qualitative measures of team satisfaction and communication. More specifically, triangulation looks to qualitative data to provide the explanation for the results gleaned from the quantitative data. According to Meyer,²¹ by juxtaposing qualitative and quantitative modes of data analysis, it is possible to compound their discrete advantages, offset their inherent liabilities, and achieve a deeper understanding than either method could have produced alone. In essence, triangulation uses both types of data to create a more complete picture of the naturally occurring event. This data analysis strategy is especially appropriate for exploratory research and naturally occurring experiments because it yields 'thick' descriptions of behavior in a context that complements numerical data and facilitates their interpretation.²¹

Sample and context

In spring 2008, our university received a 3-year Partnerships for Innovation grant from the National Science Foundation to create a BEP. This interdisciplinary program, one of the first of its kind, was designed to train science, health science, business and law students in the process of bioscience technology commercialization. The program consists of two semester-long, 11-week evening courses, which bracket a paid summer internship in an organizational setting that allows students to observe and participate in the practical intersection of bioscience and business. Over the course of the year-long program, students from these key disciplines work in four-person teams to write technology commercialization plans for bioscience research developed by scientists from one of the two major medical research centers in the area. In the first course, students learn the basics of technology commercialization by working together on a plan for the same general bioscience technology. In the second course, students remain in the same teams but each team chooses their own bioscience

technology for which they develop a unique commercialization plan.

Demographic and functional surface-level diversity

To address Meyers and Hurley's¹ suggestion that bioscience technology commercialization programs should seek to increase not only their disciplinary and functional diversity, but also the demographic diversity in categories such as gender, race, age, nationality and ethnicity, the BEP program director intentionally engaged in activities designed to achieve a high level of demographic and functional diversity among applicants, such as advertising the program across campus to each of the desired functional disciplines as well as providing tuition remission and scholarships. These efforts resulted in a highly diverse group of BEP students, including 31 per cent female, 19 per cent minority and 19 per cent international students from a demographic perspective. Additionally, four law students, two medical students, two biology majors, one physics major and seven business majors were enrolled in the program, although a number of the law and business students also had backgrounds in science as well.

Before the first class, the instructor assigned the 16 students to one of the four project teams in order to simulate an actual science industry context where cross-disciplinary teaming is the norm. The teams were formed by randomly assigning students across demographic characteristics, with each team resulting in diversity along at least two of the demographic dimensions. With respect to functional background diversity, each four-person team was assigned at least one law, one science/health science, and one business student. Personality dimensions were not considered in initial team assignments, although each student completed instruments after the course began to assess team similarities and differences, as they are for all of the instructor's courses involving team-based projects. GMA differences also were not considered in making team

assignments, as the majority of the participants were academic standouts. On the first day of class, the teams were asked to name themselves. Throughout this research and in subsequent sections of the paper, the teams will be referred to by their names: Team Synergy, Team Jedi, Team Cornrows and Team Swells.

Individual and team deep-level personality dimensions

Consistent with the standard practice of collecting personality data from students in project and team-oriented classes in order to address teaming issues that might arise during the semester, the program director administered to all students in the course questionnaires based on Goldberg's widely accepted five-factor Model,^{10,11} which assesses individual level of extroversion, emotional stability (neuroticism), openness, agreeableness and conscientiousness. Individual team members' personality dimensions were then used to compute team means and a 'distance from the highest and lowest member' measure. These measures have been shown to relate to team functioning in different contexts. Typically, teams displaying higher mean levels along these 'Big Five' personality dimensions are likely to be more socially cohesive and to achieve higher levels of team performance.²² The negative impact of personality diversity on teams seems especially strong for the dimensions of emotional stability (that is negative affectivity and neuroticism), agreeableness²³ and conscientiousness.²⁴

General mental ability

Students applying to the program were required to submit transcripts from which their GPAs could be gathered. These initial GPAs, along with information about students' concurrent performance in non-BEP courses, were used as proxies for GMA. The overall GPA average for the BEP participants was significantly higher than the averages for their respective majors.

Outcome measures

Performance outcomes were measured by external observer rankings of business plan presentation quality and instructor evaluations of team presentation quality, along with course grades and feedback on final written business plans. To judge the teams' performance on their final business plan presentations, 16 local entrepreneurs, politicians and business people (objective observers) each brought US\$100 to the presentations. After viewing the four teams' business plan presentations and participating in an informal question and answer session centered on the teams' posters, they individually awarded their capital to the team that they deemed most worthy of their investment dollars.

To assess team member satisfaction, students provided peer evaluations of each of their team members as well as themselves based on overall quality and quantity of contributions to the project. They also kept 'process' journals throughout the semester. Data from these sources were used to assess overall team satisfaction levels.

RESULTS

Outcomes

At the end of Semester 1, the performance of the four teams varied substantially, as did their levels of satisfaction. Based on the amount of money received from outside investors rating their team presentations, the rank order from greatest to least dollars was: Team Cornrows, Team Synergy, Team Swells and Team Jedi. The second measure of team performance was the grades the teams received on their written business plans. These project reports followed a similar performance order to the business plan presentations; the best was Team Cornrows ('well-organized, well-researched, complete, professional'), followed closely by Team Synergy ('well-organized, professional, reasonably researched and complete'), with Team Jedi's report being 'fairly poorly integrated – a set of separate reports bound together' and Team Swells turning in two

separate assignments – one version for which a single group member claimed entire credit and the other version that was ‘disorganized, poorly edited, and not professionally presented,’ as reported by the instructor.

A second outcome measure was team member satisfaction, which was gauged through an analysis of the student’s journals and peer feedback assessments. According to a content analysis of these sources, in Semester 1, overall satisfaction was high in Teams Synergy and Jedi, followed by moderate dissatisfaction in Team Cornrows and extreme dissatisfaction in Team Swells. A member of Team Synergy reported in his/her journal, ‘I think our team did a good job. We were well prepared (for the final presentation) and worked well together. I hope I get to continue working with the same people.’ Similarly, one member of Team Jedi wrote, ‘We have been getting along well,’ while another Jedi group member said, ‘I enjoyed working with my group. I think our personalities meshed well.’ One team member also reported, ‘My team worked well together ... we didn’t need to meet much, we mostly emailed to get things done.’

On the other hand, Team Cornrows, despite doing well on their Semester 1 final project and presentation, were not completely satisfied due to a team member’s not ‘pulling their fair share of the load.’ A member of Team Cornrows noted, ‘We worked hard over the semester and were able to be successful despite having (a group member) who did not contribute much.’ Another group member noted, ‘(a certain group member)’s expertise may have been overshadowed by (another group member) who is older and more outspoken, but this did not impact (our team performance) much at all.’

Things did not go well during Semester 1 on either outcome measure with Team Swells, as this group experienced turmoil and dysfunction from the beginning, which apparently affected both team satisfaction and, ultimately, the team’s performance. All of the team members expressed their discontentment by writing in their journals. A member of

Table 1: Semester 1: project quality vs. satisfaction

	<i>Project quality – low</i>	<i>Project quality – high</i>
Satisfaction – low	Team Swells	Team Cornrows
Satisfaction – high	Team Jedi	Team Synergy

Team Swells wrote, ‘(one group member) has appointed him/herself as the leader ... and tells the rest of us what to do!’ Another group member stated, ‘I am very unhappy working in this group ... there is always tension.’ Unlike Team Cornrows, the performance outcomes of Team Swells suffered. Team Jedi also had relatively low performance outcomes, in terms of quality of their final presentation and the written report, which contrasted with their high level of satisfaction.

Table 1 summarizes the Semester 1 team performance quality and satisfaction outcomes.

By the end of Semester 2 there was an increase in overall team performance outcomes, with both Jedi and Swells showing significant improvement. Comments from the program team teachers were that the average quality of team presentations for the second semester was significantly higher than at the end of the first semester, with all teams receiving a high grade. Performance on the written business plans followed that of the presentations, in that each team received a relatively high grade. Thus, Team Swells and Team Jedi were able to improve their overall project performance quality, with Synergy and Cornrows holding steady as before.

However, there were also significant improvements in two out of four of the teams’ levels of satisfaction from Semester 1 to Semester 2. Team Jedi seemed to hold steady on the satisfaction measure, noting, ‘We have been getting along pretty well this semester by communicating via email.’ However, one Jedi also reported, ‘I think we did a good job. We were more polished than the first semester.’ Team Synergy struggled a bit more in Semester 2 (see the explanation below) but also finished strong in terms of satisfaction. In his/her journal

one group member wrote, ‘This semester was a little tougher ... the group chemistry was a little off until about the last week of the semester.’ Another Team Synergy group member provided a possible reason for the difficulty, writing ‘This semester, we were all so busy that we had trouble finding extra time to meet.’ On the other hand, Team Cornrows exhibited significantly higher Semester 2 team member satisfaction as reported in their peer evaluations and journals. One member of Cornrows commented, ‘I felt our project was well received and everyone did a great job. It feels like a real accomplishment because of all of the hard work that we all put in.’

Interestingly, Team Swells was the ‘most improved’ in both satisfaction and performance categories. By the end of the second semester, Swells’ team satisfaction had increased substantially, as did the quality of both their final presentation and written business plan projects.

Table 2 summarizes the Semester 2 team performance quality and satisfaction outcomes.

Essentially, between Semesters 1 and 2, three teams experienced changes in outcome measures, with Team Cornrows improving their satisfaction significantly, Team Jedi improving their performance significantly and

Team Swells improving both. We were curious about the changes in both the team performance and satisfaction outcomes and decided to examine possible explanations that might account for these changes. We began with the personality dimensions. Table 3 below shows both Semester 1 and Semester 2 mean personality scores for each team on each of Goldberg’s five personality factors.¹⁰

As the table shows, mean personality scores for two of the teams – Team Synergy and Team Jedi – did not change, while scores for the other two teams – Team Cornrows and Team Swells – did change. As mentioned above, students remained in the same teams for both semesters of the program, and Goldberg’s five personality factors have been shown to be stable over time.²⁵ Then what accounted for these personality score changes? The answer is that unlike Teams Synergy and Jedi, Teams Cornrows and Swells experienced turnover, with each team losing one member, resulting in changes in the means of several key personality dimensions. Table 4 shows the changes in these two teams’ personality dimension means.

In the following discussion, we discuss the link between the outcomes in team performance and satisfaction to changes in team personality scores, and we also consider the role that diversity in GMA and enriched communication may have played.

Table 2: Semester 2: project quality vs. satisfaction

	Project quality – low	Project quality – high
Satisfaction – low	—	—
Satisfaction – high	—	Team Cornrows, Team Swells, Team Jedi, Team Synergy

ANALYSIS

The effect of turnover on deep-level personality diversity and outcomes

Recall that Team Swells had the lowest presentation and report performance as well as

Table 3: Semester 1 and 2: mean team personality dimension scores

	Extroversion		Agreeable		Conscientious		Emotional stability		Openness	
	T1	T2	T1	T2	T1	T2	T1	T2	T1	T2
Swells	3.45	3.50	4.05	4.07	3.83	3.57	3.43	3.60	4.03	4.17
Cornrows	3.25	3.30	3.73	3.60	3.70	3.57	3.50	3.57	3.90	4.10
Synergy	3.20	3.20	3.93	3.93	4.23	4.23	3.90	3.90	4.00	4.00
Jedi	3.15	3.15	4.10	4.10	3.65	3.65	3.93	3.93	3.88	3.88

Table 4: Semester 1 and 2: change in personality dimension means for teams with turnover

	<i>Extraversion</i>	<i>Agreeable</i>	<i>Conscientious</i>	<i>Emotional stability</i>	<i>Openness</i>
Swells mean change	0.05	0.02	-0.26	0.17	0.14
Cornrows mean change	0.05	-0.13	-0.13	0.07	0.20

the lowest team satisfaction during Semester 1. During the first semester, three students on Team Swells all expressed discontentment with the same member of their team. By analyzing the team’s personality dimensions and reading their journals, we were able to understand the issues that resulted in the students’ dissatisfaction. It seemed that the group’s problems stemmed from a lack of consensus on procedures and the designation of responsibility for weekly assignments. For instance, one of the team members stated that, ‘(one group member) has appointed (him/herself) as the leader ... and assigns tasks to the rest of us. We do not get to choose what we work on, (he/she) just tells us what to do!’ This same sentiment was echoed in the journals of the other group members. However, the journal of the self-appointed leader revealed that (he/she) felt the other team members were not doing their fair share of the work. ‘The members of this team do not do what I ask them to do ... they turn in poor quality work days later than we agree to have it done ... I am frustrated!’ By analyzing the qualitative data from the Semester 1 journals, we were able to better understand each team member’s perspective regarding the perceived transgressions.

After the Team Swells turnover event at the beginning of Semester 2, we analyzed the journals of the remaining three members. During the second semester, the members were more positive about their overall experience. One of the members reported, ‘I never really felt a sense of tension with this (new) group ... with the former group, I felt like I never knew what was going on and I didn’t understand why I was being given the assignments that I was given ... this time I had a say in which pieces I wanted to do ... I really really appreciated that.’ Another team

member had a similar experience; he/she wrote, ‘I think our team had a much easier time communicating and meeting (during Semester 2) ... we agreed on a timeline for getting things done in advance.’ Commenting specifically on the turnover event, one Team Swells member shared, ‘I was very relieved that the makeup of the team was what it was ... I think we were better off without (a specific group member),’ and another added, ‘So we’re one person down, oh well. It will be a little more work, but all we really need is one science person anyway ... and the other team members with science backgrounds are great.’

The changes reported in the journals before and after the turnover event affecting Team Swells were consistent with the changes along the personality dimension means. For this team, the team emotional stability mean increased, suggesting that the reduced team was more even-tempered. In addition, the conscientiousness dimension mean decreased after the turnover event. Taken together, these two events indicate that the high degree of ‘performance anxiety’ displayed by the team member who ended up leaving had a negative impact on both overall team satisfaction and performance. Perhaps even more interestingly, there was a noteworthy distance between the exiting team member and the remaining team members on both personality dimensions (the exiting team member’s score on emotional stability was 2.9 vs. a 3.6 remaining team member average while the exiting team member’s score on conscientiousness was 4.6 vs. a 3.6 remaining team member average). Thus, turnover seemed to have a positive impact on this team, as the calmer, less grade-driven Semester 2 Team Swells clearly outperformed the Semester 1 team and were more satisfied with the process. This finding is

consistent with recent research by Trimmer *et al.*²⁶ who found that higher levels of team conscientiousness and greater diversity in team emotional stability are associated with higher levels of team conflict.

The effect of turnover on general mental ability and outcomes

Recall that team Cornrows' Semester 1 performance was outstanding, but their team satisfaction levels were low. Examining the students' Semester 2 journals, as well as noting changes in the team's GMA after the turnover event, proved to be valuable in understanding why Team Cornrows' overall satisfaction increased. For instance, just after the turnover had occurred in mid-Semester 2, one team member wrote, 'Now it is just the three of us, (one team member) dropped the class, and it is totally fine with me. I think the (remaining) three of us work quite well together and now we won't be distracted by all the drama.' These same feelings were echoed in the journal of another student, 'This week (our teammate) was confronted about not doing his/her work and will no longer be on the team. It should not affect our group, and will likely make us more efficient since we won't have to wonder if (he/she) will be doing (his/her) part or not ... It is too bad it had to come to this but ... it should make life easier for all of us.'

Interpreting the reasons for Team Cornrows' improved satisfaction was somewhat more difficult until we considered the possible role of diversity in openness to experience and GMA. In the case of Team Cornrows, after the turnover event, the level of team openness increased. Team Cornrows' Semester 1 dissatisfaction probably stemmed from a lack of openness because of one team member's inability and/or unwillingness to communicate effectively with fellow team members. This team member's unwillingness to speak up (thus, possibly reflecting agreeableness to a fault) resulted in his/her being ignored and marginalized by remaining team members. There was an 'elephant' in

the room that the team did not seem to feel comfortable talking about. Once the uncommunicative team member resigned, the remaining team members seemed to relax, be less resentful and were able to communicate more openly.

More significant was the fact that the departing team member entered the program with the lowest GPA of BEP program participants and was struggling in most other subjects at the time of his/her resignation. This fact may suggest that in addition to deep-level personality issues, this team may have been dealing, more than the other teams, with underlying GMA diversity. There may have been a link between the outlier's lower GMA and his/her inability to contribute to the team and to communicate comfortably and confidently with other team members.^{17,27}

Other outcome changes

While 'deep-level' team personality diversity and GMA changes created by turnover help explain positive outcome changes experienced by Teams Swells and Cornrows, they do not explain the increase in performance experienced by Team Jedi. Admittedly, a simple learning effect could account for that change; however, we are proposing an alternative explanation. Organization theorists suggest that collaborating frequently to perform tasks can reduce the negative impact of surface-level diversity.²⁸ In addition, 'media richness theory' proposes that communication media can be arranged along a 'media richness continuum,' with electronic media below face-to-face and telephone communication.²⁹ Effective communication depends on selecting the appropriate channel for the situation,³⁰ with complex team problem solving requiring a high degree of communication richness. Given the high level of functional or disciplinary diversity (that is law, science, health science and business) inherent in our BEP program teams and the complexity of developing bioscience commercialization plans, we felt that increased and enriched

team communication could possibly account for Jedi's improved performance.

To gain information about the type and frequency of communication on each of the teams, we used information from the students' journals and peer reviews in the first course, followed by a more detailed communication log in the second course. These instruments taken together with the journal comments support our hypothesis that Jedi's performance improvement stemmed from increased (although involuntary) team communication. For instance, in the first semester, Team Jedi usually did not use the allotted 'team time' at the end of each class session to meet, nor did they choose to meet face-to-face outside the class, electing instead to interact via email, with mixed success. However, by the end of Semester 1, when it was time to integrate the material for final presentations and reports, their journal entry data showed that their communication deteriorated, which is most likely why Team Jedi's end of term performance was low, despite the group's high overall level of satisfaction.

During Semester 2, the entire class met together as a group only twice: once at the beginning of the semester to choose their technologies and again at the end of the semester to present their business plans. During the remaining 8 weeks, however, each four-person team was required to meet together face-to-face once per week with the professor at a time of their choosing to discuss the team's progress and to troubleshoot problems that arose. Each team also was asked to keep a communication log. Team Jedi's Semester 2 communications log showed that they chose to meet four times as a team in addition to the required once-a-week meetings, while continuing their pattern of email communications as in Semester 1. Individual team members also met face-to-face five times with the professor. One Jedi team member wrote, 'This week we met after our weekly meeting to make sure that everyone knew their role and to see what needed to get done before the final

presentation. I think this resulted in our group being more polished than we were first semester. In general, I think we did a better job about keeping up on communications.' Thus, in the end, the enriched communication process, especially toward the end of the course, provided an opportunity for the team to better integrate their individual contributions and practice their final presentations.

DISCUSSION

Through the analysis of the quantitative personality, interaction frequency and outcome data along with the insightful information we gained from the more qualitative communication logs, peer evaluations and journals, we were able to not only determine which groups experienced dysfunction but, more importantly, we were able to understand the reasons underlying the dysfunction from the students' own perspectives, as well as from more theoretical points of view. The results of this research help to illuminate the impact that turnover can have on teams, and more specifically, the positive effects that can be attributed to turnover in teams in certain circumstances.

Our results suggest support for the hypothesis that by reducing the amount of deep-level diversity within a team, levels of team performance and satisfaction will subsequently increase. Consistent with prior research that has been conducted on teaming, we believe that the negative effects of deep-level diversity on team performance are more pervasive than are those of surface-level diversity, especially when one team member scores significantly higher or lower on personality dimensions or GMA than the rest of the group. The qualitative data provided by Team Cornrows and Team Swells suggest that the negative effects of convening a team with members of dissimilar personality and GMA dimensions also seem to be exacerbated over time. This reinforces our hypothesis that differences in personality dimensions and GMA traits negatively affect a team's ability to

successfully organize and implement tasks, leading us to conclude that the negative effects of deep-level diversity are not as easily overcome as are those of surface-level diversity.

These findings have significant implications because they offer insights into ways to potentially increase the productivity, work quality and satisfaction of teams. Because interdisciplinary teams are ubiquitous in bioscience commercialization, our findings may help to expedite the process and result in more rapid development of vital bioscience tools and resources. By engineering interdisciplinary work group teams to be more similar in terms of deep-level diversity it may be possible to maintain high performance outcomes while preserving the satisfaction of team members.

Specifically, this study has significant consequences for educating and training work group teams in bioscience entrepreneurship and technology commercialization. As Meyers and Hurley¹ argue, because diversity can be a considerable barrier to successful teaming, learning strategies for communicating and collaborating with people who are different from us is crucial. For instance, in their recent book pertaining to educating the next generation of bioentrepreneurs, Meyers *et al* suggest that learning how to 'lead knowledge workers like scientists and physicians' as well as 'how to create high-performance leadership teams' should be areas of focus.³¹ Research suggests that, more frequent communication and face-to-face meetings, as well as working in the same teams over time, may help overcome negative effects of team diversity and ultimately enable teams from diverse disciplinary and personality backgrounds to outperform those that are more homogeneous.³

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