## From the Classroom

# Teaming in biotechnology commercialisation: The diversity-performance connection and how university programmes can make a difference

Received (in revised form): 23rd September 2008

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**ABSTRACT** **Collaboration across disciplines in the sciences is on the rise. Yet, practitioner papers abound that describe a range of dysfunctional team experiences, especially in contexts where science and business intersect. A critical issue currently preventing successful bioscience commercialisation is management's lack of 'soft skills,' such as the ability to direct complex and functionally diverse teams to achieve productive outcomes. Our paper first reviews the diversity and teaming literature from several disciplinary perspectives in order to better understand how different types of diversity affect team outcomes and processes, as well as how to create higher functioning teams to engage in bioscience technology commercialisation. Research suggests that the 'surface-level' diversity issues associated with demographic and disciplinary differences may diminish over time, as team members move beyond initial stereotypes and gain more knowledge about their fellow group members. However, problems**

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**stemming from 'deep-level' diversity such as personality and values differences are more difficult to overcome and require a high degree of interaction frequency among team members, as well as strong communication skills. Going beyond the literature review, we demonstrate how these 'lessons learned' can be addressed through bioscience entrepreneurship education, using a case study of a Midwestern university programme funded by an NSF Partnerships for Innovation grant.**

*Journal of Commercial Biotechnology* (2009) **15,** 3–11. doi:10.1057/jcb.2008.47

**Keywords:** bioscience; entrepreneurship; education; interdisciplinary teams; personality; diversity

## INTRODUCTION

According to Meyers and Hurley,[1] the three major resources required to successfully commercialise bioscience research are technology, money, and a supply of qualified scientific and managerial talent, with the factor of most concern being the latter. Translating research into a marketable product requires cross-disciplinary knowledge and skills, including the basics of intellectual property, early-stage technology finance, regulatory and reimbursement rules, and marketing.[1] In addition, bioentrepreneurs require special personality traits and 'soft skills' such as communication, conflict resolution, team building, optimism, self-control, and empathy, which are often neglected in university curricula.[1]

These observations, along with Myers and Hurley's[1] assertion that 'soft skills' can be 'learned and improved with training and practice' suggest that university programmes that develop graduates capable of managing across disciplines to commercialise bioscience research will be filling a much-needed niche. However, the relatively small body of academic research that has been conducted on interdisciplinary team effectiveness, especially in the biosciences, suggests that translating the complex body of skills and knowledge required to successfully commercialise technologies in this emerging and important field is a difficult task for which few are prepared either by experience or by education. In fact, management researchers assert that managing diverse work groups is one of the most difficult challenges in today's organisations and that it is not 'going smoothly.'[2]

The purpose of this research is to review the extant literature on the effects of diversity in teams, including differences in demographic characteristics, disciplinary skills and backgrounds, personality traits, and overall values, to better understand how each may contribute to successful (or dysfunctional) teaming in the biotechnology commercialisation domain. We then offer suggestions for incorporating these needed skills into educational curricula and work settings.

## TEAMING ACROSS DISCIPLINES IN THE BIOSCIENCES

Team-based work is proliferating in today's organisations,[3] with research suggesting that 48 per cent of organisations accomplish their work through the use of teams.[4] By team, we mean 'a collection of individuals who are interdependent in terms of their tasks, who share responsibility for collective outcomes, and who see themselves and are seen by others as a social entity.'[4] Fiore[5] argues that increasingly 'science is paying attention to teams.' Further, he suggests that 'team science' involves truly 'interdisciplinary' collaboration, which entails integrating across disciplines to achieve solutions or new understandings that are beyond the scope of a single discipline. Although this may seem a daunting task, Fiore[5] proposes that the questions raised in the scientific community about how to foster this new paradigm are very similar to the

questions managerial research into teams has been investigating for years, albeit with mixed success. Also, because interdisciplinary collaboration is inherently a team activity, Fiore[5] argues that it is a process that can be learned rather than a product that naturally emerges. As such, incorporating relevant interdisciplinary teaming skills into science education could significantly enhance both bioscience research and commercialisation success.

Although Fiore[5] focuses more on interdisciplinary teaming with respect to conducting scientific research, we argue that learning to collaborate across disciplinary boundaries is even more important when it comes to commercialising bioscience research. Scientists already bring a wide variety of disciplinary approaches to research, adding intellectual property, finance and marketing experts to the mix results in ever-widening paradigm gaps. As such, training students and practicing scientists in the 'soft' management and teaming skills needed to be successful in the commercialisation environment is more difficult but also more important for success. To begin the conversation about how educators and trainers might approach this task, we review below the general literature on group diversity and team performance. We will then suggest ways in which the 'lessons learned' from teaming research in the management disciplines might be incorporated into the educational and workplace environments within a bioscience context.

## DIVERSITY AND TEAM PERFORMANCE

Although the industry association literature abounds with papers on dysfunctional teams,[6] management research has not necessarily found a negative relationship between work group diversity and team performance. Diversity has been shown to increase the level of conflict in teams; however, such conflict is generally believed to be positive when it stays task-focused.[7] Interestingly, not all types of diversity have been found to affect team performance in the same way. In the following sections, we review the literature addressing two different types of diversity: surface level (based on demographic and disciplinary differences) and deep level (based on personality and value differences). Although much of the literature reviewed comes from the organisational behaviour domain, Fiore[5] contends that these strategies for managing diversity can and should be used to improve the functioning of interdisciplinary teams in the science domain.

### Surface-level diversity

Surface-level diversity generally involves easily observed differences among team members on demographic dimensions such as age, race, gender, national culture and ethnicity[7] as well as differences along disciplinary background.[8] As a result of the globalisation of science, which allows the rapid exchange of information anywhere in the world and 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 from a demographic perspective.

Because demographic characteristics such as age, ethnicity and gender are easily observable, team members tend to use them to attribute, both to themselves and to others, specific patterns of thought, attitudes and behaviours.[8] Initial thinking about demographic diversity suggested that people are attracted to, and prefer to be with, others demographically similar to themselves; thus, this assumption led to the hypothesis that team members would be less positive about working with others who look less like themselves.[9] Results from a recent study involving a wide range of team diversity categories suggest that a negative relationship between perceived demographic diversity and team performance may exist initially. However, this study also suggests that early stereotypes based on such characteristics are likely to be replaced by more accurate knowledge as team members get to know

each other better.[10] In essence, such differences tend to become less important as groups continue to interact over time.

Although demographic diversity has long been a general characteristic of teams, more recently disciplinary diversity (which arises from both content and process differences in work experience and education across a wide range of disciplines) is on the rise. This increased disciplinary diversity is especially evident in the sciences, with the lone scientist rapidly becoming the minority.[5] Cross-disciplinary teaming, which involves putting together individuals from different educational backgrounds, work experiences and paradigms to analyse and solve complex problems,[11] does not fare as well when it comes to assuring strong team performance. Research findings on this dimension, which are fewer and more inconsistent than those on demographic diversity, tend to be more negative than positive. For example, some studies suggest that team members with different skill sets may also bring with them organisationally based power and status dynamics (for example, a team including a surgeon, nurse, lawyer, patient and hospital administrator, all of whom would have different levels of power and status within a hospital), which in turn may affect individual team members' attitudes and behaviours even when those dynamics are not related to the team's purpose.[11] Others argue that organisational position and status diversity may at times play a positive role in team performance but that disciplinary diversity is more likely to have a consistently negative effect.[12] Although the negative effects of disciplinary diversity can often be mitigated by learning behaviours (such as seeking feedback, asking for help, and talking about errors), similar to the demographic diversity domain, such behaviours take time, which is becoming less of an option in today's fast-moving environments.[13]

Despite a rich history of studies examining the relationship between surface diversity and team performance, historical findings are mixed.[9] Most researchers agree that managing diversity in the workforce is one of the major challenges of the twenty-first century, and that all things equal, work groups that are homogeneous across demographics and disciplines may result in more positive team outcomes, especially when routine problems are involved. However, research also suggests that for creative tasks requiring the use of unique information, groups with surface-level diversity are more likely to discover and incorporate such information.[14] Not surprisingly, the team orientation of individual group members, defined as 'the general tendency to be comfortable in team settings, to exhibit interest in learning from others, and to have confidence in the productivity of the team,'[10] has been found to moderate the surface diversity and team performance relationship in a positive way. In sum, these findings suggest that surface diversity involving demographic and disciplinary differences plays a less significant role in team outcomes than originally hypothesised, and that, over time and in certain contexts, surface-level diversity may actually have a positive impact on team performance.

## Deep-level diversity

Unlike the easily observable characteristics of surface-level diversity, deep-level diversity involves differences among team members' personalities, values, and attitudes.[8] Typically, differences in these more psychological dimensions are inferred over time through behaviours, communications, and disclosure of personal information as opposed to being immediately observable. Deep-level diversity affects team functioning in similar ways regardless of the organisational or disciplinary context in which the team exists. Thus, we would expect deep-level diversity in bioscience teams to resemble deep-level diversity in teams across a wide variety of contexts. 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 with

similar personalities and values; thus, this assumption leads to the hypothesis that team members will not react positively to working with others who do not behave or believe like themselves.[9]

However, unlike surface-level diversity, the negative effects of deep-level diversity on team performance are more pervasive in that they tend to both emerge and persist over time. Personality diversity involves differences in personal preferences which affect a team's ability to successfully organise and implement tasks. One of the most accepted typologies of personality diversity is Goldberg's[15] 'Five Factor Model.' Typically, teams displaying either higher mean levels and/or lower variances along the 'Big Five' dimensions of extroversion, emotional stability, conscientiousness, openness and agreeableness are more likely to be more socially cohesive and achieve higher levels of team performance.[16] The negative impact of personality diversity on teams seems especially strong for the dimensions of emotional stability and conscientiousness.[17] Further, research suggests that in addition to means and variances along these dimensions, having even one person lacking a minimal level of an important personality trait can harm group functioning, because of emotional 'contagion' (that is, negative emotions can be 'caught' from others within the group).[17]

According to Dose,[18] values also are extremely relevant in the context of team processes, especially when they relate to the work environment. Some researchers believe that values diversity may be more strongly linked to negative team outcomes than diversity on personality traits. Values can be defined as standards or criteria for choosing goals or guiding action.[19] Research on values has been undertaken in a wide range of applications in the management literature, including both the organisation behaviour and strategy domains, which have found that agreement on equitable implementation processes is more important to performance than agreement on outcomes or goals. Even the scientific community does not seem immune to this issue; decades ago, Einstein lamented science's tendency to perfect means but confuse goals.[20]

The results of values diversity studies are surprisingly consistent. As expected, organisational research shows that agreement on both processes and goals is the best combination for achieving the highest team performance. However, somewhat surprisingly, agreement on goals without agreement on the process for achieving those goals is strongly correlated with *poor* team outcomes, whereas agreement or satisfaction with the process is associated with a greater acceptance of the outcome, even if team members do not agree on that outcome. Conversely, disagreement or dissatisfaction with the team process is associated with strong negative attitudes, even if team members initially agreed upon the outcome or goal.[4,21] This research is related to the organisational behaviour literature on procedural justice,[22] which argues that when individuals have negative perceptions of outcomes (that is, distributive justice, which involves fairness in terms of amount and allocation), it is very important that they believe the resource allocation process was fair (that is, procedural justice). These findings suggest that achieving consensus on means rather than ends and assuring that team members believe that the team process is fair should be more of a focus than achieving agreement on specific goals or outcomes.

Both types of deep-level diversity (personality and values) tend to have strong negative effects on team functioning and performance. Additionally, there is some evidence that the two types of deep-level diversity may interact with and exacerbate each other.[4,23] As mentioned above, there is no evidence to show that the negative effects of this type of diversity are mitigated over time. Curiously, one recent study has found that grouping teams with similar deep-level diversity characteristics together does not result in higher performance in teams with

high surface-level diversity.[14] Recommendations for reducing the impact of these sorts of differences to improve team performance include engaging in collaborative team activities such as getting together frequently.[8] However, overcoming the effects of deep-level diversity through processes that focus on leadership development and enhanced coordination and communication depends on active intervention and thus may require longer periods of time and more resources and training to accomplish.

## IMPLICATIONS FOR EDUCATION AND TRAINING IN THE BIOSCIENCES

Clearly, managing various levels and types of team diversity, most of which can have negative effects on team performance, is a challenge in educating scientists to work more effectively across disciplines in technology commercialisation. Walfe[6] calls such teams 'cross (dys) functional teams,' observing that too often, they are adopted by organisations that are not prepared properly for reaping the potential benefits. He specifically cites biopharmaceutical companies as being guilty of relying on 'wishing' or 'magic' to create the synergies and collaborations they desire from teams.

To address this issue, Meyers and Hurley[1] argue that university-sponsored bioentrepreneurship programmes, which are beginning to emerge throughout the world, may be the best vehicles for meeting the interdisciplinary teaming and management talent challenges facing biotechnology commercialisation. They strongly suggest that one of the key issues that such programmes should take on is the challenge of teaching collaboration and teaming skills, because each of the key disciplines required to commercialise bioscience technology – science, business and law – will need to fill different knowledge gaps as well as social and emotional skills gaps. For example, students interested in careers in this field need to know that certain personality characteristics may be more likely to lead to success as a bioentrepreneur. Structured properly, bioentrepreneurship programmes cannot only equip students with an awareness of their own teaming strengths and weaknesses, but also can provide them with tools for, and the opportunity to engage in, personal development.

## A SAMPLE BIOSCIENCE ENTREPRENEURSHIP TEAM-BASED MODEL

So how can universities train students and practitioners to collaborate in the context of cross-disciplinary teams? This final section of our paper describes the efforts of a Midwestern university to address these issues through an innovative curriculum known as the Bioscience Entrepreneurship Program (BEP). This interdisciplinary programme, which began in February of 2008 and is funded by a 3-year grant from the National Science Foundation's Partnerships for Innovation programme, was designed to train science, health science, business and law students in the process of bioscience technology commercialisation. Over the course of the year-long programme, students from these key disciplines work in four-person teams to write a technology commercialisation plan for a bioscience technology developed by one of the two major medical research centres in the area.

The BEP consists of two courses that bookend a summer internship. In the first course – bioscience technology commercialisation, which is offered in the spring, students from the four areas work in cross-disciplinary teams on the same project to learn the process of bringing bioscience research and technologies to market. The paid summer internship allows each student to spend at least 80 hours working in an organisational context in which bioscience and business intersect. This might include law offices specialising in intellectual property protection and licensing, university technology transfer offices, and bioscience startups and

commercial laboratories. In the second and final fall course – bioscience entrepreneurship, the same teams of students choose a technology from a local medical research centre and write a business plan for commercialising that technology through licensing or startup. Although the primary goal of the BEP is to teach law, business, science and health science students how to commercialise bioscience technology, because of the importance of 'soft skills,' the course was structured to implement lessons from current research on team diversity (reviewed above). As such, teams were designed to capture a wide range of diversity types, including demographic, disciplinary, and personality. Depending on the relative effects of the different types of diversity on team performance, interventions would be designed as needed during the second course to address problems that arose and to improve team functioning.

In terms of programme and team composition, to address Meyers and Hurley's[1] suggestion that programmes should seek to increase not only their disciplinary diversity but also the demographic diversity in categories such as gender, race, age, nationality and ethnicity, BEP marketing approaches were designed to achieve a high level of diversity among applicants. Examples include advertising the programme extensively to a wide variety of relevant groups such as the Intellectual Property Law Club; first year medical, pharmacy, physical and occupational therapy, and nursing student orientations; and undergraduate summer science research programmes, as well as conducting general e-mail campaigns, producing flyers, and writing letters to students and their families from the targeted four disciplines. To attract initial interest in the programme and to reach less affluent students, the respective university departments and schools provided tuition remission for the BEP courses, matched by outside donor scholarships, of up to US$5000 per student. Although participant selection was based primarily on a student's academic merit and interest in the programme as determined through an application statement, transcripts and in-person interviews, the candidate pool and ultimately the 16 students chosen to participate were highly demographically diverse, with 31 per cent female, 19 per cent minority, and 19 per cent international students participating. Additionally, in terms of disciplinary diversity, 25 per cent were from law, 31 per cent science/health sciences, and 44 per cent business (although most of the business and law students had some background in a science-related discipline). Finally, 43 per cent of the participants were upper division undergraduate students, with 57 per cent graduate students involved.

Teams were formed with random assignment across demographic characteristics (gender, age, ethnicity, culture), with each team having some demographic diversity along at least two of the dimensions. Each team was intentionally assigned one law, one science/health science and two business students to approximate equivalent disciplinary diversity. Teams were relatively similar with respect to average, Grade Point Average (GPA), which researchers use as a proxy for GMA or 'general mental ability.' As discussed above, current research supports the creation of teams with high disciplinary and demographic diversity, as surface-level diversity has been shown to increase team performance over time over and above more homogeneously demographic teams,[10] especially on tasks such as technology commercialisation, which requires creativity and the sharing of unique information.[14] Random assignment across deeper level personality characteristics was effectively achieved because instruments to assess personality dimensions were not completed until after team assignments were made yet before the professor had gotten to know the students.

Because valid and reliable instruments exist in the management literature to assess 'deep level' teaming diversity characteristics, team process and team orientation characteristics,

and both subjective and objective performance variables (such as degree of team conflict, team satisfaction, and outcome quality), from the beginning in the first course we were able to use existing scales and measures to assess these variables. For example, the personality diversity of the student teams was measured using questionnaires based on Goldberg's[15,24] five factor personality scale to assess each individual's level of extroversion, emotional stability, openness, agreeableness and conscientiousness and to compute means, variances and 'distance from the lowest member of the team' measures. All of these measures have been shown to relate to team functioning in different contexts. Anderson and West's[25] team climate inventory instrument, which measures the four factors of vision, participation safety, task orientation, and support for innovation, was used to assess the quality of team functioning. Students also provided peer evaluations of each of their team members as well as themselves, kept journals throughout the semester, and filled out a five-question instrument about leadership in the group. Outcomes were measured by external observer evaluations of team presentations, along with course grades on final written business plans.

In the first semester of the programme, when the students were learning the process of technology commercialisation as a group, the curriculum did not focus specifically on teaching team process skills such as communication, leadership, conflict resolution and team building. However, these team characteristics were measured, using the instruments described above. Essentially, although demographic and disciplinary diversity did impact team functioning over the course of the first semester of the programme, the effects seemed dwarfed by personality diversity effects. Because the literature supported the fading over time of the surface-level diversity teaming effects, we decided to keep the teams intact for the second semester course.

Also, based on the findings from the first course, at the start of the second course specific instruction on team process skills and models was introduced to the BEP students by an organisational psychology expert, who remained available throughout the semester as a resource to individuals and teams. By this time students had a set of experiences through which to view the material presented by the instructor. Thus, when asked to discuss their team process concerns at the conclusion of the session they were able to actively engage the topic through discussion of their own critical incidents. Students were asked to keep records of their team interaction, including e-mails, meetings, and phone conversations, in addition to their journals. At the end of the semester, team performance and functioning will again be assessed using the same instruments and processes as those used in the first course, and the outcomes will be compared with the first semester results to determine whether efforts to improve team processes and 'soft skills' have resulted in better team outcomes and higher levels of team member satisfaction. Because of space limitations and ongoing data collection, results from that study will be reported in a future 'From the Classroom' section of this journal.

## CONCLUSION

This paper has reviewed the management literature about the relationship between different types of diversity and team performance. Like Meyers and Hurley,[1] we agree that bioscience entrepreneurship and technology commercialisation programmes involving science, law and business students must address this increasing need to work effectively across disciplines, demographics, personalities and values. Our description of the teaming structure and process of a new BEP at a Midwestern university provides a roadmap for other universities that wish to adopt such a focus. By using the tools and information reviewed in this paper, not only educational institutions, but also firms and organisations facing similar teaming challenges, can better understand the complex interaction

of demographics, discipline, personality, and team processes in order to reduce conflict, make more creative decisions, and positively impact team performance.

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