Synergistic Knowledge Development in Interdisciplinary Teams

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ABSTRACT Problem solving, interpersonal skills, information literacy, and critical and independent thinking are essential qualities that employers seek, yet many undergraduates lack. We structured an interdisciplinary classroom and experiential learning environment where students from three undergraduate courses (Hospitality and Tourism Management, Landscape Architecture, and Forestry and Natural Resources) designed a sustainable community master plan by investigating the economic, social, and environmental components of a U.S. highway relocation project. Interdisciplinary teams of students were charged with a "problem" that was articulated in the form of a Request for Proposals (RFP). This RFP served as the basis for the group work, which required an interdisciplinary approach. The ability of students to work together to complete the project was analyzed using the construct of synergistic knowledge development (SKD), a process by which a group constructively integrates diverse perspectives of individual group members. We posited that SKD would increase over the semester and that SKD would be influenced by various team dynamics such as task conflict, psychological safety, social interaction, attitudes toward problem-based learning (PBL) in a team setting, and behavioral styles of team members. Assessment of SKD and the variables hypothesized to influence it were assessed via a survey administered after the initial phase of the project and a post-project survey. Results confirmed how social interaction, psychological safety, and attitudes toward PBL in a team setting influence SKD.

Synergistic knowledge development (SKD) is defined by Mu and Gnyawali (2003) as the process by which teams of students constructively integrate diverse perspectives of individual team members. They used a survey (11 questions related to team dynamics) of 136 business students working on a case study to determine if SKD is influenced by the following aspects of team dynamics: task conflict, psychological safety, and social interaction. Taken together, these three aspects explained 31% of the variance in SKD in their study (Mu and Gnyawali, 2003).

Task conflict is a function of the different viewpoints and opinions of the team members (Jehn, 1995; Jehn and Mannix, 2001). Although conflict is inevitable in teams, and the lack of it can result in "groupthink," much high-task conflict may be detrimental especially if such conflict is not properly managed (Mu and Gnyawali, 2003). Mu and Gnyawali (2003) reported a negative relationship between task conflict and SKD.

Psychological safety is the belief that the group environment is safe for discussing diverse viewpoints (Edmondson, 1999). When a team has high psychological safety it means they feel comfortable speaking out without fear of embarrassment, harsh criticism, or being ignored (Mu and Gnyawali, 2003). Mu and Gnyawali (2003) reported a positive relationship between team psychological safety and SKD. They also noted that psychological safety was even more important to SKD when task conflict was high (Mu and Gnyawali, 2003).

Social interaction is defined as the process of communication among group members (Barker and Camarata, 1998). Although social interaction makes it easier to understand each other's perspectives and combine diverse views into integrated knowledge, Mu and Gnyawali's (2003) data did not show a relationship between social interaction and SKD.

Problem-Based Learning in Teams

Educators use student-centered, cooperative learning methods such as problem-based learning (PBL) to prepare students for the challenges and problems they will encounter in their respective careers. Problem-based learning is a powerful use of engagement that reaches beyond traditional methods of teaching and learning and seeks to actively engage students in the learning so that they will retain and apply important course content later in their careers (McDonald and La Lopa, 2005). In the PBL approach, learning results from the process of working toward the understanding and resolution of a complex and typically messy problem (Barrows and Tamblin, 1980). The problematic situation encountered jumpstarts the learning process and it is then the student's job to identify the crux of the issue (problem identification or problem finding), to

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Abbreviations: CAC, community advisory committee; FNR, Forestry and Natural Resources; HTM, Hospitality and Tourism Management; INDOT, Indiana Department of Transportation; LA, Landscape Architecture; PBL, problem-based learning; RFP, Request for Proposals; SKD, synergistic knowledge development.

ask the critical questions that must be answered (problem formulation), to seek out the information and tools needed to investigate and understand it, and to use new insights to proceed to a solution (Merrill, 2003).

Regardless of the source of the problem used in class, good problems should meet several criteria (Duch et al., 2001). The problem should be engaging; people are more motivated to learn when they are interested in the subject and the more relevant the problem is to the student, the greater the interest level. The path to the problem's solution should be structured, but students should be encouraged to propose their own, not their teacher's, solutions. The problem should be adaptable so the learner can see whether one set of solutions for a situation can be applied to similar situations. Finally, the problem must be solved in a collaborative manner because everyone has their own expertise and students must learn to harness the talents of the entire team to solve the problem. The benefits to students include enhanced critical thinking, mastery of communication skills, and team building (Duch et al., 2001).

Behavioral Styles

Tony Alessandra's Platinum Rule (Alessandra and O'Connor, 1996) classifies the four basic business personalities as Director, Relater, Socializer, or Thinker. The Director, who generally wants to manage the team, is firm, forceful, confident, competitive, decisive, risk-taking, and wants to be team manager. Relaters are agreeable team players who like stability more than risk and care greatly about relationships with others. They are likeable, but sometimes too timid and slow to change, and may be overrun by the Director. However, they will do all they can to promote team harmony, and are good conflict mediators. Socializers are outgoing, optimistic, enthusiastic, and love to be at the center of things. They have lots of ideas and love to talk, but may distract the team with their socializing. Thinkers are self-controlled, cautious, logical, linear, and prefer analysis to emotion. They love clarity and order, but may come across as a bit stiff. They can help a team think through a decision, but may impede the team progress if they are unwilling to make a decision until the data are "studied to death." They are great as team accountants and syllabus expediters (Alessandra and O'Connor, 1996).

Research Questions

In this semester-long, problem-based, service-learning project, the specific research questions were:

1. Does SKD increase as a result of participation in a semester-long, problem-based, service learning project?
2. How do task conflict, psychological safety, social interaction, and PBL attitudes in a team setting influence SKD for students who participate in a semester-long, problem-based, service learning project?
3. Do student attitudes toward PBL in a team setting aid in predicting SKD beyond task conflict, psychological safety, and social interaction for students that participate in a semester-long, problem-based, service learning project?
4. How do behavioral styles influence SKD for students that participate in a semester-long, problem-based, service learning project?

Research Methods

College juniors and seniors from Hospitality and Tourism Management (HTM), Landscape Architecture (LA), and Forestry and Natural Resources (FNR) formed interdisciplinary learning teams to design a sustainable community master plan that required them to draw upon the expertise of their respective disciplines and bring it to the team project. The interdisciplinary project teams were established using a two-stage system. The LA professor created teams that had a diverse mix of LA interests and learning styles. The HTM and FNR professors then randomly allocated their students to the six core teams to make up the larger project teams that were comprised of approximately 20 students, for a total of 126 students. The gender composition of the combined courses was 44% males and 56% females. The behavioral style mix of each team was determined by having the students complete Tony Alessandra's Platinum Rule Assessment (www.platinumrule.com).

Sixteen 50-minute Friday sessions were reserved solely for interdisciplinary team work. Activities included introducing concepts that bridged the three courses such as information literacy, group dynamics, service learning, and disciplinary perspectives; summary and discussion of behavioral styles and mixes of each group; providing time for the teams to meet and work on their respective projects and to strategize the next steps needed to move toward project completion; consulting with professors; and conducting assessment sessions where teams evaluated the work of the other teams.

The problem selected for this activity was a highway relocation project planned for the north of the campus because it was a real-world problem that was sufficiently complex and relevant to the interdisciplinary team—all in accordance with PBL principles. After teams were formed instructors took students on two field trips: (1) to view the highway development corridor and (2) to view examples of communities where sustainable community development principles informed the design as well as examples where they did not. The initial field trip ended with panel presentations by the Indiana Department of Transportation, Tippecanoe County Area Plan Commission, Purdue University Landscape Architect, Purdue University Landscape Engineer, and a representative from the Community Advisory Committee representing citizen interests in the US-231 road relocation.

The students received copies of the Request for Proposals (RFP) for the US-231 Relocation Project: Accommodation Study and Master Plan. The RFP essentially informed the students that:

1. The Indiana Department of Transportation (INDOT) presented the final alignment for US-231 from Wabash River to US-52 and was seeking feedback from a community advisory committee (CAC), a representative group of stakeholders that would be affected by the relocation of the highway.

2. The student teams were charged with the task of conducting a land-use impact assessment and site accommodation study/master plan in response to the relocation of US-231 that is informed by a thorough understanding of the physical, social, and economical issues.
3. Each team was to ultimately deliver an optimal final physical design for US-231 and adjacent properties, keeping in mind the interests of those represented in the disciplines specific to forestry and natural resources, landscape architecture, and hospitality and tourism marketing and sales issues.
4. The final projects submitted by the student teams were to be based on informed decision-making and land-use planning process to propose a sustainable community design that utilized natural resources while contributing to the social and economic growth of the community.

The first assignment was the creation of a team charter to increase their probability of successful project completion. The charter consisted of an upbeat name for the team, the roles and responsibilities of the team members, the rules of conduct, and the rewards or consequences (including termination) for social loafing or other disruptive behavior.

We used a 1-group, pre-post test design for the surveys used to measure SKD and the factors that influence it. Students were advised of their right to opt out of completing the survey and participating in the research component of the course, but all students agreed to participate in the study. The pre-test was near the beginning of the semester, and the post-test at the very end of the semester.

Table 1 presents the survey questions used for the four independent variables and SKD, each measured using a 5-point Likert scale (strongly disagree = 1, strongly agree = 5), with several reverse-coded items. A paired *t*-test was used to provide analysis to answer research Question 1. Multiple linear regression using standardized beta-coefficients (βstd) was used to provide analysis to answer research Questions 2, 3, and 4.

The reliability over time of the variables used in this research as measured by Cronbach's alpha are also presented in Table 1. The Cronbach's alpha reliability for the behavioral styles scale was 0.77, but because behavioral styles use a proprietary scale, we are unable to list the question items here. To prevent perfect multicollinearity, we created dummy variables for the nominal behavioral style variable and used the Director behavioral style as the reference category (the category to which all others are compared). The reliability of the scales developed by Mu and Gnyawali (2003) were established in this study by determining the Cronbach's alpha via SPSS (Chicago, IL). The Cronbach's alpha data show that the scales reliably measure the independent and dependent variables given the population of students used in this study.

Results

To answer research Question 1, results showed that SKD increased between the Phase I survey (M = 3.06) at the beginning of the semester and post project survey administered (M = 3.46) at the end of the semester (t = 3.842, $p < 0.001$). Therefore, involvement in semester-long, problem-based service learning project improved SKD.

For research Question 2, our analysis using multiple regression after Phase I and Phase III of the project revealed the importance of factors affecting SKD and how they changed as a result of the project (Table 2). Synergistic knowledge development was influenced by psychological safety, social interaction, and attitudes toward PBL in a team setting. Task conflict was not a significant variable in the model. The amount of variance in SKD explained by the predictors was 55% after Phase I and 44% after Phase III.

At the beginning of the semester, attitudes toward PBL in a team setting exerted the most influence on the criterion variable of SKD as indicated by the size of the beta coefficient. After working on the project over the course of the semester, student SKD was influenced most by psychological safety. Moreover, the construct validity of the scales used in this study was furthered due to their ability to predict and measure SKD.

Although not depicted in tabular form, we also conducted a regression analysis with the original model variables (psychological safety, social interaction, task conflict) developed by Mu and Gnyawali (2003) and our revised model with the addition of the new variables (original variables + behavioral styles and PBL). The original model had an adjusted R^2 = 0.508 at Phase I ($p < 0.001$) compared with our revised model that showed an increase in the amount of explained variance in SKD (R^2 = 0.553, $p < 0.001$). At Phase III, the original model had an adjusted R^2 = 0.411 ($p < 0.001$) compared with our revised model that showed an increase in the amount of explained variance in SKD (R^2 = 0.438, $p < 0.001$).

As posed in research Question 3, our results showed that attitudes toward PBL in a team setting contributed to SKD after both Phase I and Phase III (Table 2). For research Question 4, we found that behavioral styles did not influence SKD (Table 2).

Discussion

This study builds on previous research regarding factors that affect SKD in college students working in teams. By providing an interdisciplinary learning environment, we observed an increase in SKD over the semester. The variance explained in SKD was increased by including the additional variable of attitudes toward PBL in a team setting (e.g., confidence in working collaboratively, taking responsibilities in the team, ability of group to solve problems). This was a critical finding because it strongly suggests that SKD can be compromised unless students have a positive attitude about working together on team-based inter-disciplinary projects. In effect, these attitudes likely serve as the foundation from which social interaction, task conflict, and psychological safety evolve.

Our results suggest that it is very important to provide an environment where students feel psychologically safe to participate fully and express their ideas in interdisciplinary teams. Creation of a psychologically safe environment can be accomplished in two ways. First, students must

Table 1. Phase I and Phase III survey questions and construct reliability statistics.

Task conflict (α = 0.68)

- There are conflicting opinions in my team about key issues about the project.
- Members of my team sometimes disagree about how to analyze the assigned case.
- The members of my team have disagreements on how to approach the task from time to time.

Social interaction (α = 0.47)

- My team had a feedback session to evaluate our team processes and discuss how to improve our team work.
- To get the team task done, we have to collaborate extensively with other members of the team.
- There is sufficient communication between our team members to get the team task done in an effective way.
- More collaboration between our team members is needed to get the team task done in an effective way.

Psychological safety (α = 0.81)

- Members of my team sometimes reject others for being different.
- Members of my team feel comfortable to bring up problems and tough issues.
- Members of my team have a hard time listening to an opposing point or perspective.
- Members of my team respect each other's opinions.

Problem-based learning attitudes (α = 0.71)

- I am confident in my ability to work collaboratively.
- I am comfortable studying in a group with my peers.
- I enjoy studying with a group if everybody contributes equally.
- I am comfortable taking on different responsibilities in group study.
- I prefer studying with a group to solve problems that have many solutions.
- I am comfortable learning in student-led groups.
- I don't think studying with a group is a waste of my time.
- I am motivated to take on different responsibilities in group work.
- I am confident in the ability of groups to work together to find solutions for solving problems.

Synergistic knowledge development (α = 0.67)

- My team work integrates all the different opinions of the team members.
- My team always resolves different opinions of members in a constructive manner.
- The unique skills and talents of all the members of my team are fully valued and utilized.

Table 2. Regression results showing influence of psychological safety, task conflict, social interaction, and problem-based learning attitudes on synergistic knowledge development. Values are standardized beta coefficients with associated p values in parentheses.

Independent variables	ßstd (Phase I)	ßstd (Phase III)
Psychological safety	0.477 (<0.001)	0.491 (<0.001)
Task conflict	0.016 (0.878)	–0.011 (0.876)
Social interaction	326 (<0.001)	0.284 (0.003)
Problem-based learning	0.490 (0.001)	0.353 (0.006)
Socializer†	–0.144 (0.475)	–0.015 (0.939)
Thinker	–0.178 (0.404)	–0.067 (0.757)
Relater	–0.176 (0.421)	–0.010 (0.962)
R^2	0.587	0.481
Adj. R^2	0.553	0.438
F	17.263	11.260
df	7	7
p value	<0.001	<0.001

† Reference category is Director.

acknowledge, respect, and understand that differences exist in the terminology and problem-solving approaches of each discipline. Secondly, students must identify their team's behavioral style composition and openly discuss potential conflicts that may arise over the course of the interdisciplinary project.

Social interaction between team members was another important variable in predicting SKD, particularly in the early stages of the project. However this finding was not observed by Mu and Gnyawali (2003). In their study, all students were in the same (business) major, whereas our students were from different majors that do not normally socialize together in an academic setting. Collaborative efforts often require additional time as teams go through the "forming, storming, and norming" stages before they reach the "performing" stage. By providing opportunities for students to become more familiar with and develop trust and respect for other members of their team, instructors can help ensure success. Such opportunities can be incorporated directly into field trips or other sessions where students are working together outside of class in a less formal environment.

Although Mu and Gnyawali (2003) found that task conflict was an important factor in SKD, we did not. We provided the students with much information about group dynamics and conflict resolution at the beginning of the project, which might have lessened the potential for task conflict.

Behavioral styles were not found to influence SKD. This study finding suggests that projects of this type could lead

to SKD regardless of the behavioral style of the students involved because of what was at stake. Because the interdisciplinary team project made up a large part of the students' grades in their respective discipline-specific class (1000 points or 30+% of total points), they all had a vested interest in completing the project correctly and on time, regardless of their behavioral style.

Students likely gained many insights as a result of working on this semester-long project with peers from other disciplines. Some of these insights may not be readily apparent to students until they are in the workforce and find themselves in a similar circumstance. However, by providing this opportunity for students to learn from each other and by applying their knowledge and skill set to the project, they will be equipped not only with the content knowledge but also the skills to work in an interdisciplinary team environment that recognizes the contributions of everyone.

Limitations and Future Research

Tasks involving examination and integration of multiple perspectives are likely to help students develop more holistic knowledge (Mu and Gnyawali, 2003). Interdisciplinary team experiences can develop this higher order holistic knowledge—the analysis, synthesis, and evaluation levels of Bloom's taxonomy (Bloom, 1956). However, more understanding is needed of the factors that hinder or facilitate the development of SKD. Although this research provided key insights and extended the work of Mu and Gnyawali (2003), additional work is needed to discover other factors that influence SKD among interdisciplinary groups of students. For example, future research could investigate the role of faculty in terms of how instructors hinder or facilitate SKD.

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