Problem Solving Approach and Success in a Design Project

S. K. Scott, D.S. Koch and A. Stover
Department of Industrial & Engineering Technology
Southeast Missouri State University, Cape Girardeau, MO 63701

ABSTRACT: The ever changing technical work environment requires students who can think and solve complex problems. Research shows that individuals approach problems differently and this approach does have an effect on problem solving. The research undertaken sought to investigate the following question: does problem solving approach affect success in solving a graphic design problem? Kirton’s Adaption-Innovation Inventory (KAI) and Heppner’s Problem Solving Inventory (PSI) were used to measure the problem solving approach of high school engineering design students (n=17) and college engineering design students (n=10). Students were placed in similar and different teams based on their KAI scores. The results of this study indicate that teams formed according to problem solving approach did not impact success on a design project. However, the findings suggest that forming teams according to problem solving approach can play a role in group dynamics.

I. Introduction

Pendlebury, Grouard and Meston (1998) recognized that the rate of change is accelerating and there is a need for people to manage this change. Kirton (1976, 1999, 2000) established that humans seek to manage change by solving problems. There is a distinction between ability and the way in which the problems are solved. Unfortunately, much of the problem solving research concentrates on the ability to solve a problem, rather than focusing on the way the problem is solved, the approach. The right problem solving ability with the wrong problem solving approach could translate into ineffective team performance. Adaption-Innovation (A-I) theory is founded on the assumption that people solve problems in different ways (Kirton, 1999). A-I theory states that individuals have a preference on how they approach problem solving. The Kirton Adaption-Innovation Inventory (KAI) measures individuals approach to problem solving (Kirton, 1976). Individuals prefer to approach problems according to their style, but sometimes behave in a different way, called coping. Heppner and Peterson (1982) established the Problem Solving Inventory (PSI) to measure an individual’s self-appraisal of their problem solving which they believe is synonymous with coping. Individuals who overestimated their problem solving style may over commit and not meet the expectations of the team. A low score on the PSI is considered a positive appraisal of problem solving approach.

The purpose of this study was to determine the effect of problem solving approach utilizing the KAI on team performance. By studying teams in education, the investigators sought to determine if design teams whose members use similar approaches perform differently from teams whose members use different approaches. The research question was: Does problem solving approach, according to KAI scores, affect performance in solving a design
problem? The hypothesis was: There will be no difference in the performance of teams with similar KAI scores compared to teams with different KAI scores. In addition, the PSI score will be used in observing the teams and the team’s performance. It was also hypothesized that team members with similar confidence and approach styles as measured by the PSI would help the team perform better.

II. Problem Solving Approach

Design students need to be proficient in problem solving. Problem solving styles are consistent individual differences in the ways people prefer to approach new ideas, manage change, and respond to problems. Understanding problem solving approach can be helpful in many ways to individuals in teams. In addition, understanding how individuals cope with problems can help in understanding how they function on a team. This study utilized the KAI and the PSI.

Kirton Adaption-Innovation Inventory (KAI)

Early observations made by Kirton (1976) indicated that critical differences existed in the ways people approached problems that were not related to ability. These differences became the basis of A-I theory. He observed that these differences in problem solving approach produced distinctive patterns of behaviors. The KAI was created to measure problem solving approach and puts individuals on a continuum from highly adaptive to highly innovative, each with their own set of distinct patterns of behavior.

There are no pure adaptors or innovators; however, individuals can be classified as more adaptive or less adaptive and more innovative or less innovative in their approach to solving problems. Individuals with KAI scores ranging from 32-95 are considered relatively adaptive, and individuals with scores ranging from 96-160 are considered relatively innovative in their approaches to solving problems. The population mean is 95. The value of A-I theory is that it offers fresh insight on how individuals approach and ultimately solve problems (Kirton, 1999, 2000). Hammerschmidt (1996) agreed that problem solving approach does make a difference in how individuals tackle problems and these differences influence problem solving performance.

Problem Solving Inventory (PSI)

The PSI is based on Carl Jung’s theory of personality types (Heppner & Peterson, 1982). The PSI consists of 35 statements describing responses to situations and problems. The PSI provides a single, general index with three subscales:

- Problem Solving Confidence - self assurance while engaging in problem solving activities.
- Approach-Avoidance Style - a general tendency to either approach or avoid problem solving activities.
- Personal Control - determines the extent of control one has over their emotions and behaviors while solving problems.

Problem solving approach is not related to problem solving ability. The PSI was deemed a reliable instrument that will help the researchers understand the problem solving approach of engineering design students. While the KAI measures the approach individuals prefer in solving problems, the PSI assesses the individual’s perceptions of his or behavior or attitude towards problem solving. Both the KAI and the PSI do not assess problem solving ability.
III. Problem Solving Approach and Teams

Individuals with similar abilities may approach problems in different ways that have a direct effect on team performance (Isaksen, Dorval, & Treffinger, 1994). Richards (2003) acknowledged that a team member’s knowledge and expertise is not enough for a team to obtain the desired results; individual approaches should also be considered. Many technical teams jump into the problem solving process and ignore the approach that individuals prefer in solving problems. Teams that approach problems in a similar manner have relatively small amounts of tension, but may not produce the best solution (McClough & Rogelberg, 2003). Selecting individuals for a productive team is an important activity. Little evidence exists on the formation of teams, leading to unproductive teams. It is beneficial to form a team based on problem solving approach.

According to the KAI, adaptors and innovators have contrasting approaches to solving problems in the team environment. Kwang, Ang, Ooi, Shin, Oei and Leng (2005) found that adaptors are less ready for change, so they are more likely to control their impulses. In contrast, innovators are uncomfortable following the status quo and prefer to find a radical solution that challenges conventional wisdom. Using KAI scores to assess problem solving approach may shed some light on understanding conflict associated with teams. This conflict impacts the performance of the team (Kirton, 2000) In addition; (Kirton et al, 1976) found that within a team environment, small differences in KAI scores (10 or less) among team members resulted in minimal conflict. Intermediate differences in KAI scores (11-19 points) resulted in team members experiencing some conflict. Gaps of significant differences (20 or more points) in KAI scores seemed to cause increased conflict and friction among the team members. Successful team performance depends on several outside factors, including approach. Although important, ability, environment, and problem solving techniques (including conflict resolution) were not considered within the scope of this study. Problem solving approach was the independent variable used in this study. Buffinton, Jablakow, and Martin (2002) found that the KAI can help with understanding and appreciating different approaches in teams. Hammerschmidt (1996) also reported that problem solving approach does influence team performance. Research indicates that if a class is divided into teams based on their KAI scores, the teams will perform according to their preferred problem solving approach (Bobic, Davis, & Cunninngham, 1999). The KAI will be used to assess how students approach problems on a team.

The PSI is a global appraisal of an individual’s evaluation of his or her ability to solve problems (Heppner b, 1988). The total score is a reflection of confidence, approach or avoidance, and personal control. Heppner (a, 1988) found that low scores present a positive appraisal of problem solving. He believes that the value in the PSI is in understanding how individuals cope with problems. On a team, the PSI may predict a member who might lack confidence in bringing new ideas to the team or following through with the project. It may also predict members who might avoid work or participation. Kirton (1999, 2000) found that individuals prefer to approach problems according to their KAI approach, but can behave outside of their preferred approach by using coping mechanisms. The PSI seeks to measure how an individual copes with the subscales of the instrument; problem solving
confidence, approach or avoidance, and personal control.

IV. Methods

This study investigated student design teams that were formed according to similar and dissimilar problem solving approaches and asked to solve a graphic design problem. There were two projects examined in this research.

Subjects

Project 1 - The study involved 17 students in a high school engineering technology class. The students ranged in age from 17-18 and were juniors and seniors. The study was approved by the Research Involving Human Subjects Committee to ensure that the rights of the subjects were protected. All students gave informed consent. Students completed the PSI and the KAI.

Project 2 - The study involved 10 students in an industrial education college class. The students ranged in age from 18-50. The study was also approved by the Research Involving Human Subjects Committee to ensure that the rights of the subjects were protected. All students gave informed consent. Students completed the PSI and the KAI.

Instruments

The KAI and the PSI were administered in both studies.

KAI. The KAI was used to assess problem solving approach. The KAI is a self-reporting 33-item questionnaire with scores ranging from 32 to 160. The lower the score the more adaptive style an individual has and the higher the score the more innovative. Someone with an adaptive style will typically score in the 60-90 range and some with an innovative style will score in the 110-140 range. Those with scores between these two often demonstrate some of both characteristics. The measure of KAI has been used in many countries over the last two decades and is reported to be a consistent and reliable measure of problem solving approach (Bobic, Davis, & Cunningningham, 1999; Clapp, 1993; Kirton, 1999).

PSI. The PSI is a self reporting 35 item questionnaire that asks individuals to describe how they react to problems. The possible range for the PSI is 32-192. Overall, a low score on the PSI indicates a positive self-appraisal of problem solving and a high score indicates a general negative self appraisal. The PSI has been found to be significantly correlated with behavioral observations of actual problem solving competence (Heppner, Hibel, Weinstein, & Rabinowitz, 1982). Reliability estimates revealed that the three factors were internally consistent coefficient alpha a = 0.72 to 0.90.

Design Project 1

The PSI was not used to form the teams. The students completed the KAI and were placed in 6 teams according to their KAI scores. There were 3 similar teams (KAI score within 10 points of each other) and 3 dissimilar teams (KAI scores with 20 points or more from each other). Next, the teams of students were given a 5S (sort, set in order, shine, standardize, sustain) tool storage design project. The teams were given some of the parameters for the project. The students were graded on: dimensions; functionality; and teamwork. Examples of the designs are in Appendix A.
Design Project 2

The PSI was not used to form the teams. The students completed the KAI and were placed in teams according to their KAI scores. There were two similar teams (KAI score within 10 points of each other) comprised of three members and two dissimilar teams (KAI scores with 20 points or more from each other) with two members. The teams of students were given a design problem in which they had to construct a device that would convert rotary motion to reciprocal motion to advance a small block 3.5” in order to be successful (See Appendix B for examples of the designs). The designs were dichotomously scored as either successful or unsuccessful.

V. Findings & Discussion

The purpose of this study was to determine the effect of problem solving approach on team performance.

Research Question & Hypothesis

Research question: Does problem solving approach, according to KAI scores, affect performance in solving a design problem? The hypothesis: There will be no difference in the performance of teams with similar KAI scores compared to teams with different KAI scores.

Finding of Design Project 1

Problem Solving Inventory. The problem solving approach of students according to the PSI is in Table 1.

<table>
<thead>
<tr>
<th>Team</th>
<th>Total Score</th>
<th>AA</th>
<th>Con</th>
<th>PC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>106,102,101</td>
<td>67,30,57</td>
<td>25,24,29</td>
<td>14,18,15</td>
</tr>
<tr>
<td>2</td>
<td>131,72</td>
<td>63,40</td>
<td>44,18</td>
<td>24,14</td>
</tr>
<tr>
<td>3</td>
<td>58,91,100</td>
<td>30,57,54</td>
<td>19,18,21</td>
<td>9,16,25</td>
</tr>
<tr>
<td>4</td>
<td>65,104</td>
<td>31,54</td>
<td>15,21</td>
<td>19,25</td>
</tr>
<tr>
<td>5</td>
<td>73,104,62</td>
<td>35,57,36</td>
<td>19,29,18</td>
<td>19,18,6</td>
</tr>
<tr>
<td>6</td>
<td>106,107</td>
<td>60,59</td>
<td>24,28</td>
<td>22,20</td>
</tr>
</tbody>
</table>

The PSI provides a single, general index of Problem-Solving Confidence (CON) or self assurance while engaging in problem solving activities, Approach-Avoidance Style (AA) which is a general tendency to either approach or avoid problem solving activities, and Personal Control (PC) which determines the extent of control one has over their emotions and behaviors while solving problems.

Teams 1 and 6 had close PSI scores which would indicate that they perceive themselves to have similar problem solving styles. They may tend to cope with problems in similar ways.

Kirton Adaption-Innovation Inventory

The teams, KAI scores, and pass or fail of project 1 are shown in Table 2. There were 3 teams with similar scores (teams 4, 5 & 6) and 3 teams with different scores (teams 1, 2 & 3). The data indicates that 3 teams passed the project and 3 teams failed the project.
In general, all the teams performed well. In this study, different (KAI scores with 24 or more point spread) teams performed better with a pass rate of 2 out of 3 compared to the similar (KAI scores within 10 points of each other) teams. The data indicates that more teams (2 out of 3) failed that were similar in problem solving approach. The research contradicts previous research that large KAI point spreads will result in unproductive teams. It is assumed that these teams had conflict, but the team members were able to work through the conflict and complete the project.

Observations of the teams indicated that some of the teams that failed had different PSI scores, which could indicate that the team members lacked confidence and may have avoided some of the work. Many of the team members acted according to his or her problem solving approaches. For example, the more innovative members often came up with unique designs and adaptors tried to stay within the dimensions of the project. It should be noted that this was a small class and the results may not be generalized in all design teams.

Finding of Design Project 2

Problem Solving Inventory. The problem solving approach of students according the PSI is in Table 3.

<table>
<thead>
<tr>
<th>Team</th>
<th>Total Score</th>
<th>AA</th>
<th>Con</th>
<th>PC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>69, 70</td>
<td>24, 16</td>
<td>30, 39</td>
<td>15, 15</td>
</tr>
<tr>
<td>2</td>
<td>101, 53</td>
<td>31, 22</td>
<td>51, 24</td>
<td>19, 7</td>
</tr>
<tr>
<td>3</td>
<td>91, 75, 54</td>
<td>20, 20, 18</td>
<td>55, 42, 27</td>
<td>16, 13, 9</td>
</tr>
<tr>
<td>4</td>
<td>80, 113, 71</td>
<td>20, 31, 31</td>
<td>43, 63, 51</td>
<td>17, 19, 19</td>
</tr>
</tbody>
</table>

Team 1 had close PSI scores which would indicate that they perceive themselves as having similar problem solving styles. Team 2 had a much greater difference in their total scores indicating their problem solving styles may vary greatly. Teams 3 & 4 had moderate total score differences among the members.

Kirton Adaption-Innovation Inventory. The teams and their KAI scores are shown in Table 4.

<table>
<thead>
<tr>
<th>Team</th>
<th>KAI Scores</th>
<th>KAI point spread</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>66, 101</td>
<td>35</td>
</tr>
<tr>
<td>2</td>
<td>80, 112</td>
<td>30</td>
</tr>
<tr>
<td>3</td>
<td>81, 84, 90</td>
<td>9</td>
</tr>
<tr>
<td>4</td>
<td>95, 95, 98</td>
<td>3</td>
</tr>
</tbody>
</table>

There were 2 teams with similar scores (teams 3 & 4) and 2 teams with different scores (teams 1 & 2). All

Table 2. Teams, KAI Scores, and Pass/Fail of Project 1.

<table>
<thead>
<tr>
<th>Team</th>
<th>KAI Scores</th>
<th>KAI point spread</th>
<th>Pass or fail</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>66, 105, 97</td>
<td>39</td>
<td>Pass</td>
</tr>
<tr>
<td>2</td>
<td>75, 105, 94</td>
<td>30</td>
<td>Pass</td>
</tr>
<tr>
<td>3</td>
<td>79, 103, 99</td>
<td>24</td>
<td>Fail</td>
</tr>
<tr>
<td>4</td>
<td>82, 87, 90</td>
<td>8</td>
<td>Fail</td>
</tr>
<tr>
<td>5</td>
<td>82, 87, 90</td>
<td>8</td>
<td>Fail</td>
</tr>
<tr>
<td>6</td>
<td>90, 100</td>
<td>10</td>
<td>Pass</td>
</tr>
</tbody>
</table>

Table 3. Teams and PSI Scores Project 2.
four teams constructed a successful design. The teams all seemed to function well together and quickly overcame any conflicts. Notable differences were observed in how the group members functioned together and the tasks they undertook as part of the project. The adaptors within the different groups took on the roles of cutting and assembling the majority of the design and the innovators took a distinct roll in designing and generating design solutions and testing possible solutions.

The PSI total scores for team 1 members were very similar at 69 & 70. The low scores suggest that the members have a positive appraisal of problem solving. Observations on how the group handled the project and worked well with one another would indicate that they were very confident in their approach to the problem and comfortable working together. The other groups had a varying range of total PSI scores and informal observations showed that the individuals with the lower scores in three of the four groups tended to take a leadership role. All of the teams worked well together and no members of any of the teams dominated or dictated how the group functioned, but those with lower scores seemed to be a little more influential.

VI. Conclusions

In this research, the forming of teams according to approach did not impact team success. This study did not validate research suggesting that problem solving approach does have an impact on team performance. Observations of the teams did indicate that individuals did act according to their problem solving approach. Forming teams according to problem solving approach and team success could not be established with this study. However, this study has implications for educators and engineering designers. For educators, understanding problem solving approaches may be helpful when making team assignments. The focus should not be on the differences among adaptors and innovators, but on helping members understand their differences. Although this study was performed in an educational setting, the researchers expect similar behaviors in industrial and engineering work environments. The practical implications of this research lie in the fact that teams are necessary in many engineering design organizations. Managers responsible for teams in engineering should consider the team members’ problem solving approaches when forming teams. This study was limited by the small sample sizes. More research needs to be done in engineering design classrooms.

VII. References


