AC 2007-1132: USING AWARENESS OF LEARNING PROCESSES TO HELP STUDENTS DEVELOP EFFECTIVE LEARNING STRATEGIES

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Using Awareness of Learning Processes to Help Students Develop Effective Teamwork Strategies

Introduction

A large body of research in engineering education has been devoted to the study of engineering student teams. This work focuses on understanding the factors that shape the dynamics, interactions, and performance of teams, identifying pedagogical strategies and resources that improve team functioning, and developing methods of assessment to measure team skills[1,2,3,4,5,6]. Among the factors that have been studied are students' learning processes, commonly measured using learning styles inventories.

This study employs a particular instrument, the Learning Connections Inventory, and methodology, the Let Me Learn® process, for characterizing the individual learning processes of students. The Let Me Learn® (LML) process is a comprehensive strategy for building metacognitive awareness in students. LML differs from learning styles approaches in that learning styles typically identify the learner with a personality type or category rather than a profile reflecting degree of preference for multiple interacting patterns, and also in that LML emphasizes the learner's capacity to use his/her patterns strategically to adapt to different learning expectations instead of merely seeking compatible learning conditions. The process begins by having students take the Learning Connections Inventory (LCI). Responses to the LCI's 28 statements about learning preferences, using a Likert scale ranging from Always to Never Ever, yield a profile of the extent to which an individual utilizes each of four types of patterned learning processes, listed below with some of the key preferences characterizing each pattern:

- **Sequence** (organization, planning, order, structure)
- **Precision** (information, details, knowing for the sake of knowing)
- **Technical Reasoning** (hands-on learning, relevance, self-sufficiency)
- **Confluence** (risk, innovation, alternative views, freedom from rules)

All learners are capable of using any or all of these patterns but have preferences which the LCI quantifies. The scaled responses are scored on a scale of 1 (Never Ever) to 5 (Always) and there are seven statements associated with each of the four learning patterns, so scores for each pattern range from 7 to 35. Each individual pattern is measured along a continuum of "Use First" (25-35), "Use as Needed" (18-24), or "Avoid" (7-17). Once a student understands his/her own learning patterns, he or she can:

- Forge or intensify use of patterns that he or she prefers to avoid or use only as needed, but needs for particular tasks
- Tether, or reduce, use of preferred, but task-inappropriate, patterns
- Understand, appreciate and value peers who have different learning patterns
- Formulate effective strategies for group tasks based on individual learning patterns

LML has now been implemented by hundreds of teachers with thousands of K-12 students, demonstrating that children as young as six years old can learn to do these things, and that the process improves student learning, attitude towards school, and working relationship with peers and teachers. LML is used at more than a dozen higher education institutions and in several corporate settings nationally and internationally.[7]

This study investigates the use of LML in engineering education in the context of the Sophomore Engineering Clinic, a course at Rowan University that covers technical writing and engineering design and is team-taught by communication and engineering faculty. The course consists of two 75-minute lecture periods devoted to technical writing instruction and one three-hour lab period per week. Most of the graded assignments in the course are written reports about the design projects completed in lab. The design and communication components of Sophomore Clinic have been reported elsewhere[8, 9], as has the application of LML to understanding the challenges faced by many engineering students in writing courses.[10]

In 2006, the Sophomore Engineering Clinic was divided into six sections of approximately 20 students. All six sections participated in a common three-hour weekly lab, and completed the same design projects and writing assignments. The Let Me Learn® process was implemented in two of the six sections by the writing instructor; the other four sections did not use LML. This paper will describe the specific approaches used for integrating LML into Sophomore Clinic and give the results of a comparative assessment of the performance of the two LML sections and the four control sections.

Background and Methodology

An earlier study of chemical engineering students working in teams in the Junior/Senior Clinic at Rowan University found that students' perception of team experiences as well as their performance on team projects were positively influenced by instruction in learning pattern differences coupled with ongoing reflection in the form of periodic writing assignments. Teams who received this instruction and wrote reflections exhibited improved perceptions of teamwork and scored higher on a team project assessment than teams who did one or the other or neither.[11] The current study was undertaken for several reasons. Because we had over 20 teams all working on the same project, the Sophomore Clinic course provided us with a much larger and more uniform sample. We also had the opportunity to compare various levels of intervention and examine what level of intervention is necessary to gain a persistent understanding and application of the LML process. Almost all of the students, with the exception of those who had newly transferred into the program, had taken the LCI in Freshman Clinic and had the results explained to them. Finally, the current study was designed to help us better understand *why* awareness of learning patterns improves teamwork.

The faculty assign the teams for the major design project of the course. In all six sections of the course, information about student course and work schedules, study habits, major, and GPA were taken into consideration in order to create compatible teams. Of the six sections of Sophomore Clinic, two received no instruction and engaged in no activities involving the LCI beyond what they had done in Freshman Clinic, and LCI scores were not considered when we formed the

teams. For two of the remaining sections, LCI scores were used in addition to the other factors in order to balance the composition of the teams according to learning patterns. Students were reminded of what their LCI scores were and occasional references to the characteristics of the four patterns were made in discussing course assignments and expectations.

Teams in the final two sections were formed with all of the above factors taken into consideration. These students also engaged in the following learning activities relating to teamwork and/or learning pattern awareness:

- Participating in a learning pattern awareness activity
- Writing a team agreement
- Developing individual pattern-specific strategies for writing a team paper
- Reassessing each team member's contributions in light of the team's expectations and needs

Learning pattern awareness activity: Before the teams for the final design project were assigned, students were assigned to groups for a one-time activity designed to raise awareness of how learning patterns are manifested when approaching a challenging task that must be undertaken as a group. Students were assigned in order to create groups with a wide diversity of learning patterns; ideally, the group would include at least one person representing each pattern at a "use first" level. One person is assigned to be an observer who takes notes in response to several questions about the actions of the group members. Each group received a set of simple supplies and a set of vague and ambiguous instructions to follow. The activity must be completed within a restricted timeframe, usually 10-15 minutes, and students are not allowed to ask questions of the faculty or the observer. In this case, the activity used was the construction of a "water clock" to measure a specified time interval via a pendulum movement, using a bowl, 4 inches of water, a piece of aluminum foil, and 3 washers. The questions that the observer is responding to highlight actions characteristic of each learning pattern, including concerns about lack of information and poor instructions, the tendency to generate many innovative ideas without worrying about rules, and the tendency to talk very little but handle the materials in an attempt to gain experiential insights into how to solve the problem. Of course, the real purpose of the activity is not to build a water clock, but to see how different learners bring different approaches to the problem. The activity also illustrates the importance of applying appropriate learning strategies to meet task expectations and simply dramatizes the reality of the learning patterns measured by the LCI. Following the activity, we led a follow-up discussion with the students in which we discussed their observations and their reactions.

Team agreement: Once the teams for the ten-week project were assigned, the teams met and composed a written agreement stating their expectations for conduct and identifying the responsibilities, skills, and strengths of each team member. One required element of the team agreement was a plot of the team's LCI profiles. The skills and strengths inventory included learning pattern characteristics, and teams were encouraged to assign responsibilities based on what a given team member was likely to be good at. Students high in sequence and precision were generally asked to assume primary responsibility for the team's project notebook, while students high in technical were likely to be asked to take the lead on producing drawings and fabricating project components. The team agreement has two main purposes. First, it articulates

the team's expectations of each other, which usually include items such as coming to meetings, performing assigned tasks, communicating with the team, contributing ideas, and supporting other team members. These expectations are not unusual and most teams would agree they are important. However, depending on their specific learning patterns, individual students might assign different—and potentially conflicting—levels of priority to these expectations if they are not made explicit. The team agreement puts them "on the table" and requires all team members to commit to them. Second, the team agreement recognizes the value of each team member. Again, it is not unusual to expect that a team would want to make the best use of its talent and would conduct some kind of inventory. In this case, however, the team agreement foregrounds the kind of learning that each individual would bring to the project. Instead of being driven by what the team identifies as its wants or needs, contributions are defined by the opportunities presented by the individual's learning patterns. Thus, in addition to assigning notebook responsibilities to a team member high in sequence and precision, the team also had to consider what role would best be assigned to a team member high in confluence, the pattern associated with innovation and risk-taking. The team agreement is thus intended to set the tone for a team dynamic based on the idea that all four learning patterns are needed for success.

An essential aspect of the Let Me Learn® process is that it calls for individual learners to take responsibility for understanding task expectations and applying their learning patterns intentionally rather than merely intuitively. That is, even though the team agreement encouraged the team to value its members based on who they are as learners, no one could effectively meet the team's expectations simply by being who they are. The learning activities that followed the team agreement were designed to take this next step.

Individual pattern-specific strategies for writing a team paper: The first writing assignment relating to the major project is a progress report that the team writes collaboratively. In connection with a prior individual writing assignment, a white paper on an engineering solution, students were asked to write self-descriptions of their learning patterns, to analyze the pattern-specific demands of the assignment, and to identify strategies they would need to use to successfully complete the assignment. In preparation for writing the progress report, students were asked to continue this kind of strategizing with respect to the expectations of the team. Figure 1 shows what they were asked to complete.

Reassessment of each team member's contributions: During the final weeks of the semester, as the project drew to a close, the teams were asked to review the responsibilities that had been assigned to each team member, reflect on why the team valued the contributions of that team member, and decide, in essence, whether that team member was meeting the needs and expectations of the team and determine whether he/she should continue to perform at the same level, increase the quality of his/her contributions, or assume new or additional responsibilities. At this point, we expected that students would be able to use the "vocabulary" of learning patterns as a way of evaluating how well each team member was meeting the team's expectations without becoming judgmental and to help each team member use his/her learning patterns to contribute to the team's success. Figure 2 shows the chart they were asked to complete as a team.

Assessments

Three methods of assessing student perceptions of their teamwork experiences were used in all six of the sections. One was a peer evaluation, which was also used to determine each student's grade for team contributions. The second was an open-ended questionnaire, which asked various questions about barriers or frustrations and what the students learned about teamwork and about themselves. The third was a survey designed to collect information on students' perceptions of the following:

- Team alignment and commitment to the project objectives
- Team recognition of individual value
- Team appreciation for the importance of all four learning patterns

The peer evaluation form is shown in Figure 3; the survey is shown in Figure 4. Responses to the open-ended questionnaire have not been analyzed and will not be part of the present discussion.

Results and Discussion

The assessment results were collected at the end of the Fall 2006 semester and the beginning of the Spring 2007 semester and are currently being analyzed. Eventually, we hope to explore three key questions. First, we want to see whether perceptions of teamwork experiences differ among the three different levels of LML application. Second, in the two sections that received the most intensive LML practice, we want to see whether the students use the language of learning patterns to discuss their teamwork experiences, which would suggest that awareness of learning patterns influenced their conduct. Finally, we want to characterize what a successful team approach to the design project entailed and whether teams who were encouraged through the LML process to develop an appreciation of different approaches to learning actually had more diverse, and potentially more successful, approaches to the design project. In the remainder of this paper, we present a preliminary analysis addressing the first question, whether perceptions of teamwork experiences differ among the three different levels of LML application, and partially developing the third question, whether teams who were encouraged through the LML process to develop an appreciation of different approaches to learning actually had more diverse, and potentially more successful, approaches to the design project. Specifically, we will discuss results of our attempt to measure student perceptions of alignment of their teams regarding shared commitment to goals and sense of appreciation of their skills, knowledge, and abilities by their team members.

The current analysis focuses on a selected subset of the data collected from the survey. Statements 1 (my team worked together to define its project goals) and 2 (my team worked together to reach its project goals) were combined to yield a measure of alignment in terms of team goals, as perceived by the student. Statements 3 (my team recognized my skills, knowledge, and abilities) and 4 (my team utilized my skills, knowledge, and abilities) were similarly combined to yield a measure of appreciation of individual skills, knowledge, and abilities, again as perceived by the student. Mean combined scores for these two measures were

calculated for the entire sample, for the two sections that had intensive LCI instruction, and for each individual section.

These scores were also calculated for the sample of students who had been identified as "problems" by their teams, for all students with the combination of Use First Technical Reasoning plus Use First Confluence and for students with this combination who were in the sections with intensive LCI instruction. This combination was singled out for further analysis because it was the one most frequently exhibited by the "problem" students. "Problem" students were defined as those who received peer evaluation ratings of "Marginal" or lower (Figure 3 shows the complete scale). "Problem" is shown here in quotation marks to reflect the premise of this paper, which is that these students may not necessarily be problems, but rather may be perceived as such because of misunderstandings rooted in learning pattern differences. Of the 12 "problem" students, seven had the combination of Use First Technical Reasoning plus Use First Confluence. Not all of these students filled out a survey, in many cases because they are no longer in engineering. Of the eight that filled out a survey, five had the combination. Although the sample size is not large, the frequency of this pattern combination seems meaningful.

The mean Technical Reasoning score for the "problem" group is somewhat higher than the overall mean, but on the whole is consistent with the general profile of Rowan engineering students. Out of a possible score of 35, most will score in the 30s; a score of 25 or higher is considered Use First. As a result, some hallmarks of these students are that they:

- Prefer to learn by doing
- Want practical relevance and despise busywork
- Prefer to work alone
- Keep knowledge in their heads rather than writing it down
- Are reluctant to express feelings
- Like to figure things out
- Want to get right to work and find the most efficient way to get the task done
- Are not likely to read instructions
- Will seek assistance and further information as needed

The characteristics of this pattern in general explain some of the challenges engineering educators have faced when trying to improve teamwork skills—technical learners tend to prefer autonomy and privacy. It seems likely that the slightly higher preference for technical learning seen in the "problem" group could exacerbate these issues.

The mean Confluence score for the "problem" group is 23.8, compared to 22.0 for the entire sample. Confluent learners:

- Are stimulated by challenges and risks
- Feel restricted by rules and constraints, including deadlines
- Enjoy generating unique and unconventional ideas
- Are easily distracted
- Are good at multi-tasking
- Have an aptitude for innovation and "thinking outside of the box"

- Do not like to do things over and over
- Get bored with predictable situations
- Would rather begin a new task than complete the current one

It is not hard to see why a high level of Confluence could result in negative perceptions by team members. The confluent learner can be seen as unfocused and irresponsible, especially by students who avoid Confluence and use Sequence and/or Precision first. Taken together, these results suggest that Confluence could well be associated with team conflicts, especially when coupled with a high preference for Technical Reasoning.

The results of this analysis are shown in Table 1. Several preliminary observations can be made from this initial look at the data. "Problem" students, not surprisingly, have by far the lowest scores on how well appreciated they felt, although their scores for alignment of the team's goals are not the lowest of the various groups. The alignment and appreciation scores for the two LML sections combined are higher than the means for the entire sample. However, when the two LML sections are looked at separately, the alignment and appreciation scores for Section 2 are clearly much higher than any other sections, but the scores for Section 3 are not. Anecdotally, we observed that these two sections behaved and performed much differently. The performance scores on the course design project and grades on written deliverables were considerably lower for Section 3 than Section 2. Further analysis of the distribution and variance of the learning patterns within these two groups might explain why they apparently responded differently to the same instruction. It may also be that factors beyond learning patterns are responsible for these differences.

The scores for the group identified as potential "problems" because of their combination of Use First Technical Reasoning plus Use First Confluence suggest that this observation is worthy of further investigation. The alignment and appreciation scores for all students with this combination are lower than the mean for the entire sample. However, students with this combination who were in LML sections have higher scores for both areas; indeed, their alignment and appreciation scores are higher than for the larger sample of all students in LML sections. These results could simply be an artifact of generally more positive perceptions by Section 2 as a result of their higher performance and grades (six out of the nine students with this pattern combination were in Section 2), but it is certainly worth pursuing. Also, although purely anecdotal, it is noteworthy that only one of the 13 "problem" students was on a team in an LML section, and this was a student who turned in no work during the semester and has left the university. Students with the identified "problem" profile in LML sections were not evaluated as "problems" by their teams.

Table 1. Summary of analysis of survey data. Data for sections receiving intensive LCI instruction are shaded. Scores shown in bold are a focus of the discussion. Means have not yet been analyzed for statistical significance.

	Sequence	Precision	Technical	Confluent	Alignment	Appreciation
Entire sample	25.9	20.9	29.7	22.0	1.92	1.68
LML sections	25.3	21.4	29.5	22.3	**1.71**	**1.62**
Section 1	26.3	21.3	28.4	21.3	2.06	1.54
Section 2	25.5	21.1	29.5	22.3	1.36	1.36
Section 3	25.1	21.6	29.4	22.3	2.09	1.91
Section 4	27.2	20.2	31.4	22.6	2.15	1.95
Section 5	26.1	21.5	29.4	20.8	1.91	1.69
Section 6	25.9	19.1	31.0	22.8	1.97	1.72
"Problems"	26.0	19.5	30.9	23.8	2.06	2.56
All Tech/Confluent	25.9	20.7	31.0	26.6	1.95	1.79
Tech/Confluent in LML sections	24.4	20.7	31.7	27.0	**1.67**	**1.56**

Conclusions

Previous studies have shown that knowledge of the learning patterns of teammates improves student perceptions of teamwork as well as team performance. This study involved a preliminary investigation into the mechanism of this improvement by looking at whether intensive instruction in strategic use of learning patterns would lead to a greater sense of alignment of the team's goals and appreciation for the team's diverse skills, knowledge, and abilities. Our evidence is inconclusive and does not yet rule out other factors affecting team dynamics. However, the trends observed in the data are strong enough to warrant further investigation.

The findings are also of interest when compared to those reported in a study conducted in a setting with several similarities to ours, which looked at the role of several factors including the impact of learning styles.[12] This study's results suggested that heterogeneity of learning styles among team members, as measured by the Kolb Learning Styles Inventory, increased team performance, although the sample size was too small to assess statistical significance. Teams

that were dominated by certain learning styles tended to have lower performance. The researchers discuss some of their observations about how different learning styles seemed to interact and/or influence team dynamics. However, the Kolb instrument provides little vocabulary for describing how each of the four types of learners operationalize their learning.

We believe that learning patterns offer a more powerful explanation of and approach to how to improve student team functioning. For example, one of the more definite findings of the learning styles study concerned the value of students with "good hands," or mechanical aptitude, to engineering projects, but the Kolb instrument provided no way to describe an individual's mechanical aptitude as an aspect of their learning. The technical learning pattern measured by the LCI does include this as a characteristic and thereby allows us to identify students who are "hands on" learners. Thus, our work offers a potentially useful way to extend the findings of others. Similarly, although our work does not discount the importance of other factors affecting team dynamics, especially gender and other forms of diversity, it does offer further ways in which student team interactions and dynamics can be described and one-dimensional constructions of diversity can be avoided.

Strategies for Progress Report 1

This assignment represents the first of three grades that will be subject to the teamwork weighting factor. Using intentional strategies to effectively meet the demands of this assignment is therefore **doubly important**:

- Your grade on the team's progress report may be reduced if you are not meeting expectations
- The quality of the team's progress report depends on everyone's contributions.

Think about what you know about yourself and about the demands of the progress report, and briefly answer the two questions below.

1. What is the most important strategy for you to use in order to fulfill your personal responsibilities? (In other words, how will you meet your team's expectations?)

2. What is the most important strategy for you to use in order to effectively contribute to the team's success? (In other words, what can you offer that will be most helpful to your team?)

Save this sheet. I will ask you to turn it in to me when you turn in the progress report.

Figure 1. Developing individual pattern-specific strategies for writing a team paper.

Team Member Progress Assessment
Team Number:

Team Member	Key Responsibilities, Skills, Talents, and/or Learning Patterns	The team values this team member's contributions because:	The team needs this team member to maintain level of contribution and quality, meet new expectations, and/or assume additional responsibilities as specified:

Figure 2. Reassessment of each team member's contributions.

PEER RATING OF TEAM MEMBERS **0901-201** **Fall 2006**

Name_____

Please write the names of all of your team members, INCLUDING YOURSELF, and rate the degree to which each member fulfilled his/her responsibilities in completing their team assignments.

The possible ratings are as follows:

Excellent	Consistently went above and beyond—tutored teammates, carried more than his/her fair share of the load
Very good	Consistently did what he/she was supposed to do, very well prepared and cooperative
Satisfactory	Usually did what he/she was supposed to do, acceptably prepared and cooperative
Ordinary	Often did what he/she was supposed to do, minimally prepared and cooperative
Marginal	Sometimes failed to show up or complete assignments, rarely prepared
Deficient	Often failed to show up or complete assignments, rarely prepared
Unsatisfactory	Consistently failed to show up or complete assignments, unprepared
Superficial	Practically no participation
No show	No participation at all

These ratings should reflect each individual's level of participation and effort and sense of responsibility, not his or her academic ability.

Name of Team Member	Rating

Your signature: _____

Figure 3. Peer evaluation form.

Sophomore Clinic I Team Experience Survey

Please print your name and the code number below on the sheet that is being circulated. Your responses will be reported in statistical form only and you will not be identified.

The following statements concern your experience as a team member on the Crane Project in Sophomore Clinic during the Fall of 2006. Mark the response that best reflects your experience.

1. **My team worked together to DEFINE its project goal(s).**

   Strongly agree Agree Disagree Strongly Disagree

2. **My team worked together to REACH its project goal(s).**

   Strongly agree Agree Disagree Strongly Disagree

3. **My team RECOGNIZED my skills, knowledge, and abilities.**

   Strongly agree Agree Disagree Strongly Disagree

4. **My team effectively UTILIZED my skills, knowledge, and abilities.**

   Strongly agree Agree Disagree Strongly Disagree

5. **Rate the importance of each of the following skills and abilities to your team's success.**

	Essential	**Helpful**	**Minor**	**No Role**
Brainstorming many ideas				
Analyzing designs				
Explaining the design process				
Fabricating and assembling				
Thinking outside the box				
Taking notes				
Producing drawings				
Planning meetings and tasks				
Taking risks				
Organizing information				
Writing reports				
Understanding expectations and requirements				

Figure 4. Survey to assess team perceptions.

Bibliography

[1] P. Lewis, D. Aldridge, P.M. Swamidass, "Assessing teaming skills acquistion on undergraduate project teams," *Journal of Engineering Education*, April 1998, 149-155.

[2] E. Seat, S.M. Lord, "Enabling effective engineering teams: a program for teaching interaction skills," *Journal of Engineering Education*, October 1999, 385-390.

[3] C.G. Downing, "Essential non-technical skills for teaming," *Journal of Engineering Education,* January 2001, 113-117.

[4] M.E. Natishan, L.C. Schmidt, P. Mead, "Student focus group results on student team performance issues," *Journal of Engineering Education,* July 2000, 269-272.

[5] M. Laeser, B.M. Moskal, R. Knecht, D. Lasich, "Engineering design: examining the impact of gender and the team's gender composition," *Journal of Engineering Education,* January 2003, 49-56.

[6] D. Hunkeler and J.E. Sharp, "Assigning functional groups: the influence of group size, academic record, practical experience, and learning style," *Journal of Engineering Education*, October 1997, 321-332.

[7] Let Me Learn®, http://www.letmelearn.org/.

[8] D. Acciani, J. Courtney, C. Diao, R. Harvey, B. Pietrucha, W. Riddell, and P. Von Lockette, "Converging-diverging approach to design in the Sophomore Engineering Clinic," *Proceedings of the Annual Conference of the American Society for Engineering Education*, 2006.

9 E. Constans, K. Dahm, J. Everett, C. Gabler, R. Harvey, L. Head, H. Zhang, J. Courtney, and D. Hutto, "Setting the multidisciplinary scene: engineering design and communication in the "Hoistinator" project," *Proceedings of the Annual Conference of the American Society for Engineering Education*, 2005.

[10] R. Harvey, "Beyond learning styles: understanding the learning processes of engineering students through the Interactive Learning Model™," *Proceedings of the Annual Conference of the American Society for Engineering Education*, 2004.

[11] J. Newell, K. Dahm, R. Harvey, and H. Newell, "Developing metacognitive engineering teams," *Chemical Engineering Education,* Fall 2004, 316-320.

[12] D. Hunkeler and J.E. Sharp, "Assigning functional groups: the influence of group size, academic record, practical experience, and learning style," *Journal of Engineering Education*, October 1997, 321-332.