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Teamwork attitude, interest, and self-efficacy: Their implications for teaching teamwork skills to engineering students

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Teamwork Attitude, Interest, and Self-Efficacy: Their Implications for Teaching Teamwork Skills to Engineering Students

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***Abstract*—The complex and multidisciplinary nature of today's engineering problems demands that new graduates excel in not only technical knowledge but also teamwork skills. In fact, the lack of effective teamwork has been identified among the most important factors contributing to the high failure rate of complex engineering projects. In this paper, we focus on engineering students' attitudes toward teamwork, their self-efficacy and interest in teamwork knowledge, skills, and abilities. Self-efficacy in a domain is an important construct that can predict whether or not someone is willing to undertake a challenge in that domain. Research suggests that the sufficient level of self-efficacy can encourage personal growth and skill development. The relevant research also points out that interest is a construct that can predict students' professional development in a domain. For example, as someone becomes an expert in a domain, his/her interest in the domain becomes individual, which means there is a long-term personal connection resulting in further exploration of the domain. In this paper, we postulate that the development of students in teamwork knowledge, skills and abilities can be tracked by the progress in their teamwork interest. In addition, we argue that interest development should be measured as a part of the assessment efforts to evaluate the professional skills development of students. We have developed and validated an instrument to measure teamwork efficacy and interest. The instrument was used to collect data in a geographically distributed university. The collected data were analyzed to identify the factors affecting students' attitudes toward interest and self-efficacy in teamwork as well as their relationships. The preliminary results indicated that students had a high level of self-efficacy and a low level of interest, which makes it challenging to improve students' teamwork skills.**

I. Introduction

Today's engineering challenges require a large variety of knowledge and skills from multiple disciplines, including non-engineering ones. Therefore, having effective teamwork skills in engineering contexts is important. Multi-disciplinary teams bring together a pool of talents, experiences, and knowledge base, which cannot be embodied in an individual. However, the multi-disciplinary nature of a team does not guarantee successful team performance. The research shows that the success of a team depends on how effectively team members are able to share information, assign tasks based on the strengths of team members, coordinate tasks, and provide feedback to one another [1]. It is essential that engineering graduates have teamwork Knowledge, Skills, and Abilities (KSA) to function effectively in teams. Engineering programs have responded to this need by incorporating teamwork into all levels of academic curricula. However, the absence of robust assessment frameworks constrains the effectiveness of such efforts.

Previously, we have proposed an assessment framework based on the Model of Domain Learning (MDL) [2] for the assessment of professional skills [3], [4]. In this framework, student development is measured in three dimensions- knowledge, strategic processing, and interest. Within the MDL, three experience-based stages occur (i.e., acclimation, competency and proficiency), which are progressive and incremental. In this paper, our primary objective is to evaluate the feasibility and reliability of using interest as an additional construct to track student development in teamwork KSA. We introduce several questionnaire items to measure students' interest in teamwork. These questionnaire items can also be used in a broader instrument for assessing teamwork KSA.

The MDL considers two types of interest: individual and situational. Situational interest is the temporary interest that arises spontaneously due to external factors such as a new topic or an engaging text. On the other hand, individual interest is the long lasting interest that motivates students to gain deeper knowledge in a domain. Individual interest is an indicator of how much students are willing to immerse themselves into a domain. According to the MDL, an increased individual interest in a domain is a result of higher knowledge and strategic processing abilities in that domain. As one moves from the Acclimation to Proficiency stage in a domain, his/her interest changes as described in Table I. Individual interest is also a precursor for sustaining long-term learning [5]. Therefore, evaluating students' individual interest is especially critical for professional skills assessment, where sustainable, long-term learning is paramount.

II. An Empirical Study

A. Data Collection Instrument

An online survey was designed to measure students' self-reported teamwork self-efficacy, attitudes, and interest. The survey was emailed to engineering students at a university with multiple campuses in the Northeast United States. It should be noted that the survey did not emphasize a specific engineering course or a class level, and it was available for any engineering student to take, regardless of their class standing

TABLE I. PROGRESS OF INTEREST FROM ACCLIMATION TO PROFECIENCY

Acclimation	Competency	Proficiency
Situational interest: Spontaneous, transitory, and environmentally activated interest	Increased individual interest due to increased engagement in a domain	**Individual interest:** long-term, deepening, personal connection to a domain, which in turn inspires further exploration of the domain

or the course content. Therefore, the survey measured only students' self-reported perceptions about their teamwork self-efficacy, attitudes, and interest.

To measure students' interest levels in developing their teamwork KSA, students were asked to rate their interest in performing several professional activities. After a preliminary analysis, the average rating of the following three questions (Cronbach's $\alpha = 0.738$) were used to measure interest:

- IQ1-Attending a free workshop on teamwork.
- IQ2-Reading literature about effective teamwork.
- IQ3-While you are browsing a news web site, you have spotted an article called "How to be Effective in Teamwork." Rate your likelihood of reading this article?

In addition, the following two questions were used to measure individual level interest since they demand more personal commitment than the previous questions.

- IQ4-Rate your level of willingness to take an elective course in order to improve your teamwork skills?
- IQ5-In your institution, a renowned teamwork guru will give a workshop on teamwork skills. If you have to pay $10 for this workshop, rate your level of interest in attending this workshop.

The interest questions were operationalized using a four-point Likert scale ranging from (1)-Very Uninterested to (4)-Very Interested.

Twenty-five teamwork self-efficacy questions were developed based on the KSA areas described by Stevens and Campion [6]. The questions were grouped as follows (the number of questions in each KSA area is provided in parenthesis): Goal Setting (2), Performance Evaluation (3), Team Forming (5), Team Coordination (1), Communication (7), Conflict Resolution (4), and Problem Solving (3). These questions were operationalized with a four-point Likert scale, ranging from (1)-Very Unconfident to (4)-Very Confident. These questions are available upon request.

Attitudes toward teamwork can be defined as how agreeable a person is to work in any team [7]. To measure the overall attitude toward teamwork, the following four questions given in [8] were used (Cronbach's $\alpha = 0.73$):

- I usually have a negative experience with teamwork (reverse coded)
- I would rather work on team projects than on my own
- I like to participate in teamwork
- I am usually motivated to participate in teamwork

The attitude questions were also operationalized with a four-point Likert scale, ranging from (1)-Strongly Disagree to (4)-Strongly Agree.

B. Analysis of the Results

We coded student responses to the background questions into the binary independent variables as given in Table II to investigate the effect of student background and experiences on interest, self-efficacy, and attitude.

TABLE II. CODING OF STUDENT BACKGROUND AND EXPERIENCES INTO THE INDEPENDENT VARIABLES (NUMBER OF SAMPLES)

	Value	
Independent Variable	0	1
Class Standing	Year 1 and 2 (317)	Year 3 and 4 (242)
GPA	<3.5 (319)	$\geq$ (236)
Teamwork Training or Course	None or single (416)	Two or more times (123)
Gender	Male (391)	Female (169)
Work Experience	No (127)	Yes (433)

We calculated Cohen's d values to measure the effect size of the independent variables on the dependent variables. In addition, we performed t-tests to evaluate whether the means of the dependent variables were different or not across the two levels of the independent variables. Table III presents the calculated effect sizes. In the table, statistically significant mean differences are indicated by * for p-value < 0.05 and ** for p-value < 0.01.

We did not observe any positive effect of class standing on the self-efficacy independent variables. Surprisingly, the first and second year students rated their self-efficacy as high as the third and fourth year students did. The negative effects of the GPA group on self-efficacy and teamwork attitude were unexpected. The GPA did not also have any positive effect on interest. The previous teamwork training had a small positive effect on self-efficacy and a small-to-medium positive effect on interest. In order words, students who have already gone through some types of teamwork training were more willing to invest further time and resources for advancing their teamwork KSA than the students who have not.

The dependent variables previous work experience, teamwork training, and class standing had a positive and statistically significant effect on the teamwork attitude dependent variable. In particular, the previous work experience variable had the highest effect size. This observation may imply when students are engaged in a large scope project, that draws skills and knowledge from multiple disciplines, they start appreciating the value of teamwork. At the university setting where the data were collected, the first year engineering curriculum features engineering design learning facilitated through a series of team-based projects supplemented by brief guidance on teamwork. However, these experiences do not represent the rigors of real-life engineering projects yet. Upon declaring the major at the end of the second year, as part of their studies in the third and fourth year of their curricula, students are frequently put in teamwork situations in an effort to prepare them for the actual work settings. Students are also expected

TABLE III. CALCULATED EFFECT SIZES

	Effect Size (Cohen's d)				
Dependent Variable	Class Standing	GPA	Training	Gender	Work Experience
Goal Setting	0.04	-0.06	0.23*	0.14	0.38**
Performance Evaluation	0.09	-0.04	0.17	0.05	0.26**
Team Forming	-0.07	-0.17*	0.13	0.24	0.26*
Team Coordination	-0.09	-0.03	0.07	0.15	0.32**
Communication	0.07	-0.30**	0.25*	0.06	0.32**
Conflict Resolution	-0.11	-0.22*	0.17	-0.08	0.29**
Problem Solving	-0.02	-0.13	0.19	-0.05	0.38**
Attitude	0.30**	-0.52**	0.23*	-0.12	0.37**
Interest (IQ1, IQ2, IQ3)	0.25**	0.10	0.43**	0.23	0.14
IQ4	0.02	-0.01	0.25*	0.16*	0.01
IQ5	0.04	-0.13	0.31**	0.25	0.07

to complete an internship where most of students are involved in teamwork in the context of real-life engineering projects for the first time. Specifically, capstone design experience in their last year is meant to simulate the complexity of the work setting in the rigor level of the project as well as the timeline and professionalism expected in terms of results and conduct. Frequently, students work towards a working prototype or research result sponsored by an industrial company and in doing so they hold regular meetings with company liaisons.

The most significant factor for the self-efficacy dependent variable was the previous work experience that involved teamwork. In summary, the relationships between the other independent variables and self-efficacy were not as anticipated. One of the reasons for this result is that students rated their self-efficacy very close to the level of very confident. Although the first and second year students rated their self-efficacy very high, they had relatively low teamwork attitude. This contradiction also casts a doubt on the validity of using self-reported efficacy as a construct to measure teamwork KSA. Therefore, we postulate that self-efficacy may not be a reliable construct to assess students' development in teamwork KSA based on the results observed in this research.

On the contrary, the relationships between the independent variables and the interest dependent variables conformed to the MDL. As per the MDL, an increased learning in a domain should lead to higher levels of interest in the domain. The class standing and teamwork training had a significant positive effect on interest. This result is particularly important for the feasibility of using the MDL as an assessment framework for professional skills because it shows that the changes in interest can be tracked during students' educational journey. In this paper, we did not observe a high level of individual interest development in the third and fourth year students. This observation is similar to our previous findings [4].

III. CONCLUSIONS

Teamwork self-efficacy was not found to be impacted by any of the academic background variables considered in this research. In terms of interest, we observed a growth from situational to individual interest throughout the engineering students' educational journey, which supported the MDL. In this research, interest was shown to have a stronger relationship with previous teamwork training and class standing than self-efficacy had with those variables. Therefore, we recommend interest as an additional construct to assess students' teamwork KSA. In future work, we will survey the literature further about student reported self-efficacies and gauge other fields in the STEM disciplines, according to teamwork self-efficacy, interest, and attitudes. In addition, the collected data will be analyzed in multiple dimensions to verify the primary findings in this paper. To apply our findings from our team survey in engineering courses, professors could institute more relatable, intriguing group assignments and emphasize the importance of teamwork in the engineering discipline, so students will make an effort to be more interested and have a positive attitude toward teamwork.

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REFERENCES

[1] J. E. Driskell and E. Salas, "Collective behavior and team performance," *Human Factors: The Journal of the Human Factors and Ergonomics Society*, vol. 34, no. 3, pp. 277–288, 1992.

[2] P. A. Alexander, "The development of expertise: The journey from acclimation to proficiency," *Educational Researcher*, vol. 32, no. 8, pp. 10–14, 2003.

[3] S. Kulturel-Konak, A. Konak, I. E. Esparragoza, and G. E. Okudan Kremer, "Assessing professional skills in stem disciplines," in *Integrated STEM Education Conference (ISEC), 2013 IEEE*, 2013, Conference Proceedings, pp. 1–4.

[4] S. Kulturel-Konak, A. Konak, G. E. Okudan Kremer, and I. Esparragoza, "Peer evaluation and assessment resource (pear) to assess students professional skills," *International Journal of Quality Assurance in Engineering and Technology Education*, no. 4, 2015.

[5] S. Hidi and K. A. Renninger, "The four-phase model of interest development," *Educational psychologist*, vol. 41, no. 2, pp. 111–127, 2006.

[6] M. J. Stevens and M. A. Campion, "Staffing work teams: Development and validation of a selection test for teamwork settings," *Journal of Management*, vol. 25, no. 2, pp. 207–228, 1999.

[7] B. C. Ruiz Ulloa and S. G. Adams, "Attitude toward teamwork and effective teaming," *Team Performance Management: An International Journal*, vol. 10, no. 7/8, pp. 145–151, 2004.

[8] K. Vance, S. Kulturel-Konak, and A. Konak, "Teamwork efficacy and attitude differences between online and face-to-face students," in *Integrated STEM Education Conference (ISEC), 2015 IEEE*. IEEE, March 2015, pp. 246–251.