Requirements Formation in Interdisciplinary Teams for Autonomous Systems

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The Challenge in Developing Autonomous Systems

The challenge of autonomous systems (AS)

- Unpredictable learned system behaviors
  - Traditional systems engineering (SE) approaches may be illogical

Need representation and communication of stakeholder preferences for requirements formation

- Policies, laws, and ethics must be considered in the requirements formation process

Current Concept of Requirements in SE is Challenged by AS

The concept of requirements in SE

- Built around the idea that a system's behavior does not fundamentally change given unchanging system inputs; however, AS can modify their behaviors

The challenge of verifying requirements

- AS can initially pass the requirement phase
  - May significantly fail in the future because of AI learning and modifying its own behavior

Understanding Challenges Associated with Requirements for AS

Growing interest in the introduction of automation into public-facing operations that involve direct user interaction

- As technology advances, AS will have increasing importance to everyday life
- Engineers must be aware of the challenges associated with forming, implementing, and verifying AS requirements

The Need for a Holistic Evidence-based View of AS

The integration of AS

- Developments in machine learning algorithms, machine vision, and intuitive user control will greatly affect future complex systems

What is missing?

- Holistic, evidence-based view of AS that addresses the challenges for designing AS in the traditional requirements-based processes

The Present Study

- Observations and interviews
- Student opinions and industry expectations with academia
- Preliminary investigation at the effectiveness of small group interview process on interdisciplinary collaborative projects developing requirements for an AS

Why do students struggle to engage?

- To better understand team (Team 1 = T1, Team 2 = T2) behavioral processes during INCLUDE project

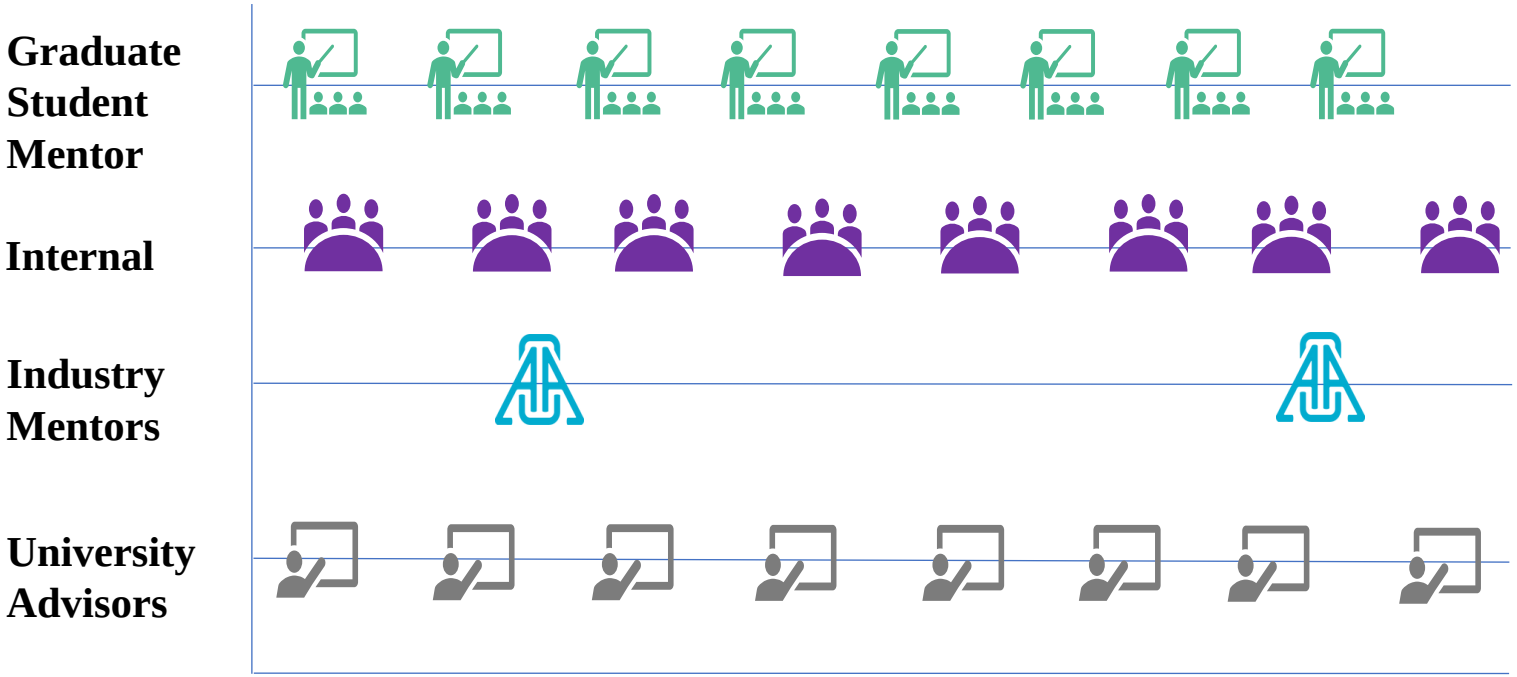
Participants

Convenience sample of undergraduate students from UAH

Team	Observed Factors		
	# of members	Fields of study *(N)*	Gender
T1	Eight	Philosophy (*1*), Art & Animation (*2*), Industrial & Systems Engineering (ISE; *4*), Psychology (*1*) [a.], Digital Marketing & Entrepreneurship (*1*)	7 out of 8 were female
T2	Four	Computer Science (*1*), Psychology (*1*), ISE (*2*)	4 out of 4 were male

a. This student had two areas of study, the second being ISE.

The Project-based Learning (PBL) Approach



- Quarter 1 -

1. Kickoff: Industry/ Practitioner Mentors
2. Midterm Progress Report: Academic Advisors
3. Final Presentation: Industry + Academia

Interview Design and Procedure

- Reflective questions about students' understanding of goals and challenges in interdisciplinary teamwork
- Subject matter expert workshop to develop questions
  - Validated through 2nd review by Systems Engineering Management

What was your experience on the project this semester?

What went well?

What went wrong?

Do you think these types of challenges will occur in the industry (i.e., on the job)?

Results

Team 1	Team 2
• Students should receive **guidance** on research practices. • Advisors should provide **clear instructions** and set expectations and roles. • If member contribution is low, **advisors** should be **present** in team meetings. • The **expertise** of Industry Mentors should be utilized as often as possible	"Having **University Advisors and Industry Mentors** to provide support and feedback was most helpful." "Once **understanding** was established, eventually all members contributed to the project." "**Communication** was difficult because of unclear deadlines." "Slow progress and the outcome was not what the team had anticipated from unforeseen **delays**."

Results cont.

Interdisciplinary vs. homogeneous team design

- Homogenous = less diversity and the greater the chance for less successful requirement development for AS
- Interdisciplinary = more diversity can lead to greater information exchange
- Small teams can work effectively under the right conditions (e.g., mentorship, level of expertise, motivation, feasible goals)
- Large teams can work effectively under the right conditions (e.g., team management, team organization, internal and external communication, motivation)

Discussion

- Different disciplines are like different cultures; it encompasses adherent attitudes, beliefs, and behavior (Okech et al., 2016)
- Complex problems demand collaborative, interdisciplinary, diverse approaches (Blaaberg et al., 2000; Pennington, 2008)
- Student-centered PBL + interdisciplinary group work
  - Real world application, fosters student initiative (Macias-Guarasa et al., 2019)

Discussion cont.

To combat challenges via academia:

- Idealized teamwork process models to inform Academic Advisors about individual differences (e.g., collective orientation) relevant to project outcomes (Hagemann & Kluge, 2017)
- Tools: student enrollment, lab slots, and student progress (Macias-Guarasa et al., 2019)

From the perspective of industry interventions:

- Survey expert opinions, cross-disciplinary research, interpersonal skills for IACs (vom Brocke & Lippe, 2015; Siemens et al., 2014)

Implications of Our Results

A potential “toolbox” for engineering organizations

- To improve AS requirement generation and management
  - Through the implementation of key performance measures at different AS requirement stages
  - Toward better effectiveness of human-autonomy teaming and reducing potential risks to the user

Conclusions

- Industry – academia collaboration (IAC) requires awareness and specific skills
- Key factors of individual, institutional, and gender influences PBL
- Research gap exists concerning how to foster co-production
- Further research is needed on assessment models (e.g., industry-academia impact)

Future Directions

- Improving the focus of requirements that influence AS performance
- Validating simulations used during AS requirement development
- Studying user interactions with AS to improve testing of requirements
- Modeling of real-time human trust in AS for adaptive transparency of systems
- Development of novel verification processes for dynamic system performance
- Research efforts to ensure that the use of AS are ethical and meet system use objectives

Thank you!

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Applied Experimental Psychology

For more information on admissions, assistantships, and courses.

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