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Inspiring the Next Generation: Challenges and Strategies for Onboarding and Retention in an Undergraduate CubeSat Design Team

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ABSTRACT

The University of Toronto Aerospace Team (UTAT) Space Systems Division is a fully student levy-funded, student-led undergraduate design team that develops CubeSats with research-oriented payloads. UTAT's mission is to provide undergraduate students with unique opportunities to develop engineering design skills outside of the classroom, and therefore has a distinct focus on member growth and education. As an undergraduate student team, UTAT faces a unique set of challenges in onboarding members and maintaining a strong knowledge base on the team. These challenges include onboarding members with limited technical experience, equipping them with satellite design skills, and maintaining high interest levels among volunteer members with limited time to contribute. The team has implemented a wide range of strategies related to onboarding and member development over the past two years. Notable examples include hosting workshops and regular work sessions, and employing practice projects for technical skill development. This paper presents these practices in depth and evaluates their impacts using both quantitative and qualitative metrics of team success including retention rates, team demographic data, and individual perceptions of team dynamics. It also evaluates these practices against scientifically backed models, while evaluating the effectiveness of these models in the student team environment. Lessons learned include the importance of emphasizing a culture of inclusivity and psychological safety as well as utilizing workshops and skill-building modules both in the onboarding phase and throughout the year to generate and maintain interest in the team. The practices presented here are relevant and transferable to similar organizations including student teams, industry projects, and research initiatives.

INTRODUCTION

The University of Toronto Aerospace Team (UTAT) Space Systems Division is an undergraduate design team that develops CubeSat missions for low Earth orbit. The team's first satellite mission, HERON Mk II (carrying a microbiology payload), is set to be launched in the next year. Design of a second spacecraft, FINCH (a hyperspectral remote sensing mission) is underway.

As a student levy-funded, student-run team of primarily undergraduate students, UTAT aims to provide the opportunity for students to develop engineering design skills outside of the classroom and to contribute to the wider aerospace community. UTAT is an open-door club that encourages any University of Toronto student to join without a formal application process. The majority of UTAT members are full-time undergraduate students who join with little technical experience and limited time to contribute. As such, it is essential that UTAT is able to effectively onboard new members, equip them with the skills necessary to contribute to the team and maintain high interest and investment from members as the year progresses.

UTAT also places a particular emphasis on equity, diversity, and inclusion in the recruitment process. While many of the recruitment strategies used in 2020 were also used in previous years, this year's events were run with an emphasis on psychological safety and establishing a space where new students felt welcomed and embraced regardless of their background. It is also important to acknowledge the virtual environment of the team in 2020. UTAT has been operating completely virtually since March 2020, and has had to make adjustments to day to day operations on the team. UTAT saw a shift from in-person worksessions to discussion based virtual meetings with offline work. There were also challenges associated with "Zoom burnout" and maintaining engagement in long virtual meetings, especially after many members had a full day of virtual work or school. At the same time, the virtual environment has made the team much more accessible. Many members commented on the flexibility of the recruitment process and the ability to watch recorded workshops after the fact. The University of Toronto also has a large population of commuter students, who benefited from not having to commute to campus for team meetings.

This paper details the strategies implemented during the Fall 2020 onboarding process. There are two primary sections: *onboarding* which discusses a member's first month on the team, and *retention* which discusses strategies implemented in the following months to maintain interest and member development. This paper builds off of existing research on onboarding processes, and addresses a current gap in knowledge specific to student teams. The strategies used are evaluated both quantitatively and qualitatively based on existing onboarding models, drawing from member surveys, the annual UTAT census and member feedback.

TEAM STRUCTURE

UTAT is organized into technical systems and subsystems that are undertaking the design of the FINCH mission. The five major technical systems are Payload, Mechanical, Electrical, Firmware, and Mission Operations. UTAT also has a Systems Engineering team, which guides design development, assembly, integration, and testing. Within each system, there are multiple subsystems. For example, the Mechanical system is composed of the Thermal, Structures, and Attitude Determination and Control Systems (ADCS) subsystems. In some cases, subsystems belong to more than one system—for example, the Payload Electronics subsystem fits into both the Payload and the Electrical systems, and works with both teams. Figure 1 outlines the structure of the UTAT team. Members typically work on projects within a subsystem, but can also work on projects at the system level or projects shared between multiple systems. Each system and subsystem has an appointed lead who is responsible for work in the system. Leads are also responsible for communication between their system and the rest of the team.

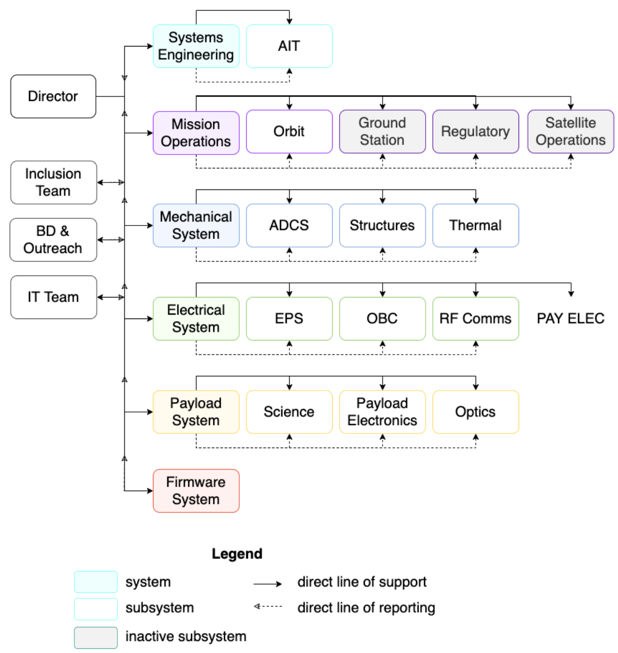


Figure 1: System and subsystem structure demonstrating relationships between systems. Non-technical systems are shown below Director.

BACKGROUND

Extensive research has been done on systematizing the onboarding processes in a corporate setting. Van Maanen and Shein's model[1] categorizes onboarding across six dimensions, which are grouped into two onboarding categories by Jones' Model.[2] These two categories are institutionalized onboarding and individualized onboarding. Generally, institutionalized onboarding is thought to be more successful than the individualized method, which is more informal and spontaneous.[3–6] Institutionalized onboarding involves six major elements, from both the Jones model[2] and the Van Maanen and Shein model:[1]

1. **Collective:** the onboarding process involves a group of people.
2. **Formal:** dedicated attention is given to onboarding which is separate from established employees.
3. **Sequential:** the onboarding process follows a clear sequence of steps.
4. **Fixed:** the onboarding process has a timeline and a fixed ending.
5. **Serial:** experienced employees serve as models for newcomers.
6. **Investiture:** newcomers are allowed to retain their personal characteristics and values.

The later development of Bauer's model[4, 7–10] has introduced a framework for further evaluating the success of onboarding methods. The model is based on having new members go through adjustments using a set of key tactics. The adjustments are listed below:

1. **Self-Efficacy:** new members feel confident in fulfilling their roles.
2. **Role Clarity:** new members understand the responsibilities associated with their role.
3. **Social Integration:** new members feel socially accepted by the team.
4. **Knowledge of Culture:** new members understand the goals and values of UTAT.

As outlined in Bauer's[7] model, the key tactics for having new members undergo these adjustments successfully are:

1. **Recruiting:** giving members an idea of the role and the culture before they decide to join the team.
2. **Orientation:** a formal process to help new members understand the team and their responsibilities.
3. **Training:** directed lessons on the skills new members will need to perform in their roles.
4. **Coaching and Support:** assigning mentors to members to help give them personalized support.
5. **Support Tools and Processes:** online resources and a written onboarding plan that new members can access at all times.
6. **Feedback:** assessment and general feedback on the performance of new members.

Lastly, a study that has greatly influenced the team's onboarding practices and team culture in the past is one conducted by Google,[11] titled "The five keys to a successful Google team". The key takeaway from the study was the importance of psychological safety[12] on a team. In such an environment, members feel safe sharing their thoughts and making mistakes. During leadership development activities and goal-setting, the improvement of psychological safety has been a consistent and popular goal. The team's success in this criteria is separate from the models, but is also evaluated in this paper.

Case studies have been performed using these models for software development projects.[6] This paper will seek to examine how well these models translate to student design teams as well as to validate the strategies that UTAT has been employing against existing scientific work.

Student Teams

A few case studies have been completed in the field of project management and leadership development for student teams,[13–16] however the focus of most of these studies is on systems engineering and knowledge transfer, rather than onboarding and retention strategies. More case studies exist in open-source software development contexts.[17, 18] While CubeSat design teams do resemble open-source software development teams in their voluntary nature, the breadth of knowledge required for aerospace design projects renders CubeSat design teams unique.

The University of Colorado produced a study on their CubeSat team methodology for their MAXWELL CubeSat.[13] Table 1 shows a summary of how the University of Colorado team performed against the Jones[2] and Bauer[7] onboarding models. This table is not an evaluation of their onboarding practices, but rather an example of how these onboarding models apply to student CubeSat teams and vice versa. They emphasize that their onboarding is an ongoing process that improves year after year. Their systematic approach to onboarding shows great investment in building up talented members who can contribute effectively to the technical demands of the team, though it is unclear whether this project was also able to successfully onboard their members culturally.

Case studies in software development also value mentorship to ensure that new developers are reaching their full potential.[17, 18] A study of a few open-source development projects tracked GitHub activity over time based on whether or not new developers had been mentored.[17] Mentored members showed much higher activity as time progressed, showing a higher, more consistent level of commitment to the team in the long term versus non-mentored members.[17] Another onboarding study of Google students showed the importance of valuing a student's specific skills and integrating those skills with the team, which improved retention considerably.[18, 19] It was also found that members getting inadequate and very delayed answers to their questions[18, 20, 21] frustrated them or caused them to leave entirely.

Overall, there is a lack of documented knowledge on creating an effective onboarding strategy for student design teams. While some have achieved technical success or managerial success, this paper aims to display UTAT's onboarding process as one that develops new members from both a technical and cultural perspective to foster a productive and welcoming team culture. It measures the success of this process against scientifically backed models, and ex-

Table 1: MAXWELL[13] onboarding practices summary. Orange represents criteria from the Bauer[7] model, and Blue represents criteria from the Jones[2] model.

Criteria	Approach
Self-Efficacy[7]	Safety training and a "mission handbook" gave members the knowledge to gain confidence in their role.
Role Clarity[7]	Members were taught how their subsystems integrate with others and to the satellite overall.
Social Integration[7]	The team does encourage members to ask questions which helps with their feeling of acceptance.
Knowledge of Culture[7]	It is unclear[13] if team values and norms are also included in onboarding materials.
Collective[2]	Many students go through this onboarding process each semester.
Formal[2]	Effort is put into making this a dedicated onboarding process to slowly integrate members with the team.
Sequential[2]	There is a clear sequence of steps to follow to join a subsystem and begin contributing to technical work.
Fixed[2]	There is a fixed time frame of one-quarter of a semester for a member to be onboarded.
Serial[2]	Chief and Design Engineers teach new members all about their subsystems.
Investiture[2]	It is unclear[13] if members are encouraged to maintain their personal values when joining the team.

amines other factors that may be crucial in ensuring successful member onboarding and retention.

PART I: ONBOARDING

Overview of Onboarding Process

Onboarding at UTAT is a month-long process, starting in early September as the school year begins for students. This is a formal, institutionalized onboarding process coinciding with the start of the school year that draws in over 100 members per year. UTAT also accepts students who wish to join mid-year, and offers a less structured individual onboarding process to those members by providing them with access to an onboarding page containing IT instructions, an overview of the team structure, and system-level onboarding documentation. While the team has made significant efforts to improve the mid-semester self-onboarding process, this paper focuses on the institutionalized onboarding process that the majority of UTAT members go through after joining in September.

The Fall onboarding process commences with a team-wide introductory meeting at which leads present background information such as the team values, structure, current mission, and upcoming projects for each subsystem. The team then moves into a two-week workshop period, during which the system and subsystem leads host workshops in a wide range of technical areas that expose students to the focuses of different subsystems on the team. At the end of these two weeks, students have the opportunity to select a subsystem for which they begin their first projects on the team.

The UTAT Space Systems Kickoff event is open to all undergraduate students. Historically, Kickoff was held in person but was held online in Fall 2020 due to COVID-19 restrictions. Leads and active members of each subsystem took turns presenting from a slideshow about ongoing projects, highlighting skills developed and showcasing tools used. After the presentation, Zoom breakout rooms were created for each subsystem so that interested attendees could talk to its respective lead and ask questions. Throughout the event, attendees were invited to ask questions through the Zoom chat function. Kickoff gave prospective members a better understanding of the team structure and the type of work that could be expected in each technical subsystem. It was also designed to give prospective members the information they needed to decide which subsystem they would like to join. In a survey of members who attended the 2020 Kickoff, 83% felt more certain of their choice of subsystem after the event, and 75% of attendees knew what subsystem they wanted to join after Kickoff compared to only 17% prior to the event.

Over the two-week period following Kickoff, UTAT hosted 10 workshops across 8 subsystems on the team. These workshops gave each subsystem the chance to provide incoming members with a more in-depth overview of their work and teach members key skills or theory that is relevant to work on the subsystem. The workshops ran between 60 and 90 minutes in length, and were both delivered virtually to a live audience and recorded for members to watch later.

After the workshop period, incoming members were invited to fill out a project assignment form, indicating their preferred projects. They were then assigned to a subsystem, onto which they were onboarded. The delivery of system-level onboarding material varied amongst systems, with some creating electronic onboarding packages, others using slide presentations, and many creating projects specifically designed to allow members to gain specialized knowledge and develop necessary skills.

The onboarding process as a whole had two primary goals. The first was to introduce members to the team and begin the knowledge transfer and skill building process. The second, which was especially emphasized in the Fall 2020 recruitment cycle, was to establish a culture of inclusion and psychological safety on the team. In preparation for the recruitment cycle, a dedicated UTAT task force created a guide to equity, diversity, and inclusion (EDI) in recruitment that all activities should follow which referenced research into best practices to foster EDI in workplaces as well as incorporated specific feedback on past recruitment cycles from existing members across the team. This feedback included making Kickoff and other recruitment events less intimidating by highlighting newer members' contributions to the team and avoiding overuse of technical jargon, emphasising the need for diversity and inclusion to current leads and members, and increasing outreach efforts to more STEM students outside of engineering.

Workshops

This section will discuss two specific examples of workshops that are representative of the two main workshop modes utilized by leads on the team. The first, the Optics workshop, was hosted in a lecture style with interactive elements dispersed throughout. The second, the SolidWorks workshops, focused on skill-building and hands-on learning.

Optics Workshop

During recruitment, the Optics subsystem held an introductory lecture-style workshop for new members joining the group. The Optics subsystem is responsible for researching and designing the entire optical system of the hyperspectral imaging satellite. As University of Toronto students do not typically learn optical theory in their early undergraduate curriculum, this introductory workshop was designed to fill in these knowledge gaps for new members, promoting *self-efficacy* in the process. Since the workshop took place during the Optics subsystem's inaugural year, the facilitators created content from scratch, unlike many other subsystems whose workshops were built upon previous workshops.

To help students visualize the delivered material, the Ray Optics Simulation by Rick Tu[22] (a simple ray tracing web applet) was utilized. In this applet, students could place mirrors and lenses as well as observe the path light rays took. Attendees were challenged to mimic a preliminary optical design of FINCH using this applet in ten to fifteen minutes. At the end of the lecture presentation, a game of Kahoot (a web-based trivia game) was played, with questions that expanded upon the material delivered.

These lecture-style workshops used a few of the main tactics of the Bauer model.[7] The workshops themselves were both a *recruiting* and *training* method. They gave prospective members a non-committal way to experience the technical work done on the Optics team, while giving them relevant knowledge to contribute to the team should they choose to continue. The ray tracing web applet was a *support tool* to encourage engagement with the material.

SolidWorks Workshops

In Fall 2020, the Structures subsystem assisted in the delivery of two virtual SolidWorks workshops attended by prospective members of all three technical divisions of UTAT, comprising Space Systems, Rocketry, and Unmanned Aerial Systems. The first workshop provided members with an introduction to the SolidWorks user interface, sketching, and basic part modelling, while the second focused on advanced part modelling. This graduated approach ensured that neither workshop was overloaded with content, and offered ample time for the hosts to effectively cover the material.

To maximize attendee engagement, a learn-by-doing philosophy was adopted for these workshops. Both workshops encouraged attendees to follow along as the hosts created a series of sketches and parts. These examples were carefully chosen to demonstrate the use of different tools within SolidWorks. In addition to examples provided by the hosts, a segment at the end of the first workshop was dedicated to individual practice. During this time, members were able to create a part based on an engineering drawing provided to them before the workshop. This allowed members to employ many of the tools and techniques they had learned earlier in the workshop, and build confidence in their ability to use SolidWorks.

As part of an effort to accommodate members in various time zones, recordings of the workshops were shared with those who signed up but could not attend, so that they could undergo the same training.

Bauer's model considers *training* as an essential tactic for successful onboarding.[7] These workshops implemented this tactic by providing members with the training necessary to more confidently undertake mechanical design projects on UTAT.

System Level Onboarding

After being assigned to projects, members were onboarded into their technical subsystems on the team. Each system or subsystem had a different set of onboarding materials and events based on their technical requirements. While the system- and subsystem-level onboarding process was not standardized across the team, the process was collective across individual subsystems or systems and served as an important second stage of the institutionalized onboarding process. The following section describes projects assigned to new members in three different systems: the Attitude Determination and Control Systems (ADCS) subsystem, the Thermal subsystem, and the Payload system. Each project was designed for new members to gain exposure to technical work in their subsystem and how it integrates with the rest of the satellite. It also gives members the opportunity to communicate with other members and their leads, building strong relationships in the process.

Orbit Propagator Project

The Orbit Propagator project is an example of how *role clarity* can build *self-efficacy* and help members gain technical knowledge. In Fall 2020, new members in both the ADCS and Orbit subsystems were able to participate in a project focusing on the simulation of the orbit of FINCH while accounting for perturbations. The project was designed such that no prior knowledge of orbital mechanics was required, and members could build valuable skills such as MATLAB/Python coding.

The project started with a virtual presentation series by the project lead introducing new concepts in orbital mechanics at weekly meetings. Members were encouraged to ask questions, and could suggest areas of interest they wished to have addressed if they wanted to learn more about a topic. These presentations were also recorded for absent members. This presentation series was designed to build *self-efficacy* among members by providing them with the required technical knowledge to contribute to the project. Weekly meetings also provided new members with *support* in the form of engagement with leads, pre-existing members, and one another. When the content presentations were complete, the meetings transitioned into a more casual work session format where members could provide updates and give feedback on code.

Every few weeks, members were assigned a new task to work on between each meeting. These began as relatively straightforward tasks (e.g. choose a coding language) and became increasingly more complex (e.g. implement an orbit propagator by solving the governing differential equation). Tasks were broken down into even smaller micro-tasks that were tracked on a shared spreadsheet and updated by the members as they made progress or needed help. This was designed to provide members with a sense of *role clarity*, as tasks were well-defined and broken down such that it was explicit how each step contributed to a final goal. Members worked on tasks individually but were assigned similar tasks, allowing them to collaborate and advise each other.

Once a member completed a task, time would be allocated at the next weekly meeting for them to present their work to their colleagues. They were encouraged to present their code and explain their process, as well as answer questions from their teammates. Finished code was then saved to a shared GitHub repository. These opportunities for *feedback* allowed members to build confidence regarding their achievements and provided an additional learning experience for teammates. In February 2021, members were also given the opportunity to present their achievements to members across other subsystems of UTAT at a general meeting. This provided division-wide recognition to members' work and promoted awareness of the project among other subsystems.

This project also facilitated *social integration* by creating a small-group environment where members felt comfortable asking questions and sharing ideas with one another. Members were encouraged to interact formally via technical discussions and presentations, as well as informally about their aerospace-related interests and goals. This allowed members to feel more connected within the project and team as a whole, even in a virtual environment.

Solar Panel Thermal Analysis Project

As part of the Thermal subsystem's onboarding process, a project was introduced to study the impact of temperature gradients and resulting vibrations on deployable solar panels. Similar to a number of the Thermal subsystem's initiatives, this project has greatly benefitted from partnerships with other subsystems and encouraged knowledge sharing and collaboration with the Electrical system and ADCS subsystem, among others. As such, not only has this project been an effective way for members to gain technical skills and experience in a variety of subjects, it also provided new members with an opportunity to become more familiar with the team's structure and projects, while meeting other members who could provide *support* and facilitate *social integration* and *knowledge of culture*.

This project started with an introductory meeting and presentation that briefly covered thermal concepts commonly used by the subsystem, notably the different types of heat transfer. An in-depth overview of solar cells and panels, as well as thermal gradients and vibrations, was also presented to provide sufficient background information and *self-efficacy* to members. Much of the introductory presentation focused on detailing the goal of the project, how it complements other Thermal projects, and where it fits with projects across other subsystems on the team. Collaboration with ADCS and Electrical was emphasized to define *role clarity* as a motivating factor for new members. Throughout the meeting, members were also encouraged to ask questions and propose suggestions to the project.

Following the initial onboarding meeting, Slack was used as the main tool of communication between members to check in on progress between meetings, and share relevant links and resources. A summary of project-specific meetings was shared on Slack, alongside some action items to help guide members and provide a clear *sequential* structure to the project. The first stage was a literature review to better understand the problem statement and review similar projects for guidance. Once complete, members would be encouraged to get in touch with other subsystems for feedback and support, which would then serve as the foundation for thermal simulations, as necessary. Weekly Thermal meetings would serve as a way to present each member's progress and receive help for any blocking points that come up during the week.

As of May 2021, this project remains underway, and is wrapping up the literature review to proceed to the second stage. While the project has so far been effective in investigating temperature gradients on solar panels, it is important to note the decreased interest of new members in the project over time, with only 33% of initial members remaining involved in the project. While the definitive reason for this project's poor retention rate is unclear, one key shortcoming so far has been the project's lack of *fixed* structure and defined deadlines. Without a *fixed* timeline for each stage, it can be challenging to find the motivation to complete a task in a timely manner, which can lead to reduced interest in the project as a whole. As such, moving forward, this project would greatly benefit from a structured timeline to encourage member involvement and participation.

Imaging Design Challenge

The Imaging Design Challenge was a formal onboarding project with the main goal of selecting a payload design for the mission. Not only did this project integrate members into the team by building their technical knowledge, it also contributed directly to the overall satellite design. In this way, it was able to successfully balance learning with productive design work.

Members joined this project at the beginning of the onboarding process, and were given an introductory briefing presentation as an *orientation* along with online *support tools and processes* such as the team's main documentation tool, Confluence, to help them get started. They were then tasked with writing a case study on a satellite of their choice with a similar mission profile to that of FINCH. The eventual goal was to design FINCH's payload, but this small, well-defined early project allowed members to build confidence in their roles and understand the overall goal of the project, promoting *self-efficacy* and *role clarity*. They were then tasked with conducting a feasibility analysis based on a greater number of satellites, which involved more design considerations than the case study. This helped members understand how their remote sensing knowledge would be integrated into the bigger picture of satellite design.

The project was designed to have a very structured timeline with a set end date, giving it a *sequential* and *fixed* structure. However, as was the case with the Solar Panel Thermal Analysis project, this timeline was not followed as the project went along. As delays were introduced and other items took priority, not enough effort was made to ensure that the project maintained a fixed sequence of steps and ended at an agreed date.

Every member that joined this project is still involved with the team as of May 2021, which suggests they were able to gain good knowledge of the team culture and socially integrate well. Outside of the onboarding models, this project worked well because it gave members meaningful work that aligned with their interests on the team. While the benefits of this project are not contained by either of the onboarding models, it is important within the context of a voluntary student team in which members have fewer incentives to stay in the long term.

PART II: RETENTION

Retention refers to strategies implemented with the goal of maintaining member interest and investment in the team after the initial onboarding process. This section discusses two strategies which approach the goal of member retention in different ways. The first strategy, illustrated by the Structures presentations, aims to continue the formal member development processes that began during the onboarding workshop period. This is in line with a focus on member *self-efficacy*, equipping them with the knowledge required to work on projects independently. The second strategy, UTAT's Mentorship Program, aims to encourage diversity in the team and develop more meaningful connections between team members that extend beyond UTAT work. This approach increases member retention by focusing on *social integration*.

Structures Presentations

After the onboarding period concluded, the Structures subsystem hosted a series of virtual presentations on solid mechanics and manufacturing which are subjects of great importance to structural design. Connections to CubeSat design were included to illustrate the relevance of these topics.

These presentations adopted a lecture-style format as the method of delivery, with intermittent breaks for questions posed by members in attendance. In addition, slides were employed to highlight key points and provide visuals. Recordings of the presentations were shared with Structures members who could not attend.

The primary goal of these presentations was to address any knowledge gaps among members. By exposing members to potentially new knowledge, they could develop a greater understanding of their project work, and thus be more inclined to remain active on the team. Other subsystems may also benefit from adopting a similar strategy when faced with gaps in specialized knowledge.

While not strictly an onboarding initiative, these presentations fulfilled the *self-efficacy* criterion of Bauer's model for successful onboarding, since they provided members with the knowledge necessary to apply the concepts to project work. This is also a *sequential* and *collective* strategy, as it delivers a coherent series of lecture material to the entire Structures team.

Mentorship Program

Another strategy to increase new member retention implemented in the past year is the UTAT-wide Mentorship Program, which paired new members with an experienced UTAT mentor. Returning members from all years and disciplines were invited to become mentors, to encourage diversity within the program. Once registered, mentors attended a training session and were given an information package, which included goals for their mentorship, implicit bias training, and appropriate discussion methods.

Incoming members were then invited to register for the program. This year, 20 mentees enrolled in the program and were matched with 15 mentors. Pairings were created on the basis of technical interests, areas of study, and general interests. The goal of the program was not only to provide new members with a technical point of contact, but also to foster a sense of community and friendship on the team. One group was paired because of their shared interest in hiking, while another was matched because they both play the guitar. This well-rounded pairing method was designed for incoming members to feel as though they had things in common with their teammates.

While there was positive feedback from some participants of the program, such as one member's mentor providing a "comforting presence" in technical meetings and allowing them to feel "more comfortable speaking" within their subsystem, there was no significant correlation between enrolment in the Mentorship Program and continued involvement in the team. This suggests that while specific mentor-mentee relationships had a positive impact, not all relationships were equally successful. This indicates that the program could be improved by potentially involving a more structured post-pairing process. By holding mentor-mentee specific events and socials, the pairings would have a more structured space to meet and continue to remain in contact. This continued contact could likely improve the retention rate.

The Mentorship Program is an example of *coaching and support*, one of the tactics from Bauer's model.[7] It is also one of the more consistent methods of *feedback* that exists on the team. Mentors are available to provide technical advice and feedback, and are available to help with interpersonal issues or issues outside the team, depending on the strength of the relationship. For successful pairings, this can have a direct impact on the *self-efficacy* and *social integration* of members, through a *serial* retention strategy.

Overall Retention Data

Overall, the Fall 2020 recruitment cycle had a retention rate of 68%, with 55 new members remaining on the team until January 2021. Retention rate is defined as the percentage of prospective members who signed up for projects during the September recruitment cycle who are present on the team the following January. Data is drawn from the September project sign-up form and January team census, both conducted through Google Forms. In contrast, the 2019 recruitment cycle saw only a 47% retention rate of 51 members in the same time period.

A useful retention metric is the number of messages sent in public channels on the team's main communication platform, Slack. For a new member, sending messages publicly can be a source of anxiety because of their perceived lack of knowledge and experience, as was recognized by senior members of the team upon reflection on their early experiences. Sending messages in public channels shows self-motivated engagement in discussions and projects, as well as social integration with the team. Figure 2 shows a plot of messages sent in public channels since the beginning of the recruitment cycle in September 2020 from new members. New members are classified based on their involvement in the technical workshops held at the beginning of the recruitment cycle. A random selection of 20 new members was taken from each group to control for sample size.

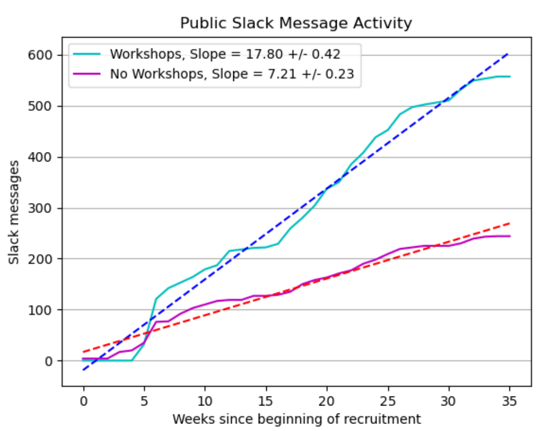


Figure 2: Public Slack message activity for new members between September 1st, 2020 and May 10, 2021. Members who attended at least one workshop were classified under "Workshops", and those that did not were classified under "No Workshops".

The sample of new members that attended workshops sent 17.80 ± 0.42 messages per week on average, while those that did not sent 7.21 ± 0.23 messages per week on average. This data does not take into account that prospective members who would have attended the workshops would likely already be more motivated to get involved with the team. However, workshop attendees would likely not stay on the team if these workshops were not inclusive and enjoyable. There is a clear improvement in member engagement when members attend the workshops at the beginning of the recruitment cycle, highlighting their effectiveness at promoting social integration and self-efficacy.

PART III: SURVEY METHOD AND DATA ANALYSIS

In order to better understand how new members felt about the onboarding process, a survey was conducted through Google Forms in May 2021 that specifically targeted members who had joined during the September 2020 recruitment period. The questions shown in Table 2 directly correspond to the onboarding criteria presented in Bauer's[7] and Jones's[2] models. These questions were not presented in this order and were not explicitly tied to a criterion, in order to elicit honest evaluations. A five point scale was used to allow for consistency across all questions. In general, a response of 1 correlates with a negative response, 3 correlates with a neutral response, and 5 correlates with a positive response. In the following section, the figures discussed also present an option for "0" which correlates to no response.

Out of the approximately 55 new members, 13 (∼24%) responded to the survey. This respondent pool may not be large enough to adequately evaluate UTAT's methods against the onboarding models, but the feedback collected from these responses signals specific areas of success and improvement. It is worth acknowledging the potential bias of the data towards the successes of the onboarding process since the members who responded to the survey were those who have remained on the team nine months later. This is also true of other forms of member feedback, as only members who felt comfortable adding detailed comments on the survey or giving leads direct feedback about the onboarding process could be captured.

Table 3 shows the results of the survey questions from Table 2, and provides a single example of a UTAT onboarding strategy that used each Bauer[7] and Jones[2] criterion, regardless of the survey result. A response that scored four or five on the five-point scale was considered a positive response. Overall, the results indicate that members thought that UTAT was successful at promoting *role-clarity* and *investiture* through a *formal*, *collective* onboarding process. However, the team can improve at culturally integrating members as well as at better structuring the onboarding process to be clear for new

Table 2: UTAT Space Systems Fall 2020 onboarding survey questions. Orange represents criteria from the Bauer[7] model, and Blue represents criteria from the Jones[2] model.

Criteria	Survey Questions
Self-Efficacy[7]	How confident did you feel in your first project or task on the team?
Role Clarity[7]	How well did you understand what was expected of you in your first project?
Social Integration[7]	Do you feel like you have integrated into the team socially?
Knowledge of Culture[7]	Did the onboarding and recruitment period give you a good understanding of team culture?
Collective[2]	Did you attend Space Systems Kickoff? Did you work on your first project alone or with a group?
Formal[2]	What type of project did you first work on?
Sequential[2]	Did you feel as though the onboarding process (from Kickoff to first project) had a clear sequence of steps?
Fixed[2]	Did you feel as though the onboarding process had a clear, defined timeline?
Serial[2]	How much assistance from your lead or another senior member did you have on your first project?
Investiture[2]	Did you feel as though you were able to express your personal values and ideas to your system?

Table 3: UTAT Space Systems Fall 2020 onboarding practices summary

Onboarding Model	Criteria	Fulfilled	Reasoning	Example
Bauer	Self-Efficacy		46.2% of respondents felt confident in fulfilling their new roles.	Orbit Propagator
	Role Clarity		69.2% of respondents thought their role's expectations were clearly defined.	Imaging Design Challenge
	Social Integration		53.8% of respondents thought that they were able to integrate effectively with the team.	Mentorship Program
	Knowledge of Culture		53.8% of respondents thought that the onboarding and recruitment process gave them a good understanding of team culture and values.	Space Systems Kickoff
Jones	Collective		61.5% of respondents worked with a group on their first onboarding project.	Onboarding workshops
	Formal		The team has a formal recruitment process that is initially separate from meetings of established members. No survey question adequately addressed the formality of the process.	Imaging Design Challenge
	Sequential		Only 30.8% of respondents felt as though the onboarding process adhered to a clear sequence of steps as the project progressed.	Structures Presentations
	Fixed		Only 38.5% of respondents felt that the onboarding process had a clear timeline.	Orbit Propagator
	Serial		Only 38.5% of respondents felt that they received guidance and assistance.	Mentorship Program
	Investiture		92.3% of respondents felt as though they were able to express personal values and ideas within the larger team setting.	Inclusion Task Force and related initiatives

members. The majority of UTAT's workshops and onboarding projects focused on criteria related to technical competency (such as *role clarity*), rather than those related to social and cultural values. This is reflected in the relatively low scores for *social integration* and *knowledge of culture*. Despite a focus on promoting *self-efficacy* across multiple onboarding strategies discussed in this paper, members did not feel as though these efforts were initially successful. This response may not be a complete representation of the success of technical projects, as confidence often takes time to build. Another valuable question to ask in future surveys is about members' confidence levels after a few months with the team.

EVALUATION AND TAKEAWAYS

The survey raises five key points of interest. First, according to Figure 3, investiture was highly rated across all responses. This shows that the leadership team and the onboarding strategies they employed helped new members feel welcome and provided a psychologically safe environment where members could express their personal values and ideas. According to a study conducted by Google[11] called "The five keys to a successful Google team," psychological safety was the first, most important factor. This is a positive indicator for the recruitment process because the UTAT leadership team is familiar with this concept and has actively worked to improve the psychological safety of the team.

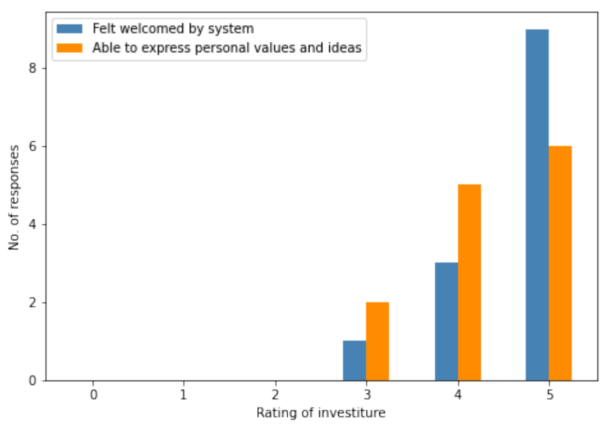


Figure 3: Participant responses to investiture-related questions.

Furthermore, according to Figure 4, members generally did not feel that the onboarding process was overwhelming. This is also a positive indicator for the onboarding process, since joining design teams can be a high source of stress for many junior students due to a perceived lack of technical knowledge and skill. This stress can be amplified by an overwhelming onboarding process, making it difficult for members to remain with the team. However, the positive responses to questions about investiture indicate that the UTAT leadership team can continue on its current course for the social initiation of new members.

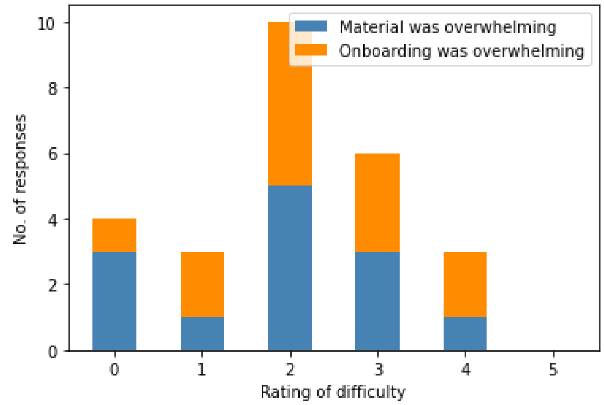


Figure 4: Participant responses about how overwhelming they found the onboarding processes and materials.

The third key takeaway was regarding the workshops conducted. Figure 5 shows that a majority of the responses pointed towards a high level of understanding and comfort during the workshops. This indicates that the leadership team was able to communicate new technical information and build basic skills in the members successfully. Members were also not overwhelmed or isolated during the workshops, further echoing that UTAT's onboarding processes are psychologically safe and inclusive.

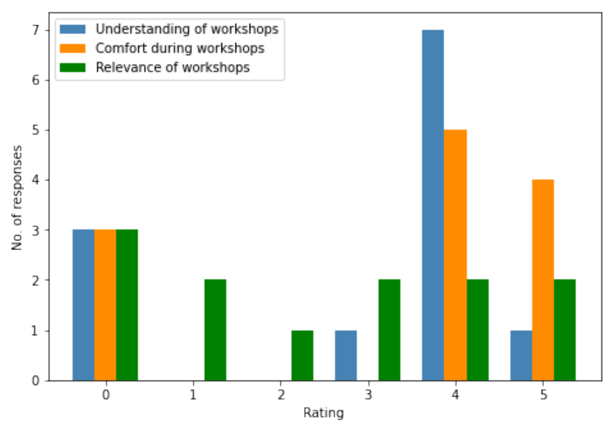
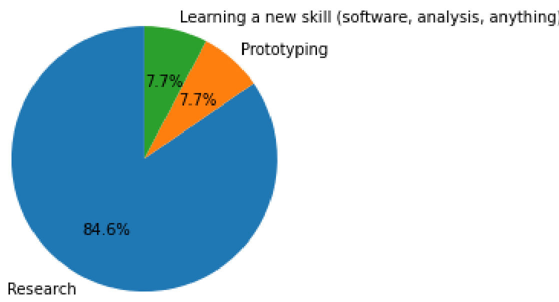


Figure 5: Participant responses to questions about workshop quality.

An unexpected result was that many members did not find the workshops to be relevant to the projects that they ended up working on. One explanation for this may be that many members were assigned a research project as their first project on the team. This is reflected in Figure 6 (left). The purpose of these projects was twofold: to allow new members to engage in technical reading to build understanding, and to contribute to the knowledge pool of the team. Due to this, members were likely



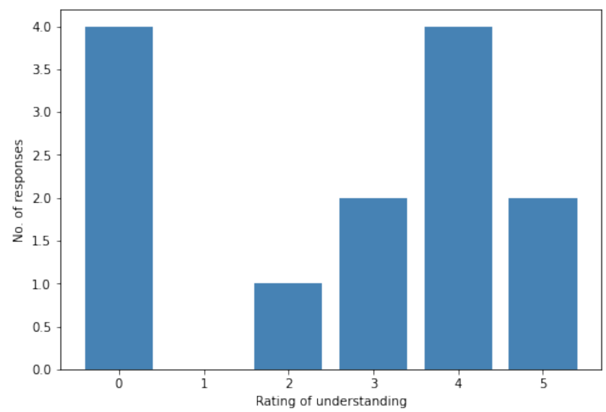


Figure 6: Participant responses to questions about their first project types (left), and participant responses to questions about comfort with and understanding of the onboarding materials (right).

not given the chance to implement the skills they picked up in the workshops. Since the workshop period occurred before project selection, members signed up for workshops in a wide range of technical areas, not all of which would be directly relevant to their work on the team.

Instead, many members found the onboarding materials provided by their subsystems to be helpful, as demonstrated in Figure 6 (right). These materials were a compilation of highlights from research already done by the team, intended to help new members catch up in technical knowledge to the rest of the team in a short period of time. They were specifically made to give members the knowledge needed to understand the current design of their subsystem, building *role-clarity* and *self-efficacy*.

At the time that this survey was conducted, many new members had already started contributing to high-level design work, and still did not find the workshops relevant, which directly suggests an area of improvement for the leadership team. It is possible that the leadership team did not correctly anticipate the technical skills that needed to be taught since technical work across the team consisted largely of research at the time of recruitment, with the design having many unknowns. With design requirements largely undefined, systems changed paths frequently. This level of uncertainty is not expected for upcoming design stages. In Fall 2020, members signed up for workshops in an average of 3 different technical areas, highlighting that members themselves were unsure of what subsystems or systems they would like to join. This is another potential reason why members did not feel as though the workshops were relevant to their first projects.

In order to increase the relevance of the workshops for future recruitment cycles, the leadership team can consult with members about the skills they actually built during their projects and focus on teaching these skills to prospective members.

Despite the lower relevance of the workshops, there is a strong correlation between workshop attendance and level of engagement with the team going forward. This suggests that the workshops served as an important element of social integration on the team.

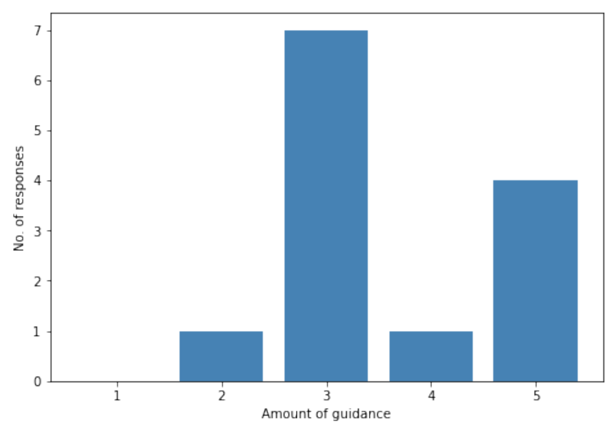


Figure 7: Participant responses to questions about the guidance received by the leadership team and senior members on their first projects.

Finally, as shown in Figure 7, participants' responses for the survey question regarding the Serial criterion ("How much guidance or assistance from your lead or another senior member did you have on your first project?") does not provide concrete guidance for next steps. Many members rated the assistance they were given at a 3/5, which does not imply that members felt as though they were given adequate assistance tailored to their starting levels of knowledge. For future surveys, this question could be modified or a question could be added, asking members if they felt they had *enough* assistance.

CONCLUSION

Overall, the Fall 2020 recruitment and onboarding process resulted in a 68% retention rate, compared to only 47% the previous year. There was also a high correlation between the involvement of new members in the onboarding process and activity on the team's messaging platform, Slack, suggesting that the onboarding process contributed to member engagement on the team. This does highlight the importance of a formal institutionalized onboarding process as outlined in the Jones model.[2] However, not all aspects of the onboarding process were effective. While the workshops helped members integrate with the team, they were often not relevant to members' eventual work on the team, suggesting that they were more valuable for social or cultural onboarding rather than technical onboarding. Some aspects of the onboarding had varied success, such as the Mentorship Program, which was very helpful for some members' integration into the team, but not successful for others.

Many of the strengths of UTAT's onboarding process were outside of these models. For example, an important aspect of the success of UTAT's onboarding process was giving members meaningful projects. This led to members feeling more invested in their work and more confident in their role on the team. As a voluntary team, UTAT has had to place a particular emphasis on maintaining engagement and investment from members; however, this lesson could also be useful for increasing job satisfaction and retention in industry. Another important aspect of UTAT's onboarding process has been the emphasis on establishing psychological safety early on. While Bauer's model highlights the importance of social integration in onboarding processes,[7] psychological safety goes beyond social integration and focuses on members feeling comfortable and accepted on the team, rather than forcing members to fit into the existing team culture.[12] Therefore, the inclusion of psychological safety as a criterion in onboarding models is suggested.

Several members of the leadership team have expressed that their workshops and materials as well as the team's onboarding strategies were not designed with Bauer's and Jones' models in mind. However, these models have guided the team's self-evaluation of and reflection upon its recruitment and onboarding practices by providing a clear set of scientific criteria.

There is also room for UTAT to improve its onboarding processes in accordance with these models. Implementing better tools and processes for managing the onboarding sequence and timeline can help members look forward to integrating into the team and applying their skills, while giving the onboarding process a more defined purpose. Employing more consistent feedback systems would also help the team adjust the onboarding strategies based on member feedback, and understand how initiatives such as the Mentorship Program are being received. Revising workshop content to focus on the most relevant information and skill-building can provide a realistic view of subsystem activities and allow members to start contributing to the team earlier. Finally, improving participation in culture-building events during the onboarding process, such as social events or any inclusion strategies, would help members build a better knowledge of the team culture and integrate with the team socially. While none of these adjustments are simple, UTAT's commitment to conscientious leadership and thorough self-evaluation will help ensure that the team's onboarding practices continue to improve and foster future generations of leaders.

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