THE STUDENT FLIGHT DATA RECORDER – BUILDING A CULTURE OF LEARNING FROM FAILURE

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ABSTRACT

This paper presents the results of a collaborative project initiated by first year teaching staff and study counsellors within the Aerospace Engineering Bachelor's programme at Delft University of Technology aimed at tackling the challenge of stimulating critical self-reflection and coping with failure. This project took the concept of a study planner and reflection journal and turned it into a symbol synonymous with learning from failure – the aircraft Flight Data Recorder. This symbol was combined with animated storytelling to introduce and explain the purpose and function of the Student Flight Data Recorder (SFDR), after which the usage of the resource was scaffolded by student mentors. Acknowledging that some students would not feel compelled to use a resource that was not required, a moment of intervention was offered at the completion of the first academic quarter after the first round of final exams. Overall, the project team has observed that the project has created more awareness and discussion about these topics within the student population. The next step in the project is to add an educational researcher to the project team with the intent of carrying out quantitative research into the effectiveness of the tool.

KEYWORDS

Self-reflection, Failure, Self-determination, Standards: 7, 8, 11.

INTRODUCTION

Many of us have been in the situation where we have observed that student learning and success has been hindered by deficiencies in their ability to plan, self-reflect, and learn from their own mistakes and failures. Students tend to focus on grades and the need to succeed rather than the process of learning and what they can learn from both their successes and failures. Furthermore, students see their instructors as assessors that are there to judge them, creating a strong deterrent for sharing authentic self-reflections that may expose or highlight their own perceived deficiencies. This creates a challenge for meaningful self-reflection exercises meant to address these deficiencies - how can we get students to perform meaningful self-reflection without triggering their student mind to simply reflect back what they think the teacher wants to see?

With this in mind, a team of study counsellors and academic teaching staff embarked on a project, known as the Student Flgiht Data Recorder (SFDR), to stimulate a culture of critical

self-reflection and learning from failure without turning it into a course assignment. The project specifically targeted incoming first year bachelor students and their struggles in navigating the transition from high school to university. Based on collective experiences in teaching and mentoring students, the project team defined the ambition that the SFDR should help:

- Instill a sense of personal responsibility for learning and development;
- Reinforce the importance of time management, self-discipline, and critical reflection in study success;
- Destigmatize the word/concept of ”Failure”;
- Equip students with the tools and mindset to learn from failure;
- Leverage the intrinsic motivation/ambition present in students entering their study programme.

It is important to note that this project was initiated based on the experiences of the practitioners involved (Rans & Teuwen, 2021; Saunders, Breuker, Rans, Schuurman, & Staalduinen, 2018; Saunders-Smits et al., 2020; Schuurman & Rans, 2022; Schuurman, Saunders-Smits, & Rans, 2018). It was not setup as an educational research project aimed to gather quantitative educational research data. Neither was it formulated based on an extensive review of the educational literature. However, the authors feel that the aims of the project align well with the intentions of the CDIO Approach (Crawley, Malmqvist, Östlund, & Brodeur, 2007). Specifically, the project aims to integrate elements of personal growth and reflection with discipline-relevant content (Standard 7), help students identify learning opportunities from their own failures (Standard 8), and provide formative feedback on the importance of soft skills in the educational journey (Standard 11). For this reason, this paper will outline the overall approach and thought process behind the Student Flight Data Recorder project, with the intent to engage the CDIO community. As formal conclusions based upon quantitative research data cannot be made, the paper concludes with a reflection on the next steps needed within the project.

THE STUDENT FLIGHT DATA RECORDER PROJECT

This project started with the concept of a study planner and reflection journal that was heavily inspired by the Passion Planner series of notebooks (https://passionplanner.com/). These notebooks creatively mix a traditional agenda/planner with various goal setting and reflection exercises that aligned with the time-management and critical reflection ambitions of the project. Sample pages from the SFDR can be viewed at https://www.calvinrans.com/sfdr. The development of this study planner and its planned utilization was governed by three guiding principals:

1. Use of the SFDR is encouraged, but not mandatory, to avoid making it an assignment.
2. The contents of the SFDR are confidential to the student. They are encouraged to discuss and share only what they are comfortable with.
3. Emphasis should be placed on failure being something one experiences rather than something one is.

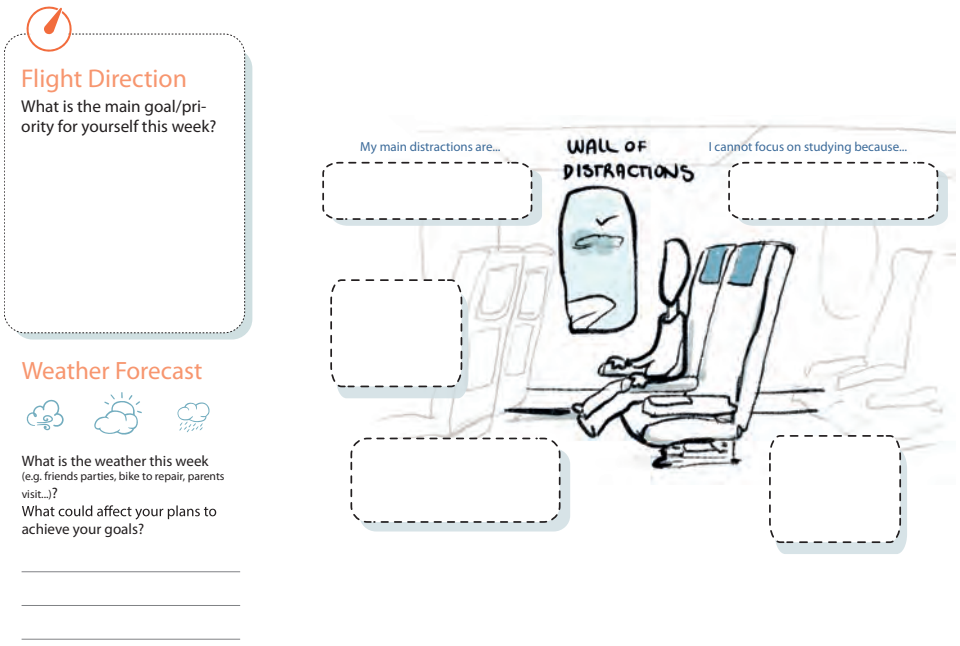

Figure 1. Examples of reflection activities connected to the aerospace theme: Flight Planning for weekly goal setting (upper left), Weather Forecast for identifying risk factors for meeting the goals (lower left) and an exercise for identifying distractions in the study environment (right).

By not making the use of the resource mandatory and further emphasizing that the reflections within it were confidential and for the student only, we wanted to create a safe space for students to engage in meaningful critical self-reflection. However, it was also acknowledged that there was a risk that students would not feel compelled to use a resource that was not required or could earn them points towards their grade. To tackle this conundrum, the project team had to look at how to connect and activate students' intrinsic motivation to use the resource in the absence of the extrinsic motivation provided by grades. The first element of this was relatively easy given the context of its usage in an aerospace engineering faculty. All incoming students have a keen interest in aircraft and spacecraft, providing the opportunity to relate various activities within the planner to this theme in a fun manner as shown by some examples in Figure 1. In addition to this, the project team focused on four different elements to help scaffold and reinforce the usage of the resource by students, known as the symbol, the story, the struggle, and the intervention. In the following sections, these elements and their connection to activating intrinsic motivation within students will be discussed.

The Symbol

Symbols hold a power that helps shape and express the identity of individuals or groups (Erel-Koselleck, 2004). It doesn't take more than a short walk around your city or campus to see this first hand. You would see social community's joined through brand loyalties, sports team allegiance, hobbies, and even interests that are identified or associated with particular symbols and/or artifacts. The sense of belonging and camaraderie that is derived by being within such a social community provides a significant intrinsic motivation for individuals who belong within that community. Thus, having a strong symbol for this project can help anchor the project ambitions and help form a sense of community around them.

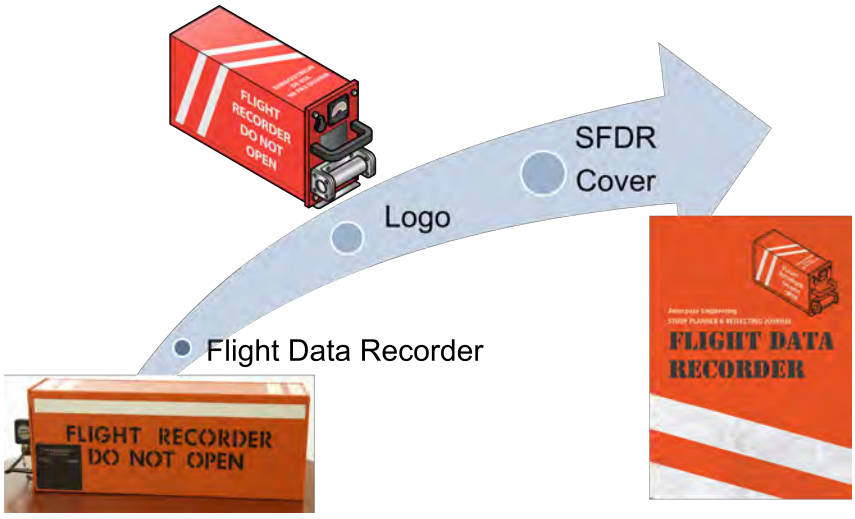

Figure 2. Flight Data Recorder symbolism transfered to the student flight data recorder

The symbol chosen for the project is already alluded to in the name of the project - a Flight Data Recorder, or FDR. The recognizable imagery associated with an FDR was translated into a logo and cover design for the SFDR as shown in Figure 2. It is quite an appropriate symbol for the project given that *1)* it is a recognizable aerospace artifact with an ubiquitous association with failure, *2)* it is used to learn from failures, and *3)* its contents cannot be used to apportion blame or liability in case of a failure.

The first two points will be treated as self-evident; however, the third point and its importance is worth discussing further. Most people outside the aviation safety sector do not realize that use of the data on a FDR is protected (see 14 CFR § 91.609 (*Aeronautics and Space.*, 2021)). This may at first be surprising, but its need becomes obvious when you realize the scenario it places pilots and other flight crew - a workplace under constant surveillance of microphones and other sensors. Such a workplace could be considered a huge invasion of privacy without the presence of strong agreements on the usage of that data. Luckily, such agreements are in place, and such data is permitted to be collected and used only in the context of an Air Safety Investigation and not a Judicial Investigation (*Annex 13 - Aircraft Accident and Incident Investigation*, 2016).

If you consider the vulnerability associated with a critical self-reflection by a student, a similar need for trust and strong agreements between students and staff is clear. The authors feel that this is one of the major failings of self-reflection exercises that are directly reviewed and assessed by teachers. In the absence of this needed trust, students tend to reflect what they feel the teacher wants/expects to see to avoid the risk of exposing themselves through their own struggles and failures, circumventing the intended purpose of the activity. This is the motivation behind the first and second guiding principals of the SFDR project, and the FDR provides the perfect symbol to encapsulate this.

The Story

To complement the symbol of the SFDR, the use of storytelling was used to communicate its function and intended use. This was achieved using an online animation software (www.Vyond.com). Although it can be difficult to fully articulate the power a story holds, the following perspective

SCAN ME

https://youtu.be/tvVu4sBhmjk

Figure 3. SFDR animated story for introducing students to the project

from Fisher (1989) provides some useful insight that is applicable here:

> ”We tell stories to give order to human experiences and to induce others to dwell in them in order to establish ways of living in common, in intellectual and spiritual communities in which there is conformation for the story that constitutes one’s life.”

This underpins the ambition behind creating a story for the SFDR project. We wanted to create a relatable story that aligned the ambitions of incoming students with the well-known challenges of adapting to university studies in a way that fostered a culture of learning from failure and critical self-reflection. To achieve this, a team of first year lecturers and student mentors defined a story which makes an analogy between university as a journey to their career ambitions and a flight from one destination to another. Only in this flight, it is not possible to be a mere passenger. The flight is only the end of the journey that begins with the student needing to learn and train the skills required to pilot the flight themselves. It is difficult to explain all of the elements of the story without ruining the story itself, so the reader is first directed to the QR code in Figure 3 to view the animated story firsthand.

It is important to point out the contribution of the student mentors within the project team that helped ensure the story was engaging and effective from a student perspective. Several key details of the story that emerged based on their input is important to highlight:

- Male and female avatars, and extroverted and introverted personas were used to maximize the relatability of the student-based characters in the story
- The concept of a learning community where teachers and peers all help each other was embedded in the story
- Lighthearted but relatable examples of mistakes and failures were introduced to help student connect with the role of self-reflection in learning
- The overall story remained positive and encouraging from a student perspective despite the difficult touchy subject matter of failure and personal responsibility.

In addition to these contributions, efforts were made to make the symbol of the FDR evident in the video (reinforcing guiding principles 1 and 2) and to destigmatize failure (guiding principle 3) throughout the video.

The Struggle

With the symbol and accompanying story to connect students to the purpose and usage of the SFDR in place, the next stage of the project occurs - the Struggle. This stage has a bit of a double meaning in that it refers to the struggle is felt by teachers and student mentors as they observe some students not engaging with the project and to the overall struggle of students learning to cope and adapt through this transitional phase of their lives. It comes as a natural consequence of guiding principal one of the project - use of the SFDR is not mandatory.

Although its use is not mandatory, this does not mean its use is not encouraged. The cohort of incoming bachelor students are placed in groups and assigned a student mentor to help guide them in their first month of their studies. Those student mentors receive training in mentoring and guidance of students, are briefed on the purpose and intended use of the SFDR, and are asked to engage their students in discussion of the exercises and activities within it and encourage its use. Student mentors have given feedback to the project team on the usefulness of the resource simply in terms of providing a fun and almost gamified basis for discussing the struggle to adapt to university within their mentor groups.

Teachers in one of the first year courses also indirectly do their part to reinforce the relevance of specific reflection exercises within the SFDR. A conscious decision was made not to have teachers directly refer to the SFDR in their courses, as this could create a false connection between the SFDR and a particular course, or a false expectation that use of the resource was required for that course. Direct reference to and discussion of the SFDR was contained within the mentor groups. Instead, the teachers were informed of the nominal timing of specific self-reflection exercises within the SFDR and encouraged to engage students in related topics naturally within the context of their own teaching. For example, in one week approaching the exam period of the academic quarter, students were confronted with a self-reflection exercise where they needed to assess their self-study space and the possible distractions contained within it (see Figure 1). In the same week, teachers within the Engineering Statics course sparked a class discussion on effective study practice.

The Intervention

Acknowledging that some students would not feel compelled to use a resource that was not required or graded, a moment of intervention was planned after the first final exam period of the academic year. This intervention was setup as a lunch lecture entitled *Engineering Success out of Failure*, which was designed to help students reflect on how to learn from failure by examining the purpose and process of an Air Safety Investigation. Students were unaware beforehand that this lecture had any connection to the SFDR they had recieved at the beginning of the year, nor did they know the lecturer (Calvin Rans) was connected to the project either.

The first aim of the lecture was to help students see failure as something you experience, not something that you are. Most students entering the Aerospace Engineering Bachelor programme were the top of their class in high school and likely did not struggle to do well there. If they failed a course or exam, or even passed but with grades far lower than they have ever received, they often see themselves as a failure, not having developed the skills to cope and respond to this type of event. To try to dispel this belief, the lecturer begins the lecture with a personal story of their time in university when they failed an exam. Having a university professor

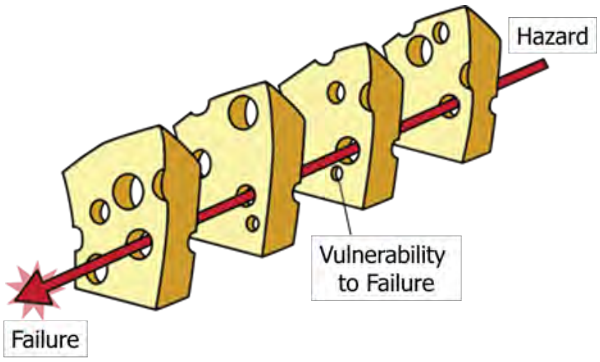

Figure 4. Swiss Cheese Model illustrating multiple vulnerabilities/causes needed for failure.

- a figure of academic success in many students minds - describe a moment of failure in their academic past has a profound effect on many of the students. It helps them see that such a moment doesn't necessarily define them, and the failure can simply be a moment or event, if it is responded to in the right manner.

The second aim of the lecture is to discuss how to respond to failure in a professional manner through examining how an Air Safety Investigation is carried out. The authors would like to make clear that we do not equate the gravity of an aviation accident with that of a student failing an exam or a course. However, both types of failure can elicit strong emotions and create an overwhelming desire to apportion blame for the event. With this commonality, the objective of an Air Safety Investigation as stated in *Annex 13 - Aircraft Accident and Incident Investigation* (2016) carries a lot of relevance:

> "The sole objective of the investigation of an accident or incident shall be the prevention of accidents and incidents. It is not the purpose of this activity to apportion blame or liability."

The importance of this objective is discussed in detail, particularly with respect to ensuring the willing cooperation of all parties involved in the safe operation of an aircraft. Additionally, a simple conceptual model known as the Swiss Cheese model (see Figure 4) is also presented to them to highlight that failures are rarely caused by a single event, but require vulnerabilities across multiple layers of safety to permit a failure to occur. This is then reflected back into the student experience, where we challenge students to think of their own failures like Air Safety Investigators. They should aim to prevent future failures rather than fixating on their desire to blame for the present failures, and recognize that there are other vulnerabilities they may identify and are responsible for.

The last aim of the lecture is to iterate the importance of data and collecting data for an investigation. The function, importance, and agreements behind the FDR in the context of an Air Safety Investigation are discussed. It is at this moment that the lecturer then refers to the SFDR, and reveals their part in bringing the project to fruition. Students are challenged to review their own data recorder in a bid to identify possible vulnerabilities and make recommendations to themselves to remedy them. The lecture is closed off by a harsh but necessary truth - if their SFDR

is empty, then the data recording process was faulty, and they should make recommendations to themselves to find an effective way to critically reflect and gather the data they might need to help investigate future failures.

EARLY RESULTS AND NEXT STEPS

The following is a reflection from one the of the student mentors that was responsible for encouraging the usage of the SFDR with their mentor group.

> As a first-year mentor, you are responsible for 22 students. You meet them at the beginning of September and from that point onwards you see them once a week for the first 6 months of their university life. Most of the students have a lot of questions and at the same time, as a mentor, there is a lot of information to relay. Staff and Academic counsellors within the university prepare you with what is important, however having something like the SFDR helps students not feel so overwhelmed. The SFDR condenses the essential information and makes it easily accessible to each student.
>
> Every mentor has their own method of communicating but it is natural that sometimes we forget to mention something. Therefore, having all the most important parts written and given to each student prevents a significant amount of miscommunication and stress on the mentor's part. In addition to this, it makes explaining many of the concepts easier as well. For example, explaining modules can be quite complicated; on the other hand, asking them to turn to the curriculum page in their logger and work out their final grade if they got a 6 in dynamics and 8 in statics proved to be a nice icebreaker.
>
> As a mentor I often think about what I would have wanted in my first year and the SFDR is a great start. At first, I didn't think I would use it but found myself using the same template for my personal exam study schedule as that proposed in the SFDR. So even if the students didn't use the book completely, it's still a source of inspiration.
>
> I found that some of my students would stop using the SFDR after the first exam period (around 2 months in). This makes sense, as that is when most students start to settle in and become accustomed to the TU Delft ways. Some students found it quite "cheesy" to reflect on their week, but others benefited from it. Personally, I believe that, having the resource and the support available, even if you don't necessarily need it, makes all the difference.

From this reflection, it is evident that the SFDR became a useful resource for students and mentors. Although it did not always become a pervasive tool that students used throughout their entire academic year, it served as an effective symbol/artifact to facilitate discussion on personal responsibility and critical reflection within academia.

The instructor perspective is limited mainly to the experiences from the intervention lecture. It was found that this intervention was extremely powerful and effective, and gave the SFDR a renewed sense of purpose, both as a resource and a symbol for the students education. After

the lecture, many students approached the lecturer thanking him for framing failure in such a constructive way. Most had never learned to deal effectively with failure, and were stuck in a state of feeling inadequate or angry, and the intervention helped them see that they needed to put these emotions aside and investigate what vulnerabilities contributed to their own failure, and find ways to mitigate them and prevent future failures. In the weeks and months following the intervention, the instructor also experienced a rise in the number of students approaching him to discuss their own study habits and strategies, which was taken as evidence that the principals instilled by the SFDR project continued well after the completion of the cycle of the project.

Although the project team feels the project has been a success based on their own observations, there is a desire to better quantify its effectiveness. As a result, the next step in the project is to engage with educational researchers to design surveys and other monitoring tools to gain the data necessary to verify (or disprove) this perception.

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BIOGRAPHICAL INFORMATION

Calvin Rans is an Associate Professor at Delft University of Technology's Faculty of Aerospace Engineering. In 2007, he received his PhD in Aerospace Engineering from Carleton University for his work on fatigue crack growth in riveted lap joints, and he has since continued his research in structural failure and safety. Calvin is an educator at heart. In addition to his research, he strives to be innovative in his teaching methods, both online and on campus, and is a master of video and animation. He distinguished himself as a teacher by being named Best Lecturer TU Delft 2018 and *Docent van het Jaar* in the Netherlands 2019.

Julie Teuwen is an Associate Professor at the faculty of Aerospace Engineering of Delft University of Technology since 2016. She holds a PhD in the field of liquid moulding of thermoplastic wind turbine blades from TUDelft (2011). After obtaining her PhD, Julie worked as a materials and production process engineer at a wind turbine blade design and blade manufacturing company. Her research now focuses on materials and production processes for future wind turbine blades that can be structurally re-used after their lifetime as a blade and easily recycled at the end of the material life.

Helena Momoko Powis is a Masters student at Delft University of Technology's Faculty of Aerospace Engineering. Following the profile, Space Engineering. Member of the faculty student council and founder and chair of Artemis - The space track study society. Active student teaching assistant since 2020. Momo hopes to continue her studies with a thesis on test methods of Cube Satellites while continuing to pursue a career in academia.

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