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Automated Feedback Tool for Student CAD Models Using the Fusion 360 API

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Learning Objectives

- Explore how Fusion 360 includes a comprehensive API that can be used as an automation and data insights tool.
- Discover how the API can be used in ways that will enhance the effectiveness of teaching and learning.
- Learn how to locate the user documentation for the Fusion 360 API and have an awareness of some of its capabilities.
- Discover the possible future development plans for the API and how to learn more.

Description

Fusion 360 software is a cloud-powered CAD, CAM, and CAE tool, and it is the primary software for the instruction of degree apprentices at the AMRC Training Centre, part of the University of Sheffield. With rising student numbers, it was becoming increasingly difficult to provide detailed and timely feedback to students as they learned the basics of Fusion 360. In this session, Joe Palmer will present a bespoke feedback tool that has been coded in Python and implemented using the Fusion 360 API. This tool provides instantaneous feedback to students about the quality of their CAD models by assessing key model metrics. These metrics enable a complete picture of model quality to be determined by the script without any input from course tutors. This has empowered tutors to spend more time on valuable activities within the classroom. We will discuss a background of the Fusion 360 API, the tool's development process, and details of the scoring algorithm. We will also present a road map for future development.

Speaker Bio

Joe Palmer is a Lecturer at The University of Sheffield AMRC Training Centre and a Senior Design and Development Engineer AMRC's Design and Prototyping Group (DPG). Currently, Joe divides his time between managing and delivering design focused R&D projects for the DPG and lecturing on the subjects of Design, CAD/CAM and additive manufacturing at the AMRC Training Centre.

Joe obtained his MEng in Mechanical Engineering from Imperial College London before working as a powertrain design engineer for Triumph Motorcycles in Hinckley, Leicestershire. In 2010 Joe came to the AMRC and held several design focused posts before taking on teaching responsibilities in 2016.

Fusion 360, its App Store and API

Fusion 360 App Store

Fusion 360 has its own app store. Installed apps can enhance the core functionality of Fusion 360; you can browse these apps here:

https://apps.autodesk.com/FUSION/en/Home/Index

The first app example shown in the talk is the helical gear generator, find out more about this app here:

https://apps.autodesk.com/FUSION/en/Detail/Index?id=9029586664984391977&appLang=en&os=Mac

All apps on the App Store have been developed using the Fusion 360 API.

Fusion 360 API

The acronym “API” stands for Application Programming Interface and in simple terms is a per-agree set of commands which allows one program to control another.

Not all software has an API, and it is the software developer who decides how capable their particular API is. Software API’s are also not always immediately accessible by the user; a user may have to create a developer account or pay licencing fees to access it.

Fusion 360 is different; the API is highly capable and free to use and easy to access for everyone!.

Autodesk also supplies many resources to allow new users to get up to speed with the API:

- Fusion 360 on GitHub - https://autodeskfusion360.github.io/
- Fusion 360 API forums - https://forums.autodesk.com/t5/fusion-360-api-and-scripts/bd-p/22
- Fusion 360 API product documentation - http://help.autodesk.com/view/fusion360/ENU/?guid=GUID-A92A4B10-3781-4925-94C6-47DA85A4F65A
- Fusion 360 reference manual - https://help.autodesk.com/view/fusion360/ENU/?guid=GUID-7B5A90C8-E94C-48DA-B16B-430729B734DC

Motivation for developing the feedback tool

Advanced Manufacturing Research Centre (AMRC)

Advanced Manufacturing Research Centre is part of the University of Sheffield and located on the Advanced Manufacturing Park at Waverly, the former Orgreave mining site. The Advanced Manufacturing Park (AMP) at Waverley is home to some of the World's most prominent manufacturers including Rolls Royce, Boeing and McLaren Automotive. Technology developed at the AMP is already being utilised in leading-edge projects including Formula One, the military and commercial aircraft. Find out more here:

https://www.amrc.co.uk/

The AMRC was established in 2001 as a collaboration between Boeing & the University of Sheffield. It helps manufacturers of any size to become more competitive by introducing advanced techniques, technologies and processes. It specialises in carrying out world-leading research into advanced machining, manufacturing and materials, which is of practical use to industry. The AMRC possess expertise in machining, automation, robotics, digitally assisted assembly, casting, additive manufacturing, composites, designing for manufacturing, testing and training

AMRC Training Centre

The AMRC Training Centre is part of the University of Sheffield AMRC. Built-in 2014, the centre was created with the aim of training apprentices for local engineering businesses. The centre contains a "state-of-the-art" shop floor with modern CNC machining centres, as well as purpose-built robotics, welding and electronics training rooms, as well as standard teaching spaces. Students study at a wide variety of different levels. Students at the Training Centre are typically in the centre one day per week. Learn more here:

https://www.amrctraining.co.uk/

Degree Apprenticeships

The degree apprenticeship pathway offers an alternative route to university education. Students gain a degree, develop practical workshop skills and valuable transferable skills alongside gaining real-life on the job experience. Apprentices work four days per week at their employer while studying for one day per week at the AMRC Training Centre. More information on this pathway can be found here:

https://www.amrctraining.co.uk/degree-apprenticeships

CAD and CAM instruction

The mandatory first-year module “Introduction to Design and CAD CAM” uses Fusion 360 as the software for instruction. Students have 90 minutes per week of in-person contact time with the course tutor, CAD and CAM instruction typically lasts between 12 and 14 weeks. With 40+ students in each tutorial, it can be challenging for the course tutor to provide feedback to each student every week. Students also complete a lot of independent study and practice in CAD CAM, providing feedback outside of office hours is quite challenging. It was believed that a Fusion 360 App which could provide students with automated feedback could help to solve both of these problems.

Feedback tool development and the student reaction

Development of the first version of the automated feedback tool began in summer 2019, and the tool was called “Model Checker Utility”. Before starting any coding, however, decisions needed to be made on how the core algorithms would work.

What makes a “good” CAD model?

To provide useful feedback to students, we first need to agree on what a “good” CAD model looks like. This is a contentious issue, as many expert CAD users will have their own opinion here; however, after discussions with colleagues, one guiding principle was agreed upon:

“A good CAD model should be simple to understand and easily editable by other engineers.”

With this guiding principle agreed upon, eight key metric areas were defined for student models:

- Model Volume
- Model Mass
- Number of Bodies
- Constrained Sketches
- Failed Features
- Construction Geometry
- Minimum Number of Dimensions
- User Parameters

Model Checker Utility

The Model Checker Utility interrogated student models and provided numerical data in the eight key metric areas listed above. Students could then compare their metrics to an ideal to see if any improvements could be made. The tool contained three tabs of information, details of which are shown below.

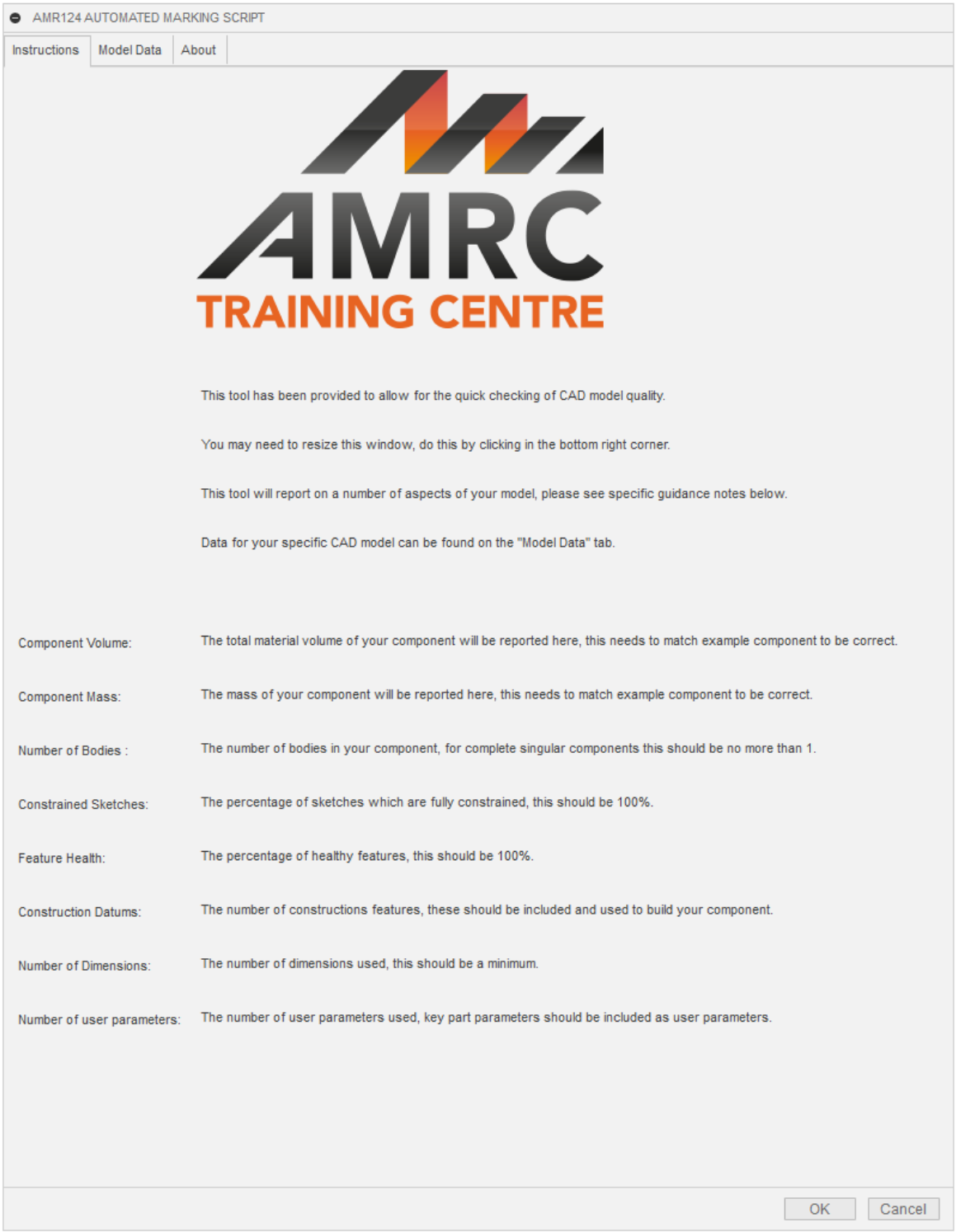

FIGURE 1 – INFORMATION TAB 1 OF THE MODEL CHECKER UTILITY. THIS GIVES GENERAL DESCRIPTIONS OF EACH METRIC.

FIGURE 2 – INFORMATION TAB 2 OF THE MODEL CHECKER UTILITY. THIS GIVES KEY MODEL METRIC DATA FOR THE ACTIVE STUDENT MODEL. STUDENTS ARE ENCOURAGED TO COMPARE THEIR METRICS AGAINST IDEAL VALUES AND SEE WHERE THEY CAN MAKE IMPROVEMENTS.

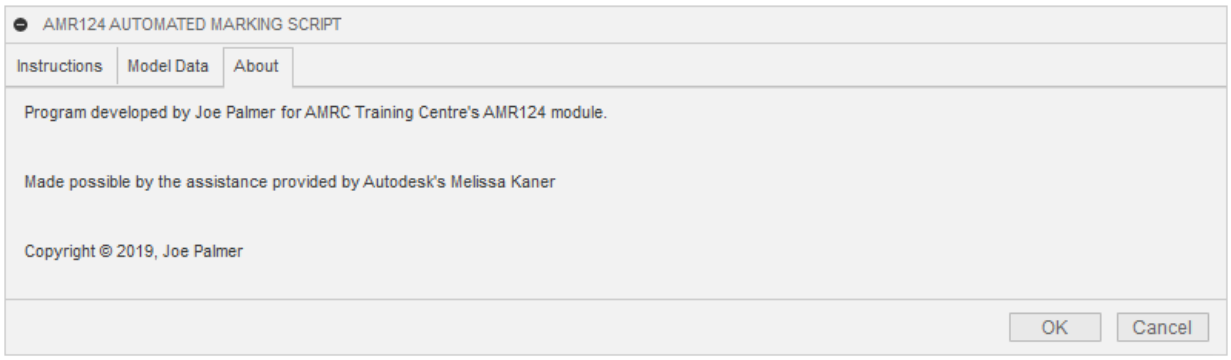

FIGURE 3 – INFORMATION TAB 3 OF THE MODEL CHECKER UTILITY. THIS TAB GIVES SUPPLEMENTARY INFORMATION ABOUT THE TOOL ITSELF.

Student Attitudes

Students in academic year 2019/2020 were encouraged to use the model checker utility, and feedback was sought from these students via a survey. As part of the survey process students were also shown visual mockups for a possible future development of the tool codenamed "FOCUS".

The following conclusions were drawn from survey data:

- Students liked the Model Checker Utility. They thought this allowed them to make quick checks of their work and correct errors without always needing tutor assistance.
- Students thought that the Model Checker Utility improved the speed at which they learnt, but did not necessarily help their depth of understanding.
- The student response to the FOCUS tool visual mockups was measurably better than the Model Checker Utility.
- Students were split almost 50/50 on whether automated feedback or tutor feedback was the most effective.

Students had communicated that they would like to see and use the FOCUS tool; therefore, the development of this software started in early 2020.

FOCUS Tool

Feedback and **O**ptimisation for **C**AD **U**tility **S**cript

Rather than just offer key metric data, FOCUS was designed to score student models in all metric categories. FOCUS awards a 100% category score if the student metric value matches exactly the ideal value for that particular exercise. Data for all ideal values are read in from an excel file; in this way, the course tutor can update the exercises any time they wish without needing to modify any code. Development of FOCUS was completed in August 2020. Details of FOCUS tool are presented below.

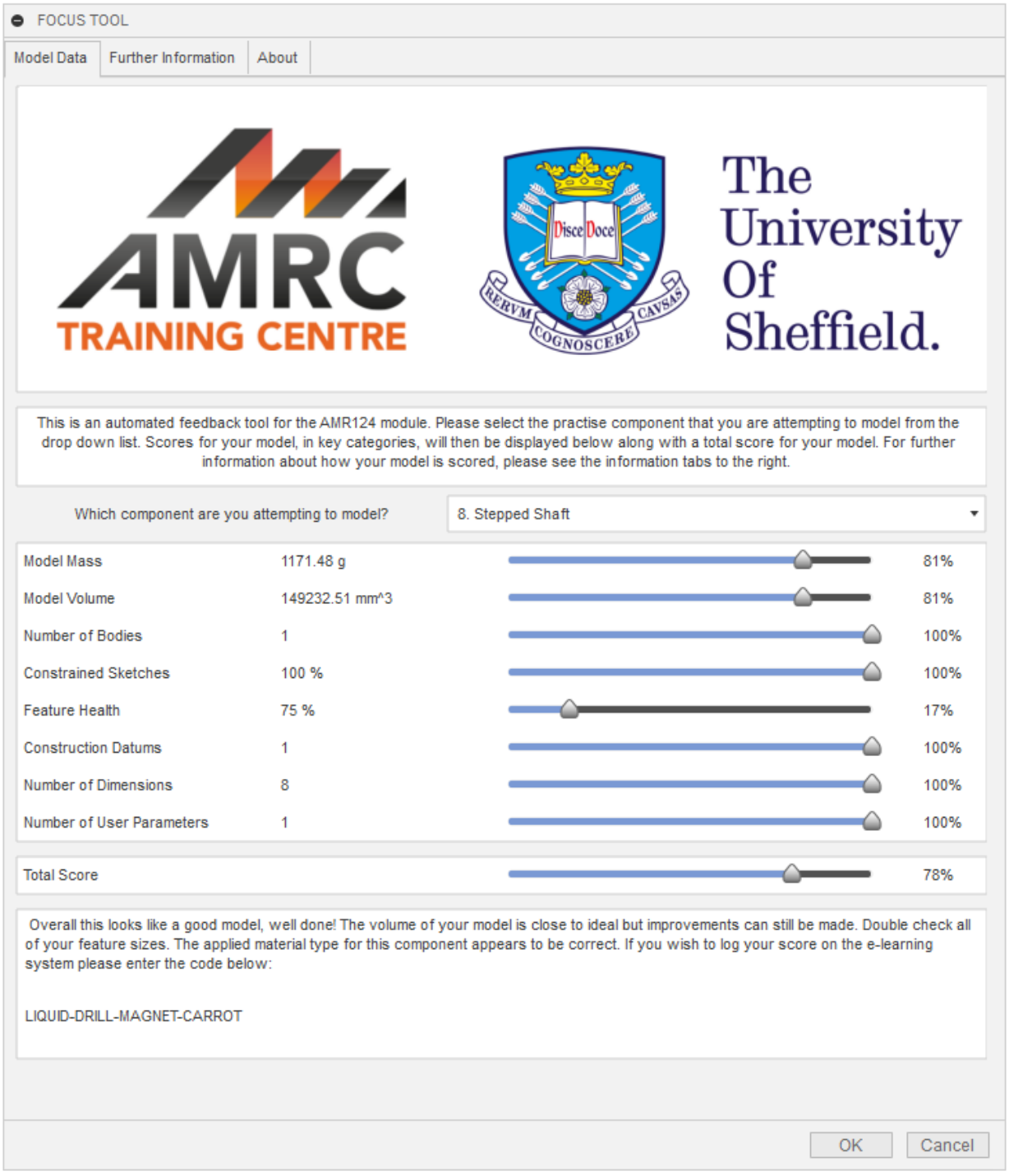

FIGURE 4 – INFORMATION TAB 1 OF THE FOCUS TOOL. ALL KEY INFORMATION IS PRESENTED ON THIS TAB. STUDENT MODEL METRIC INFORMATION IS GIVEN, PROGRESS BARS ALSO SHOW HOW CLOSE TO IDEAL THE STUDENT MODEL IS IN A PARTICULAR CATEGORY. A TOTAL FINAL SCORE IS GIVEN FOR THE MODEL AS WELL AS PLAIN-ENGLISH FEEDBACK (GENERATED FROM A WORD BANK) AND A UNIQUE CODE WORD THAT ALLOWS THE STUDENT SCORE TO BE RECORDED ON A VLE SYSTEM.

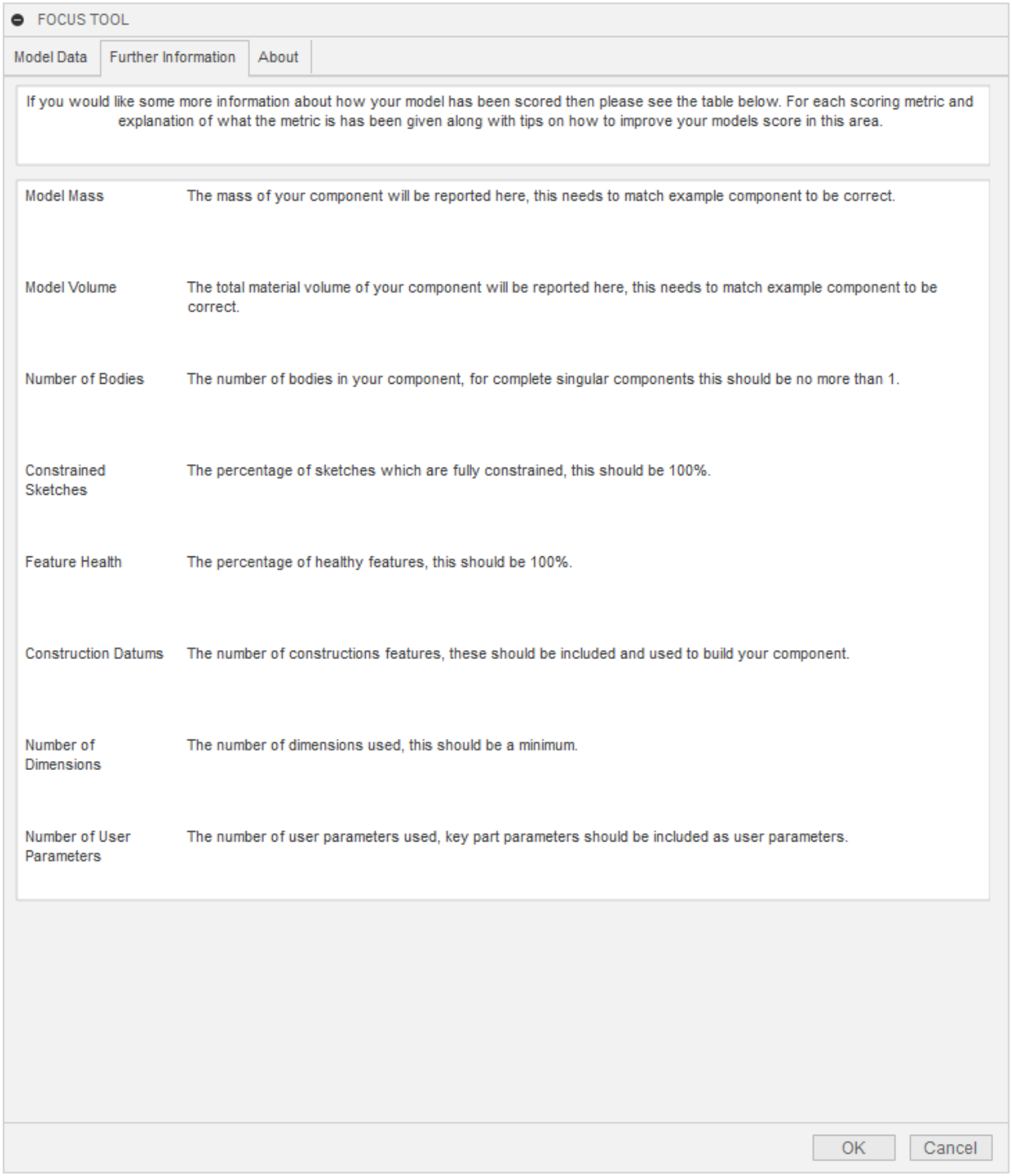

FIGURE 5 – INFORMATION TAB 2 OF THE FOCUS TOOL. HERE GENERAL METRIC DESCRIPTIONS ARE PROVIDED TO THE STUDENT.

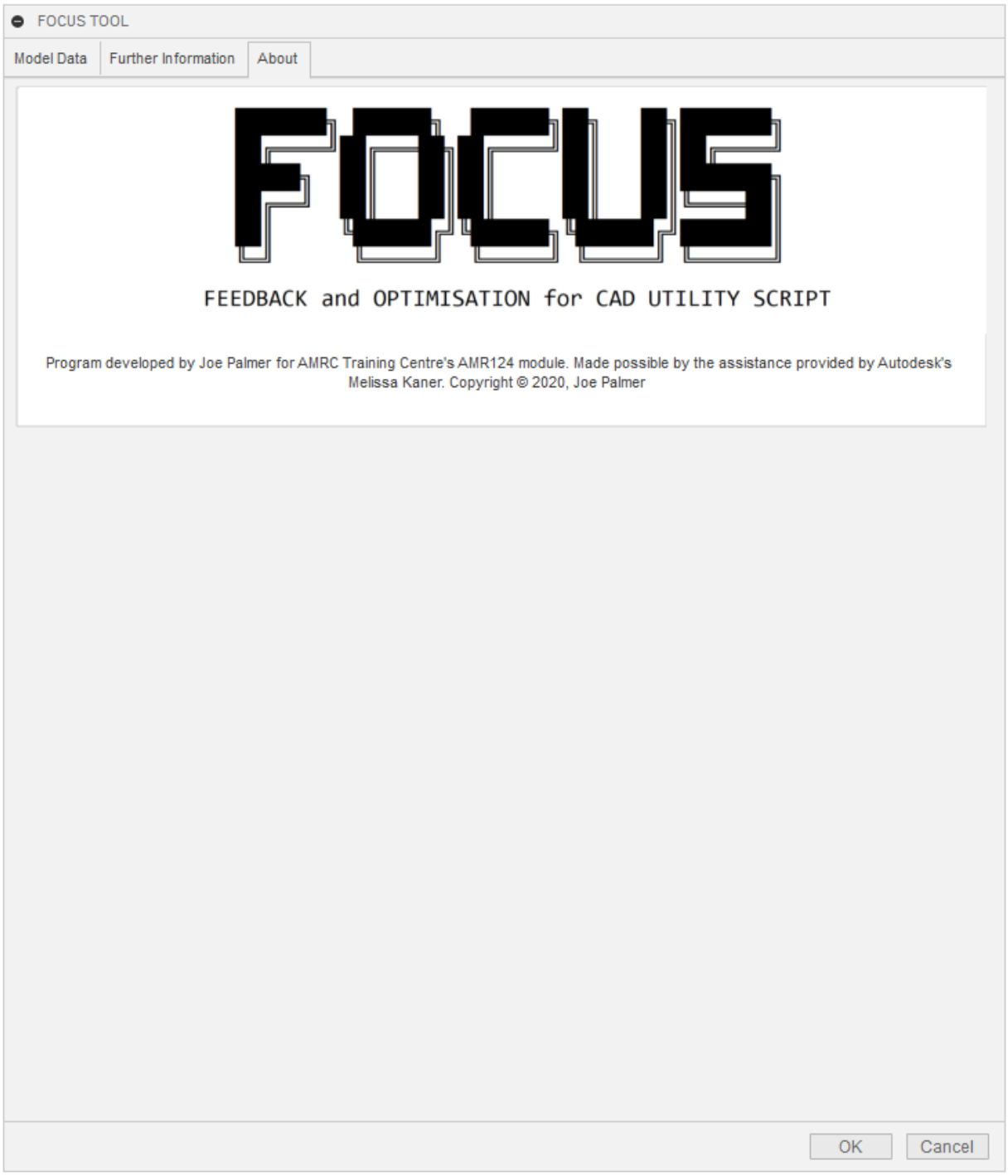

FIGURE 6 – INFORMATION TAB 3 OF THE FOCUS TOOL. GENERAL INFORMATION ABOUT THE TOOL IS GIVEN HERE, ALONG WITH A DOS-INSPIRED ASCII ART LOGO.

Future development of the tool and API

Some minor tweaks are currently being made to FOCUS tool following internal beta testing. Following these updated students in the current 2020/2021 cohort at the AMRC Training Centre will have access to the tool during their learning.

FOCUS tool on the Fusion 360 App Store

FOCUS tool will be heading to the Fusion 360 App store soon! Information keep up with information on this topic, please follow Joe Palmer on Twitter @JoePalmer55

https://twitter.com/joepalmer55

Student perceptions of Automated feedback

Data and research relating to student perceptions of these automated feedback tools, and their effect upon learning is also currently being written up in a research paper. To follow developments on this research, please follow Joe Palmer on Twitter @JoePalmer55

https://twitter.com/joepalmer55

Fusion 360 API development

The current Fusion 360 API is incredibly capable, never the less the team at Autodesk intend to develop the API further:

Recent Enhancements	API development priorities
• Improvements to CAM API allowing for the read and write of CAM properties as well as creating operations from templates. • Improved data access. • Design data improvements. • Upgrades to VS Code developer experience.	• Cloud API's. • Libraries and public data. • Expanding product coverage (Drawings, CAM, Modelling). • Custom features, products and workspaces. • Improved app store delivery, add-in management and developer experience.

Conclusions

The API offers massive potential for creating custom apps and presents an opportunity for improving teaching and student learning. Regardless of a person's experience level use of the API is highly encouraged!.