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

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Lecturer in Manufacturing Technology &
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About the speaker

Joe Palmer MEng CEng SFHEA

Senior Design and Development Engineer for the Advanced Manufacturing Research Centre (AMRC), part of the University of Sheffield.

Lecturer in Manufacturing Technology, for the AMRC Training Centre. Delivering modules for their Degree Apprenticeship course.

Talk Structure

FUSION 360 AND ITS APP STORE

- Fusion 360 App Store example
- Fusion 360 API
- Apps and scripts
- Getting started with development

MOTIVATION FOR DEVELOPING THE FEEDBACK TOOL

- University of Sheffield
- AMRC
- Degree Apprenticeships
- The need for more feedback

TOOL DEVELOPMENT AND THE STUDENT REACTION

- Prototype tool
- What makes a good CAD model
- Tool algorithm
- Feedback from students

NEXT STEPS

- Future development of the tool
- Resources and Links for API
- Future API developments

Who is this Industry Talk for? (Intended Audience)

NEW DEVELOPERS

Those interested in learning about and using the Fusion 360 API. Those wanting to learn more about the API and its capabilities.

EDUCATORS

Educators and Trainers wanting to know more about how automated feedback can be implemented and student attitudes towards this.

USERS

Those interested in using apps and plugins for Fusion 360. Those interested in using the automated feedback tool described in this talk for their own teaching or learning.

EXPERIENCED DEVELOPERS

Developers with considerable experience in using the Fusion 360 API who are looking to further their skills.

Learning Objectives

LEARNING OBJECTIVE 1

Recall that Fusion 360 includes a comprehensive API which can be used as an automation and data insights tool.

LEARNING OBJECTIVE 2

Understand that the API can be used in ways that will enhance the effectiveness of teaching and learning.

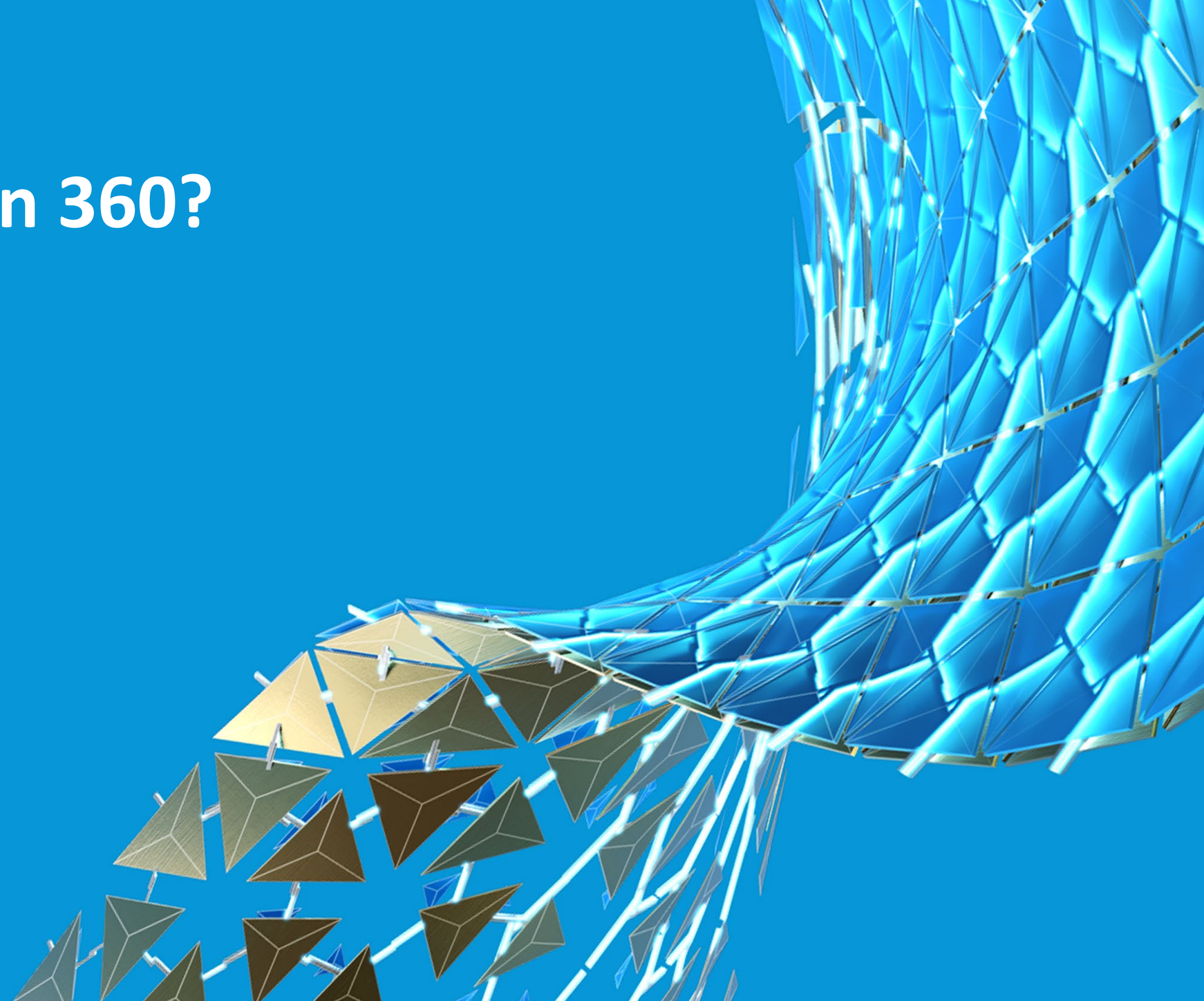
LEARNING OBJECTIVE 3

Be able to locate the user documentation for the Fusion 360 API and have an awareness of some of its capabilities.

LEARNING OBJECTIVE 4

Recall the possible future development plans for the API and how to learn more.

What is Fusion 360?

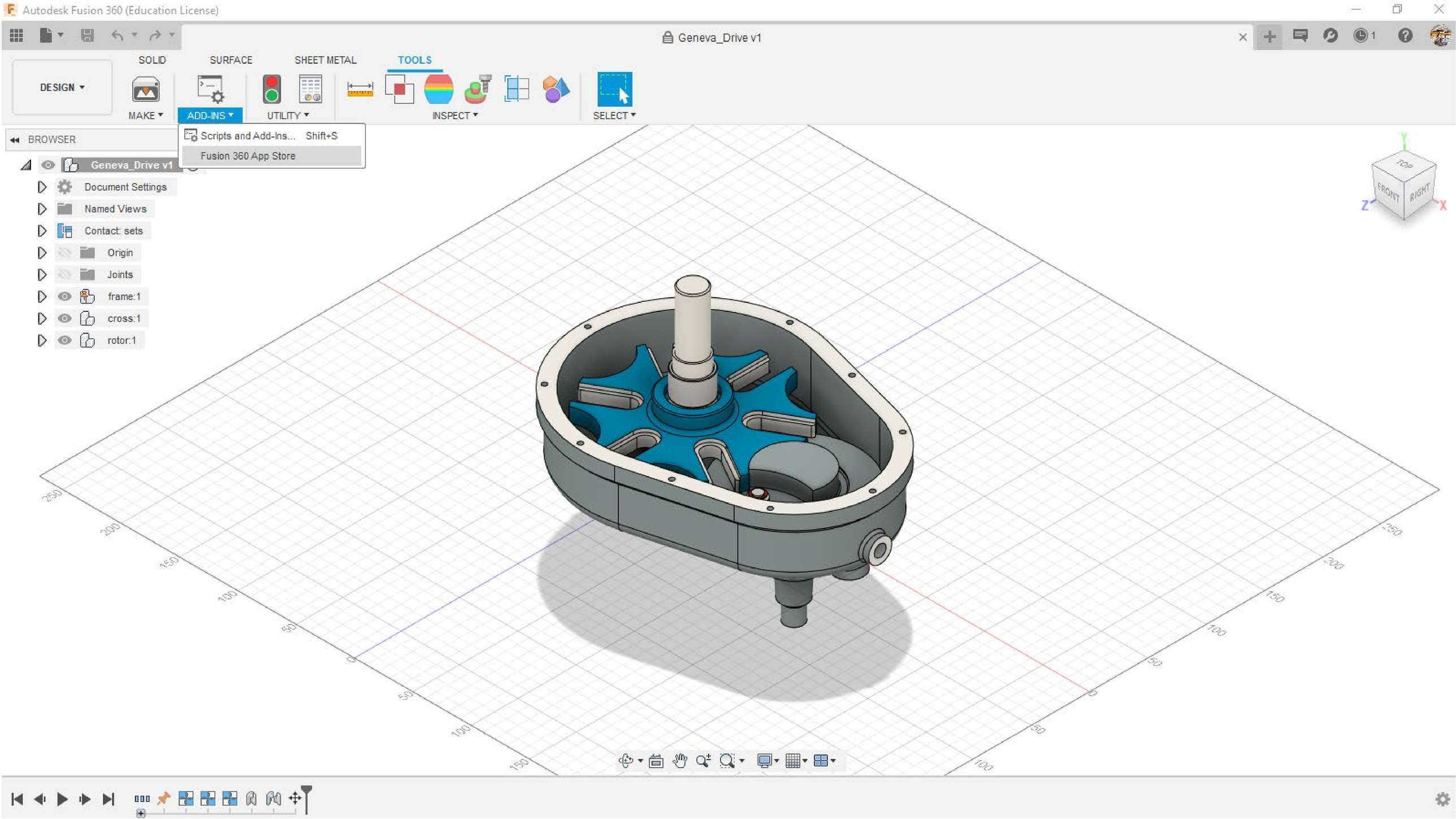


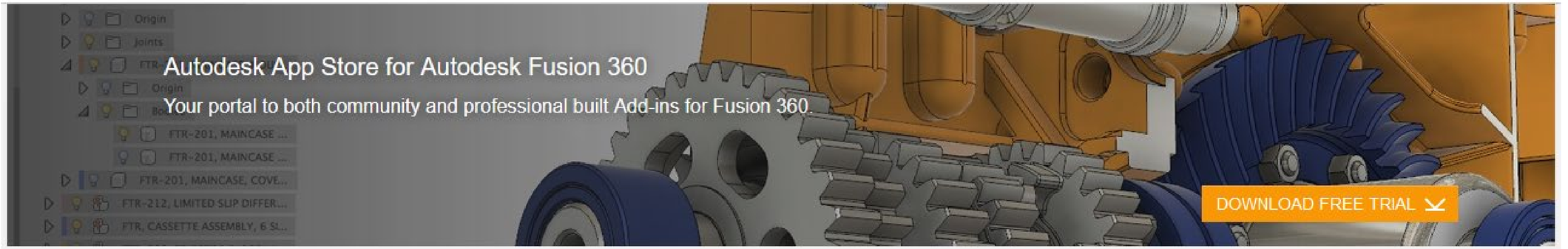
AUTODESK® FUSION 360™

AUTODESK.

Fusion 360 is a cloud-based CAD/CAM tool for collaborative product development that combines industrial design, mechanical engineering, and machine tool programming into one software solution.

Autodesk, Inc.


Autodesk Fusion 360 (Education License)
Geneva_Drive v1
SOLID
SURFACE
SHEET METAL
TOOLS
DESIGN
MAKE
ADD-INS
UTILITY
INSPECT
SELECT
Scripts and Add-Ins... Shift+S
Fusion 360 App Store
BROWSER
Geneva_Drive v1
Document Settings
Named Views
Contact: sets
Origin
Joints
frame:1
cross:1
rotor:1
TOP
FRONT
RIGHT



Fusion 360

- CAE
- CAM
- Data Management
- General Utilities
- Interoperability
- Learning
- Sustainability
- Translator
- Visualization
- Woodworking

Apps | Publishers

Search Apps | Fusion 360 | Show All

Featured Apps

Helical Gear Generator
(28)
Free

SimScale
(3)
Free

Composite Connectors
(2)
Free

Bommer
(8)
Trial

Haas Outpost
(3)
Free

NC Viewer
(1)
Free

SwiftCalcs
(1)
Trial

ExactFlat Online Publisher
(2)
Free

3D Printing App for Autodesk® Fusion 360™
(8)
Free

Dynamo for Autodesk® Fusion 360™
(3)
Free

Most Popular Autodesk Apps

Voronoi Sketch Gen...
(24)
Free

DXF Spline To Polyline
(14)
Free

Sketch Checker
(10)
Free

Intersect Mesh Body
(10)
Free

Helical Gear Generator

Hobbyist: Ross Korsky

(28 reviews)

Tweet

OS: Mac OS | Win64

Language: English

Description

ATTENTION MAC USERS: If you experience issues with the installer please see this article first. *Then if you still have trouble installing the plugin e-mail me (ross.korsky@gmail.com) and I will provide a workaround.*

Helical gears resemble spur gears with the teeth at an angle. They can be meshed in parallel or crossed orientations at 90 degrees or arbitrary angles and can be generated with as little as a single tooth forming a screw gear.

Gears may be specified in either the 'Normal' or the 'Radial' system or the fixed profile Sunderland standard, any of which can be generated as either Left or Right handed. Handedness in helical gears refers to the direction the teeth lean when the gear is placed flat on a table.

Using this add-in, proper Herringbone gears (such as the gears used for this add-in's thumbnail) can be created by using a Sunderland profile then mirroring the gear about one of its faces. In the case of Herringbone or other double-helix gears the handedness of the base gear is not as significant as it is for single helix gears - to effectively change the handedness of a Herringbone / double helix gear all you need to do is flip it over - whereas for a single helix gear it must be mirrored to change its handedness.

Finally, by setting a helix angle of 0 degrees, Spur gears can be created and defined in the metric system (as opposed to the sample Spur Gear script which defines gears in the American system) with this add-in.

Be sure to check out the Gear Down For What YouTube channel and on thingiverse - he is doing some amazing things with Helical Gears!

Read Help Document

About This Version

Version 1.0.4, 5/14/2020

1.0.4
Fix: Fusion May 2020 update breaks loft creation of tooth geometry.

Screenshots and Videos

Free

Download

Add to Wishlist

Download Size:	1.6 MB
Release Date:	12/21/2016
Last Updated:	5/14/2020
Version Info:	1.0.4
Website:	https://www.paypal.me/korsky
Cust. Support:	ross.korsky@gmail.com

Compatible with:

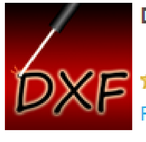
Autodesk Fusion 360

Publisher Information

Hobbyist: Ross Korsky

2 Apps

More apps from this publisher



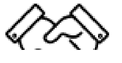
DXF for Laser

(17)

Free

Consulting services for this publisher

Custom Development



Find Service Providers

Connect, consult with, and hire trusted

Geneva_Drive v1

Untitled

DESIGN

SOLID | SURFACE | SHEET METAL | TOOLS

CREATE | MODIFY | ASSEMBLE | CONSTRUCT | INSPECT | INSERT | SELECT

BROWSER

- (Unsa
- Docume
- Named
- Or

CREATE menu:

- New Component
- Create Sketch
- Create Form
- Derive
- Extrude E
- Revolve
- Sweep
- Loft
- Rib
- Web
- Emboss
- Hole H
- Thread
- Box
- Cylinder
- Sphere
- Torus
- Coil
- Pipe
- Pattern
- Mirror
- Thicken
- Boundary Fill
- Create Mesh
- Create Mesh Section Sketch
- Create Base Feature
- Create 3D PCB
- Derive PCB from Sketch
- Helical Gear

Helical or "dry fixed" gears offer a refinement over spur gears.

The leading edges of the teeth are not parallel to the axis of rotation, but are set at an angle. Since the gear is curved, this angling makes the tooth shape a segment of a helix.

Helical gears can be meshed in parallel or crossed orientations.
[From Wikipedia]

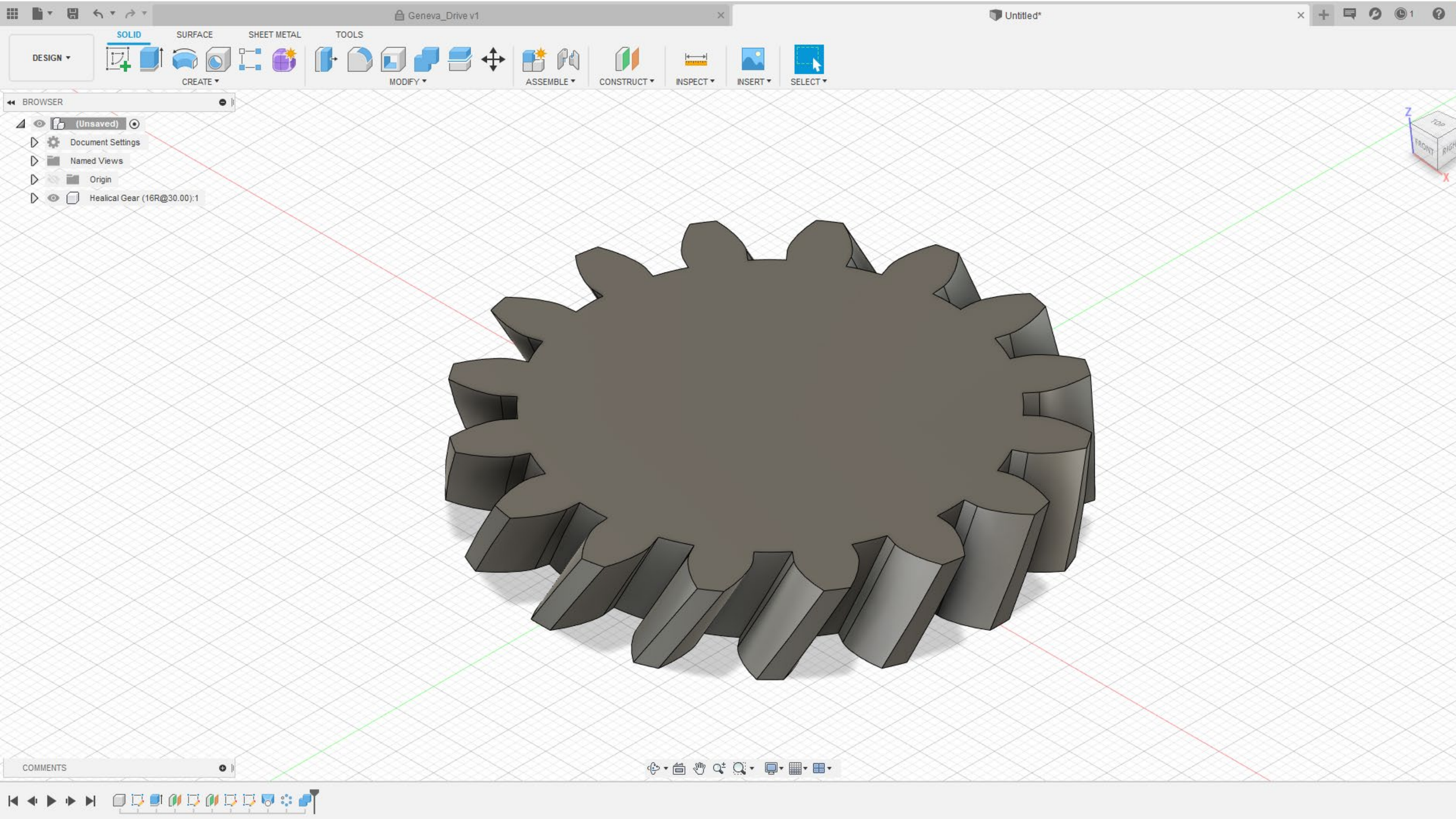
HELICAL GEAR

Gear Standard	Normal System
Handedness	Right
Helix Angle	30 deg
Pressure Angle	20 deg
Module	3 mm
Teeth	16
Backlash	0 mm
Gear Thickness	10 mm
Preview	

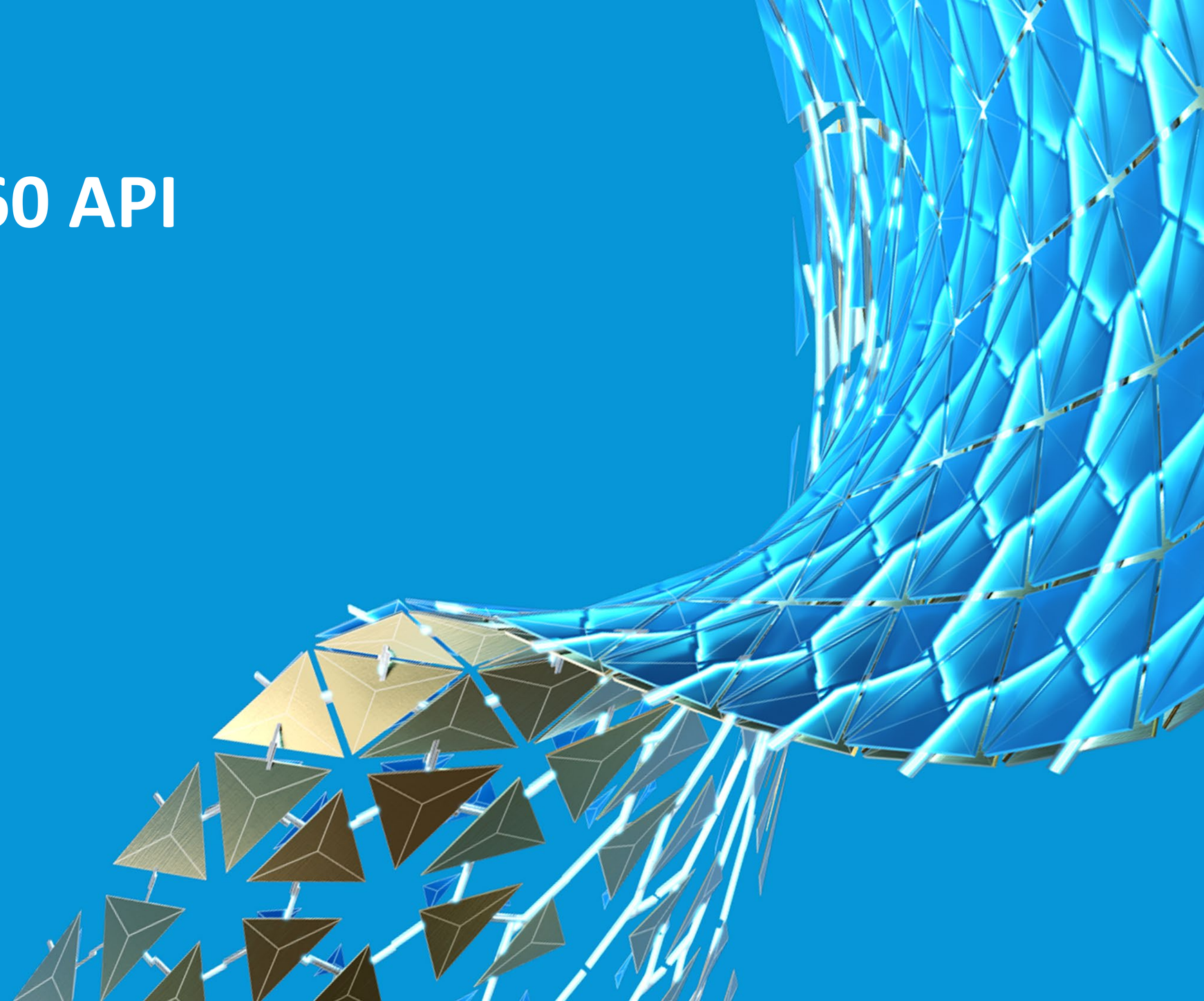
Gear Parameters

OK Cancel

COMMENTS


Geneva_Drive v1
Untitled*
DESIGN
SOLID
SURFACE
SHEET METAL
TOOLS
CREATE
MODIFY
ASSEMBLE
CONSTRUCT
INSPECT
INSERT
SELECT
BROWSER
(Unsaved)
Document Settings
Named Views
Origin
Healical Gear (16R@30.00):1
COMMENTS

The Fusion 360 API



"A set of functions and procedures allowing the creation of applications that access the features or data of an operating system, application, or other service."

Oxford Languages, 2020

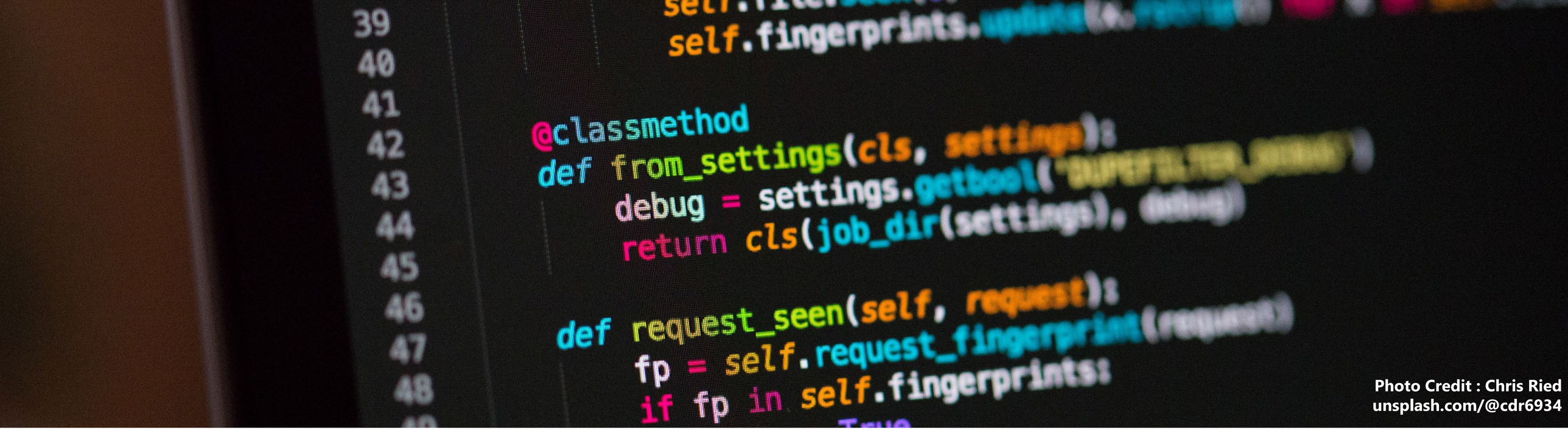


Photo Credit : Chris Ried
unsplash.com/@cdr6934

API

- Application Programming Interface
- Allows two pieces of computer software to talk to one another by using a pre-agreed list of commands.
- For some software, this list of commands is very small
- For Fusion 360, quite the opposite is true, its API is huge….

AUTODESK® Fusion 360 API Object Model

AUTODESK.

Application

- Application
- ApplicationEvent
- CustomEvent
- Data
  - DataHubs
    - DataHub
      - DataProjects
        - DataProject
          - DataFolder
            - DataFolders
              - DataFolder
              - DataFiles
                - DataFile
- FavoriteAppearances
- FavoriteMaterials
- ImportManager
  - ImportOptions (CC)
  - DXF2DImportOptions
  - FusionArchiveImportOptions (CC)
  - IGESImportOptions (CC)
  - SATImportOptions (CC)
  - SMTImportOptions (CC)
  - STEPImportOptions (CC)
- MaterialLibraries
  - MaterialLibrary
    - Materials
      - Material
        - Properties
          - Property
        - Appearances
          - Appearance
            - Properties
              - Property [CC]
              - AppearanceTexture (CC)
              - AppearanceTextureProperty (CC)
              - BooleanProperty (CC)
              - ChoiceProperty (CC)
              - ColorProperty (CC)
              - FilenameProperty (CC)
              - FloatProperty (CC)
              - IntegerProperty (CC)
              - StringProperty (CC)
- Preferences
  - GeneralPreferences
  - GraphicsPreferences
  - GridPreferences
  - MaterialPreferences
  - NetworkPreferences
  - ProductUsageData
  - UnitAndValuePreferences
  - DefaultUnitsPreferencesCollection
    - DefaultUnitsPreferences [M]
    - FusionDefaultUnitsPreferences (M)
  - ProductPreferencesCollection
    - ProductPreferences [N]
    - FusionProductPreferences (N)
- User
- ViewPort
  - Camera
- WebRequestEvent
- UserInterface
  - ApplicationCommandEvent
  - CommandDefinitions
    - CommandDefinition
      - ControlDefinition [U]
        - ButtonControlDefinition (U)
        - CheckBoxControlDefinition (U)
        - ListControlDefinition (U)
          - ListItems
            - ListItem
      - CommandCreatedEvent
        - Command
          - CommandInputs
            - CommandInput [W]
              - AngleValueCommandInput (W)
              - BoolValueCommandInput (W)
              - ButtonRowCommandInput (W)
              - DirectionCommandInput
              - DistanceValueCommandInput
              - DropDownCommandInput (W)
              - FloatSliderCommandInput (Z)
              - FloatSpinnerCommandInput (W)
              - GroupCommandInput (W)
              - ImageCommandInput (W)
              - IntegerSliderCommandInput (Z)
              - IntegerSpinnerCommandInput (W)
              - MultiSelectCommandInput (W)
                - ListItems
                  - ListItem
              - RadioButtonCommandInput (W)
              - SelectionCommandInput (W)
              - SliderCommandInput (W) [Z]
              - StringValueCommandInput (W)
              - TabCommandInput (W)
              - TableCommandInput (W)
              - TextBoxCommandInput (W)
              - ValueCommandInput (W)
              - TableCommandInput (W)
          - CommandEvent
          - InputChangedEvent
          - KeyboardEvent
          - MouseEvent
          - SelectionEvent
          - ValidateInputsEvent
  - DocumentEvent
  - FileDialog
  - FolderDialog
  - MarkingMenuEvent
    - MarkingMenuEventArgs
      - LinearMarkingMenu
      - RadialMarkingMenu
  - Palettes
    - Palette [FF]
      - TextCommandPalette (FF)
  - ProgressDialog
  - ToolbarPanelList
    - ToolbarPanel
      - ToolbarControls
        - ToolbarControl [V]
        - CommandControl (V)
        - DropDownControl (V)
        - SeperatorControl (V)
        - SplitButtonControl (V)
  - Toolbars
    - Toolbar
  - Workspaces
    - Workspace
      - ToolbarPanels
      - WorkspaceEvent
- Documents
  - FusionDocument (O)
    - Selections
    - Design (A)
      - ExportManager
        - ExportOptions [AA]
        - FusionArchiveExportOptions (AA)
        - IGESExportOptions (AA)
        - IGESExportOptions (AA)
        - SATExportOptions (AA)
        - SMTExportOptions (AA)
        - STEPExportOptions (AA)
        - STLExportOptions (AA)
      - Components
        - ContactSets
          - ContactSet
        - FusionUnitsManager
        - InterferenceResults
          - InterferenceResult
            - InterferenceInput
        - ParameterList
          - Parameter [P]
      - Timeline
        - TimelineGroups
          - TimelineGroup
        - TimelineObject
      - UserParameters
        - UserParameter (P)
      - Snapshots
        - Snapshot
    - CAM (A)
      - GenerateToolpathFuture
      - MachiningTime
      - Setups
        - Setup
          - CAMFolders
            - CAMFolder
          - CAMPatterns
            - CAMPattern
          - ChildOperationList
          - Operations
            - Operation
    - Component
      - CustomGraphicsGroups
      - PhysicalProperties
      - ModelParameters
        - ModelParameter (P)
      - Features
        - Feature [K]
        - BaseFeatures
          - BaseFeature (K)
        - BoundaryFillFeatures
          - BoundaryFillFeature (K)
            - BRepCells
              - BRepCell
            - BoundaryFillFeatureInput
        - BoxFeatures
          - BoxFeature (K)
        - ChamferFeatures
          - ChamferFeature (K)
            - ChamferTypeDefinition [X]
            - DistanceAndAngleChamferTypeDefinition (X)
            - EqualDistanceChamferTypeDefinition (X)
            - TwoDistancesChamferTypeDefinition (X)
          - ChamferFeatureInput
        - CircularPatternFeatures
          - CircularPatternFeature (K)
          - CircularPatternFeatureInput
          - PatternElements
            - PatternElement
        - CoilFeatures
          - CoilFeature (K)
        - CopyPasteBodies
          - CopyPasteBody
        - CutPasteBodies
          - CutPasteBody
        - CylinderFeatures
          - CylinderFeature (K)
        - DeleteFaceFeatures
          - DeleteFaceFeature (K)
        - DraftFeatures
          - DraftFeature (K)
          - DraftFeatureInput
        - ExtendFeatures
          - ExtendFeature (K)
          - ExtendFeatureInput
        - ExtrudeFeatures
          - ExtrudeFeature (K)
            - ExtentDefinition [L]
              - FromEntityStartDefinition (L)
              - OffsetStartDefinition (L)
              - ProfilePlaneStartDefinition (L)
              - SymmetricExtentDefinition (L)
              - ThroughAllExtentDefinition (L)
              - ToEntityExtentDefinition (L)
            - ExtrudeFeatureInput
        - FilletFeatures
          - FilletFeature (K)
            - FilletEdgeSets
              - FilletEdgeSet [Y]
                - ChordLengthFilletEdgeSet (Y)
                - ConstantRadiusFilletEdgeSet (Y)
                - VariableRadiusFilletEdgeSet (Y)
          - FilletFeatureInput
        - FormFeatures
          - FormFeature (K)
        - HoleFeatures
          - HoleFeature (K)
            - ExtentDefinition [L]
              - AllExtentDefinition (L)
              - DistanceExtentDefinition (L)
              - OneSideToExtentDefinition (L)
              - SketchPointHolePositionDefinition (L)
              - HolePositionDefinition [DD]
              - AllCenterHolePositionDefinition (DD)
              - OnEdgeHolePositionDefinition (DD)
              - PlaneAndOffsetHolePositionDefinition (DD)
              - PointHolePositionDefinition (DD)
              - SketchPointsHolePositionDefinition (DD)
          - HoleFeatureInput
        - LoftFeatures
          - LoftFeature (K)
            - LoftCenterLineOrRails
              - LoftCenterLineOrRail
            - LoftSections
              - LoftSection
                - LoftEndCondition [EE]
                - LoftDirectionEndCondition (EE)
                - LoftFreeEndCondition (EE)
                - LoftPointSharpEndCondition (EE)
                - LoftPointTangentEndCondition (EE)
                - LoftSmoothEndCondition (EE)
                - LoftTangentEndCondition (EE)
          - LoftFeatureInput
        - MirrorFeatures
          - MirrorFeature (K)
          - MirrorFeatureInput
          - PatternElements
            - PatternElement
        - MoveFeatures
          - MoveFeature (K)
          - MoveFeatureInput
        - OffsetFacesFeatures
          - OffsetFacesFeature
        - OffsetFeatures
          - OffsetFeature (K)
          - OffsetFeatureInput
        - PatchFeatures
          - PatchFeature (K)
          - PatchFeatureInput
        - PathPatternFeatures
          - PathPatternFeature (K)
          - PathPatternFeatureInput
          - PatternElements
            - PatternElement
        - PipeFeatures
          - PipeFeature (K)
        - RectangularPatternFeatures
          - RectangularPatternFeature (K)
          - RectangularPatternFeatureInput
          - PatternElements
            - PatternElement
        - RemoveFeatures
          - RemoveFeature (K)
        - ReplaceFaceFeatures
          - ReplaceFaceFeature (K)
          - ReplaceFaceFeatureInput
        - ReverseNormalFeatures
          - ReverseNormalFeature (K)
        - RevolveFeatures
          - RevolveFeature (K)
            - AngleExtentDefinition (L)
            - ExtentDefinition [L]
            - OneSideToExtentDefinition (L)
            - TwoSideAngleExtentDefinition (L)
            - TwoSideToExtentDefinition (L)
          - RevolveFeatureInput
        - RibFeatures
          - RibFeature (K)
        - RuleFilletFeatures
          - RuleFilletFeature (K)
        - ScaleFeatures
          - ScaleFeature (K)
          - ScaleFeatureInput
        - ShellFeatures
          - ShellFeature (K)
          - ShellFeatureInput
        - SilhouetteSplitFeatures
          - SilhouetteSplitFeature (K)
          - SilhouetteSplitFeatureInput
        - SphereFeatures
          - SphereFeature (K)
        - SplitBodyFeatures
          - SplitBodyFeature (K)
          - SplitBodyFeatureInput
        - SplitFaceFeatures
          - SplitFaceFeature (K)
          - SplitFaceFeatureInput
        - StitchFeatures
          - StitchFeature (K)
          - StitchFeatureInput
        - SurfaceDeleteFaceFeatures
          - SurfaceDeleteFaceFeature (K)
        - SweepFeatures
          - SweepFeatureInput
          - SweepFeature (K)
        - ThickenFeatures
          - ThickenFeature (K)
          - ThickenFeatureInput
        - ThreadFeatures
          - ThreadDataQuery
          - ThreadFeature (K)
            - ThreadInfo
          - ThreadFeatureInput
        - TorusFeatures
          - TorusFeature (K)
        - TrimFeatures
          - TrimFeatureInput
          - TrimFeature (K)
        - UnstitchFeatures
          - UnstitchFeature (K)
        - WebFeatures
          - WebFeature (K)
      - MeshBodies
        - MeshBody
          - PolygonMesh
            - TriangleMesh
      - BRepBodies
        - BRepBody
          - PhysicalProperties
          - MeshManager
            - TriangleMeshCalculator
            - TriangleMesh
            - TriangleMeshList
              - TriangleMesh
          - BRepLumps
            - BRepLump
              - BRepShells
                - BRepShell
                  - BRepFaces
                    - BRepFace
                      - SurfaceEvaluator
                      - MeshManager
                      - BRepLoops
                        - BRepEdges
                          - BRepEdge
                            - BRepVertices
                              - BRepVertex
                            - CurveEvaluator3D
                        - BRepLoop
                          - BRepCoEdges
                            - BRepCoEdge
                              - CurveEvaluator2D
      - AsBuiltJoints
        - AsBuiltJoint
        - AsBuiltJointInput
      - ContactSets
        - ContactSet
      - Joints
        - Joint
          - JointGeometry
          - JointMotion [BB]
            - BallJointMotion (BB)
              - JointLimits
            - CylindricalJointMotion (BB)
              - JointLimits
            - PinSlotJointMotion (BB)
              - JointLimits
            - PlanarJointMotion (BB)
              - JointLimits
            - RevoluteJointMotion (BB)
              - JointLimits
            - RigidJointMotion (BB)
            - SliderJointMotion (BB)
              - JointLimits
          - JointInput
      - JointOrigins
        - JointOrigin
        - JointOriginInput
      - Occurrences
        - Occurrence
          - Component
          - OccurrenceList
            - Occurrence
          - PhysicalProperties
      - RigidGroups
        - RigidGroup
      - Sketches
        - Sketch
          - SketchEntity [Q]
          - Profiles
            - Profile
              - AreaProperties
              - ProfileLoops
                - ProfileLoop
                  - ProfileCurves
                    - ProfileCurve
          - SketchCurves
            - SketchCurve [R] (Q)
            - SketchArcs
              - SketchArc (R)
            - SketchCircles
              - SketchCircle (R)
            - SketchConicCurves
              - SketchConicCurve
            - SketchEllipses
              - SketchEllipse (R)
            - SketchEllipticalArcs
              - SketchEllipticalArc (R)
            - SketchFittedSplines
              - SketchFittedSpline (R)
            - SketchFixedSplines
              - SketchFixedSpline (R)
            - SketchLines
              - SketchLine (R)
          - SketchPoints
            - SketchPoint (Q)
            - SketchEntityList
          - SketchTexts
            - SketchText (Q)
            - SketchTextInput
          - SketchDimensions
            - SketchDimension [T]
            - SketchAngularDimension (T)
            - SketchConcentricCircleDimension (T)
            - SketchDiameterDimension (T)
            - SketchEllipseMajorRadiusDimension (T)
            - SketchEllipseMinorRadiusDimension (T)
            - SketchLinearDimension (T)
            - SketchOffsetCurvesDimension (T)
            - SketchOffsetDimension (T)
            - SketchRadialDimension (T)
          - GeometricConstraints
            - GeometricConstraint [S]
              - CircularPatternConstraint (S)
              - CoincidentConstraint (S)
              - CollinearConstraint (S)
              - ConcentricConstraint (S)
              - EqualConstraint (S)
              - HorizontalConstraint (S)
              - HorizontalPointsConstraint (S)
              - MidPointConstraint (S)
              - ParallelConstraint (S)
              - PerpendicularConstraint (S)
              - PolygonConstraint (S)
              - RectangularPatternConstraint (S)
              - SmoothConstraint (S)
              - SymmetryConstraint (S)
              - TangentConstraint (S)
              - VerticalConstraint (S)
              - VerticalPointsConstraint (S)
      - ConstructionAxes
        - ConstructionAxisInput
        - ConstructionAxis
          - ConstructionAxisDefinition [E]
            - ConstructionAxisByLineDefinition (E)
            - ConstructionAxisCircularFaceDefinition (E)
            - ConstructionAxisEdgeDefinition (E)
            - ConstructionAxisNormalToFaceAtPointDefinition (E)
            - ConstructionAxisPerpendicularAtPointDefinition (E)
            - ConstructionAxisTwoPlaneDefinition (E)
            - ConstructionAxisTwoPointDefinition (E)
      - ConstructionPlanes
        - ConstructionPlaneInput
        - ConstructionPlane
          - ConstructionPlaneDefinition [D]
            - ConstructionPlaneAtAngleDefinition (D)
            - ConstructionPlaneDistanceOnPathDefinition (D)
            - ConstructionPlaneMidplaneDefinition (D)
            - ConstructionPlaneByPlaneDefinition (D)
            - ConstructionPlaneOffsetDefinition (D)
            - ConstructionPlaneTangentAtPointDefinition (D)
            - ConstructionPlaneTangentDefinition (D)
            - ConstructionPlaneThreePointsDefinition (D)
            - ConstructionPlaneTwoEdgesDefinition (D)
      - ConstructionPoints
        - ConstructionPointInput
        - ConstructionPoint
          - ConstructionPointDefinition [F]
            - ConstructionPointCenterDefinition (F)
            - ConstructionPointDefinition (F)
            - ConstructionPointEdgePlaneDefinition (F)
            - ConstructionPointDistanceDefinition (F)
            - ConstructionPointThreePlanesDefinition (F)
            - ConstructionPointTwoEdgesDefinition (F)
  - Document [O]
    - DocumentReferences
      - DocumentReference
    - Products
      - Product [A]

Custom Graphics

- CustomGraphicsGroups
  - CustomGraphicsGroup (GG)
    - CustomGraphicsEntity [GG]
      - CustomGraphicsColorEffect [HH]
      - CustomGraphicsAppearanceColorEffect (HH)
      - CustomGraphicsBasicMaterialColorEffect (HH)
      - CustomGraphicsSolidColorEffect (HH)
      - CustomGraphicsVertexColorEffect (HH)
      - CustomGraphicsBillBoard
      - CustomGraphicsViewPlacement
      - CustomGraphicsViewScale
      - CustomGraphicsBRepBody (GG)
      - CustomGraphicsGroup (GG)
      - CustomGraphicsLines (GG)
      - CustomGraphicsMesh (GG)
      - CustomGraphicsPointSet (GG)
      - CustomGraphicsCurve (GG)

3D Math

- BoundingBox3D
- Matrix3D
- Vector3D

2D Math

- BoundingBox2D
- Matrix2D
- Vector2D

Surface Geometry

- Surface [J]
  - SurfaceEvaluator
- Cone (J)
- Cylinder (J)
- EllipticalCone (J)
- EllipticalCylinder (J)
- NurbsSurface (J)
- Plane (J)
- Sphere (J)
- Torus (J)

3D Wireframe Geometry

- Curve3D [H]
  - CurveEvaluator3D
- Arc3D (H)
- Circle3D (H)
- Ellipse3D (H)
- EllipticalArc3D (H)
- InfiniteLine3D (H)
- Line3D (H)
- NurbsCurve3D (H)
- Point3D

2D Geometry

- Curve2D [G]
  - CurveEvaluator2D
- Arc2D (G)
- Circle2D (G)
- Ellipse2D (G)
- EllipticalArc2D (G)
- Line2D (G)
- NurbsCurve2D (G)
- Point2D
- CurveEvaluator2D

Miscellaneous

- Entity
  - Attributes
    - Attribute
- Color
- ObjectCollection
- Path
  - PathEntity
- ValueInput

Legend

- Collection Objects: Objects
- Standard Objects: Object
- Base Class Objects: [X]
- Derived Objects: (X)
- Modeling Related Objects:
- Assembly Related Objects:
- User Interface Related Objects:
- Construction Geometry Objects:
- Body Related Objects:
- Sketch Related Objects:

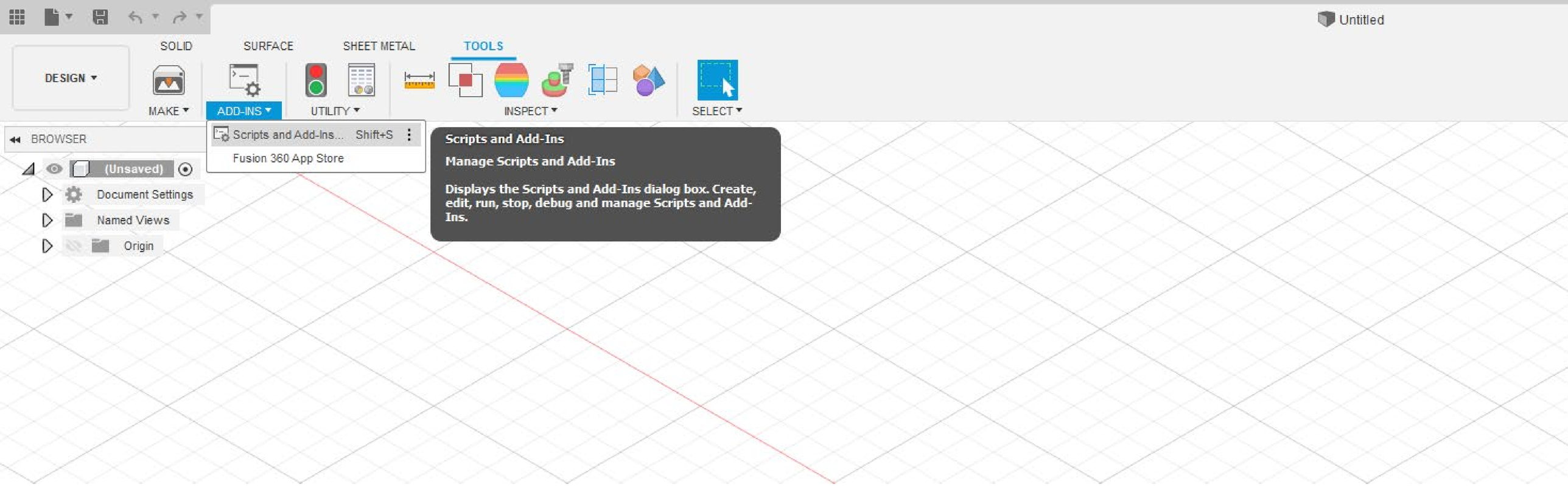
September 21, 2017

API Accessibility

- API Access for some CAD packages is restricted.
- For Fusion 360 the API is free to use, available to all and included with the basic installation of Fusion 360.
- Resources are also provided to help user with their development project.

Choice of Programming Language

- The Fusion 360 API supports Python, C++ and JavaScript programming languages.
- JavaScript support ends in December.
- For engineers and those new to programming I would recommend Python.



Scripts and Add-ins

- Custom code files are placed in the *AppData* directory for Fusion 360 either manually or by using an installer.
- This custom code can then be run from inside Fusion 360.
- Code which is run at startup and is accessible via a toolbar icon is known as an add-in. Code which is only run when the user selects the code file is known as a script.

Learning Resources

- https://www.learnpython.org/
- https://www.learn-cpp.org/

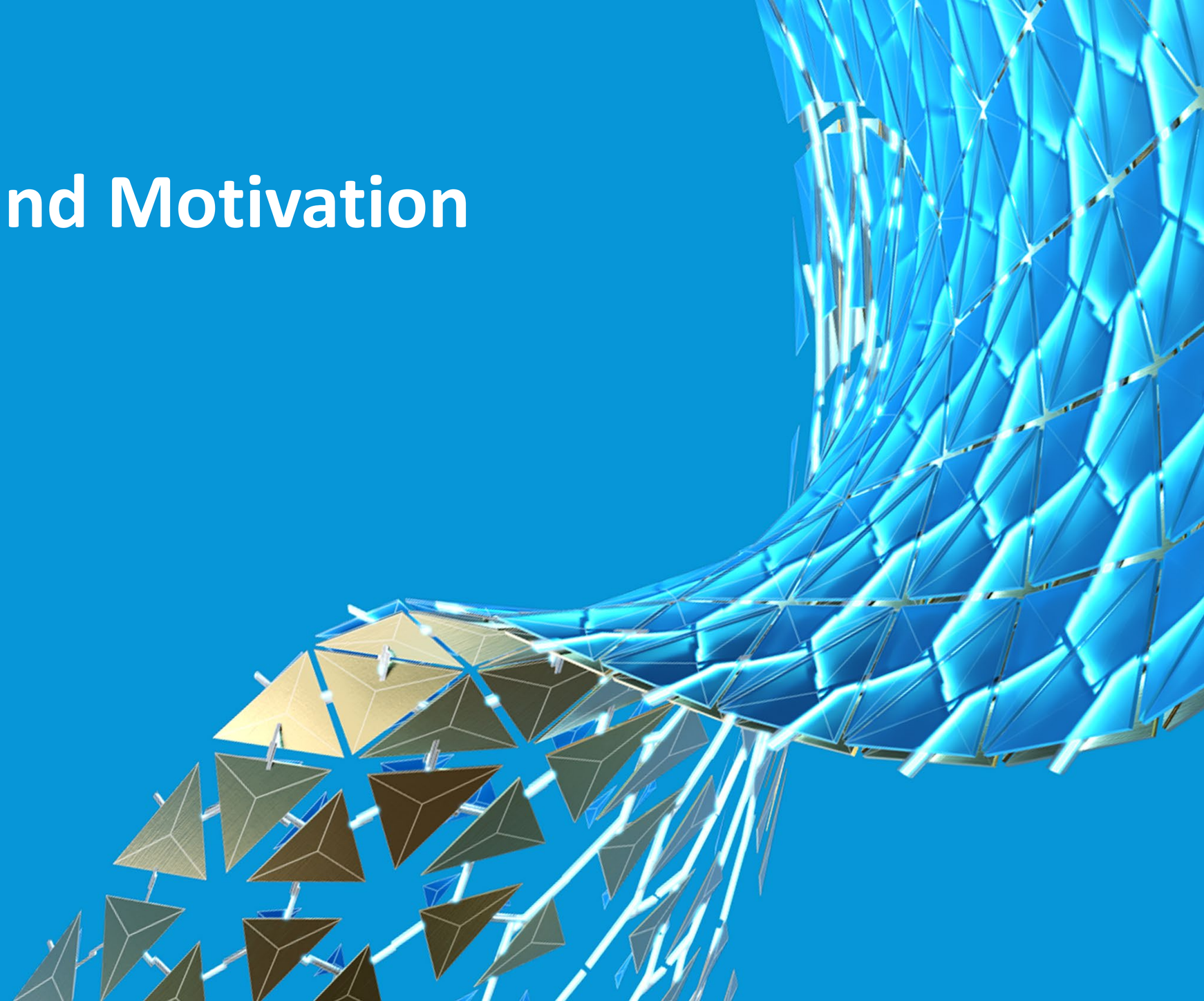
- **Two great resources that allow you to program in the browser and see results in real time; no additional software required.**

Learning Resources

- Fusion 360 on GitHub
- Autodesk Fusion 360 API forums
- Fusion 360 API product documentation
- Fusion 360 API reference manual

- Links for these resources are provided in the handout.

Background and Motivation

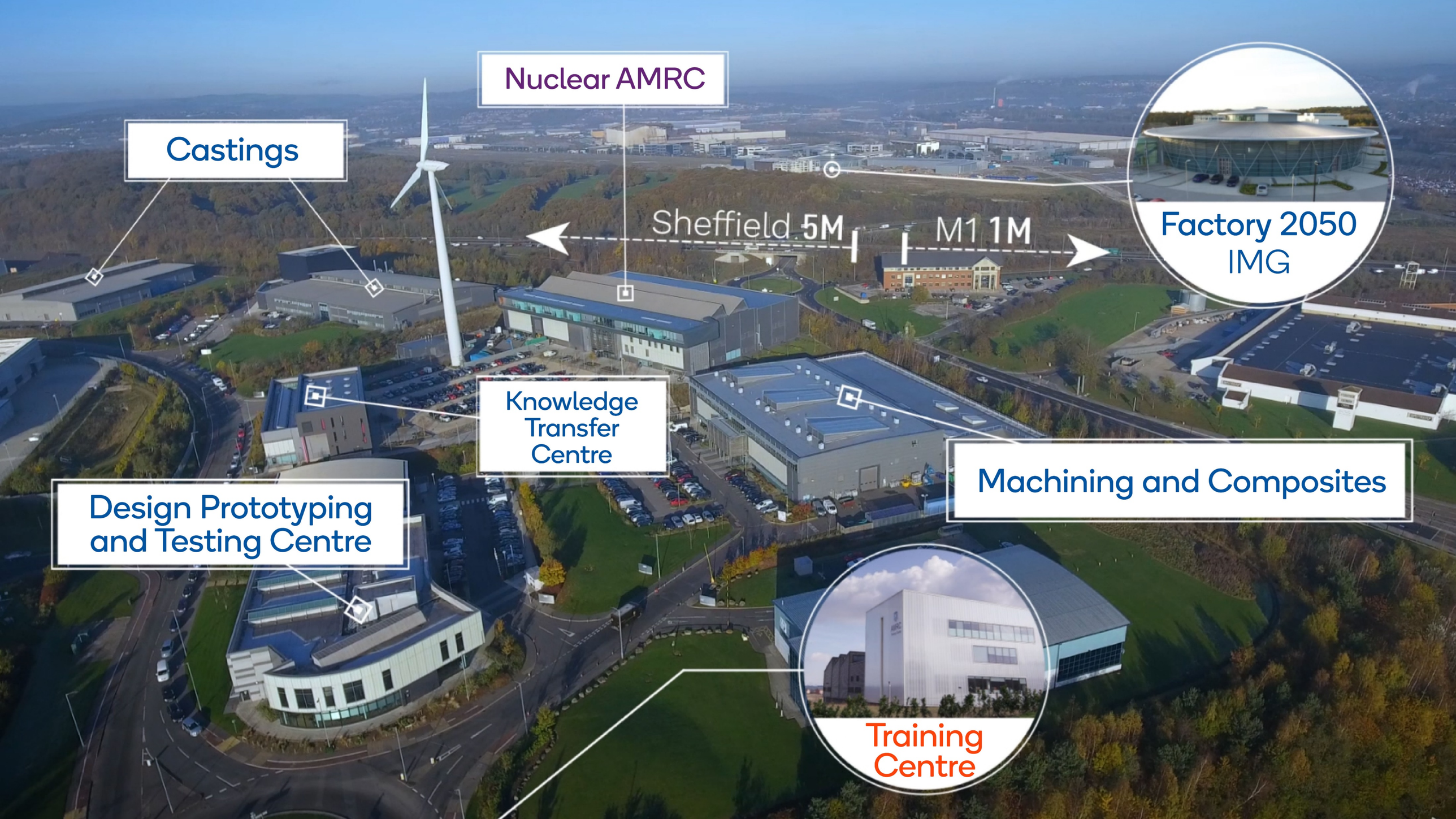


AMRC
ADVANCED MANUFACTURING RESEARCH CENTRE

The University Of Sheffield.

Advanced Manufacturing Park

Located just of Junction 33 of the M1, near Sheffield.


Nuclear AMRC
Castings
Sheffield 5M
M1 1M
Factory 2050
IMG
Knowledge
Transfer
Centre
Design Prototyping
and Testing Centre
Machining and Composites
Training
Centre

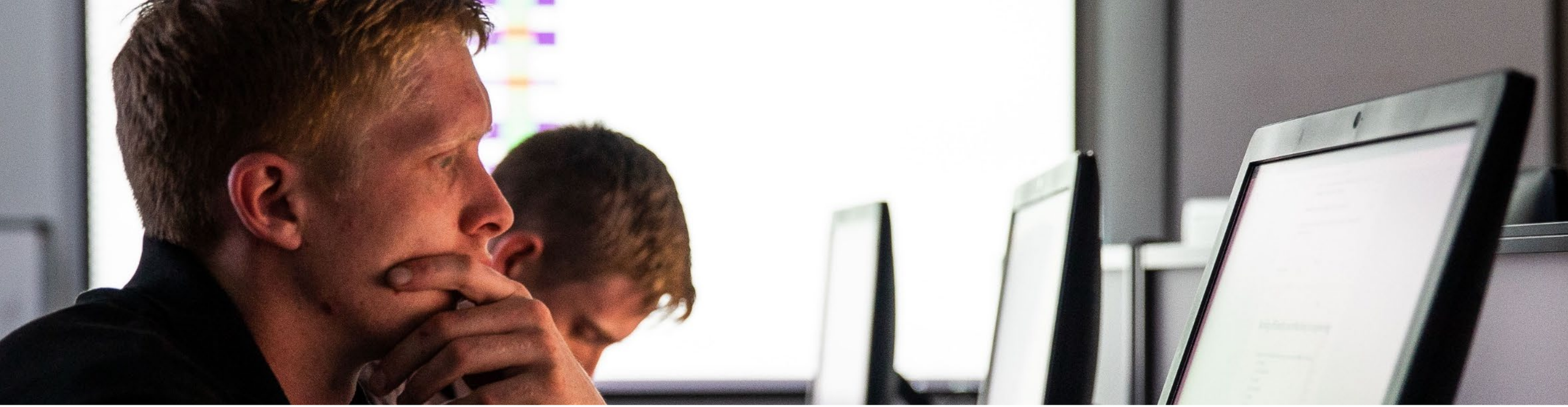
AMRC Training Centre

AMRC Training Centre

- **Part of the University of Sheffield AMRC.**
- **Built in 2014 with the aim of training apprentices for local engineering businesses.**
- **“State-of-the-art” shop floor facilities, including CNC machining centres, robotics, welding and electronics.**
- **Offers a wide variety of different qualification levels.**

Degree Apprenticeships

- **Offers an alternative path to traditional 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.**



CAD and CAM instruction

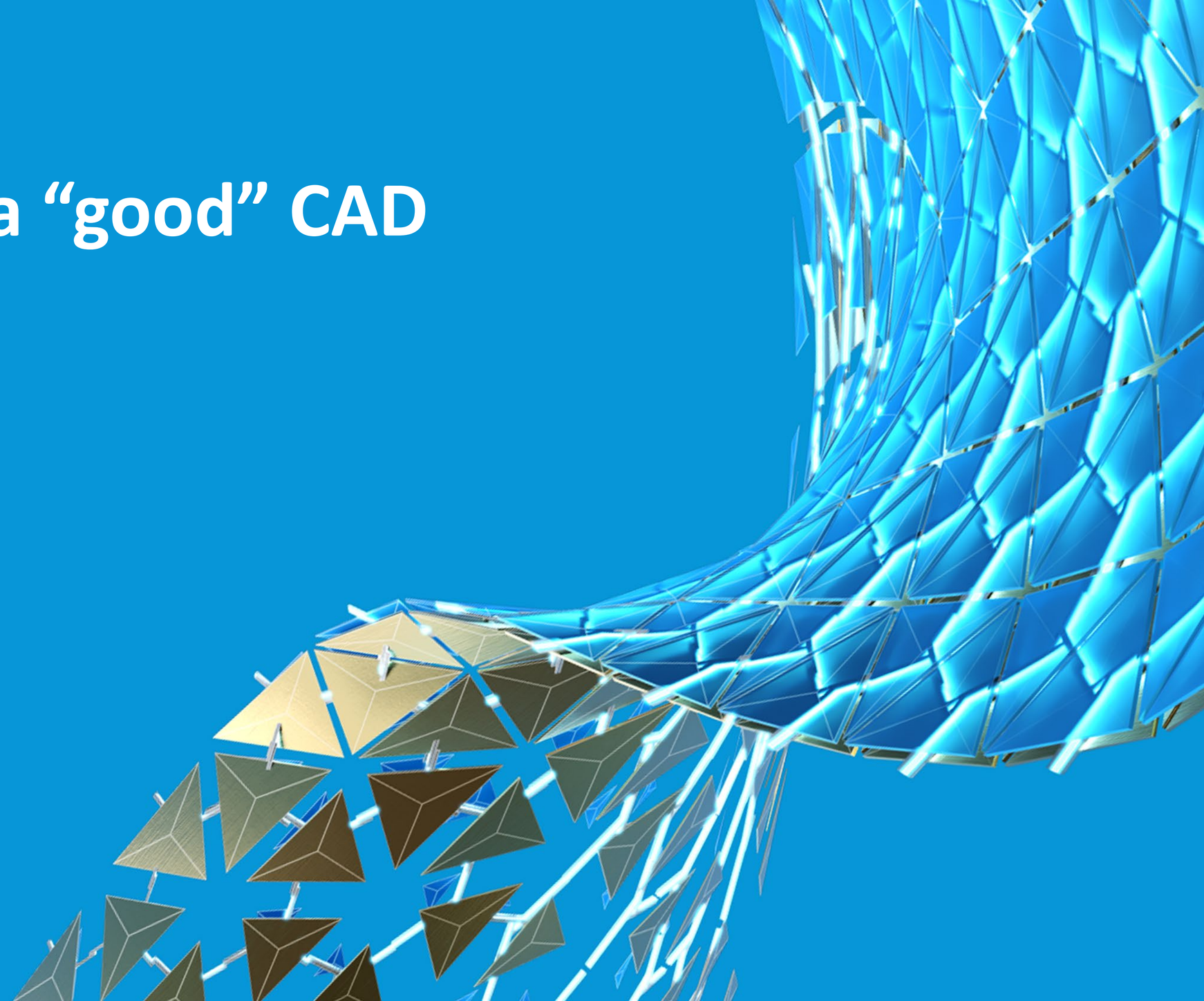
All Degree programs offered by AMRC Training Centre contain a common first year module, Introduction to Design and CAD CAM.

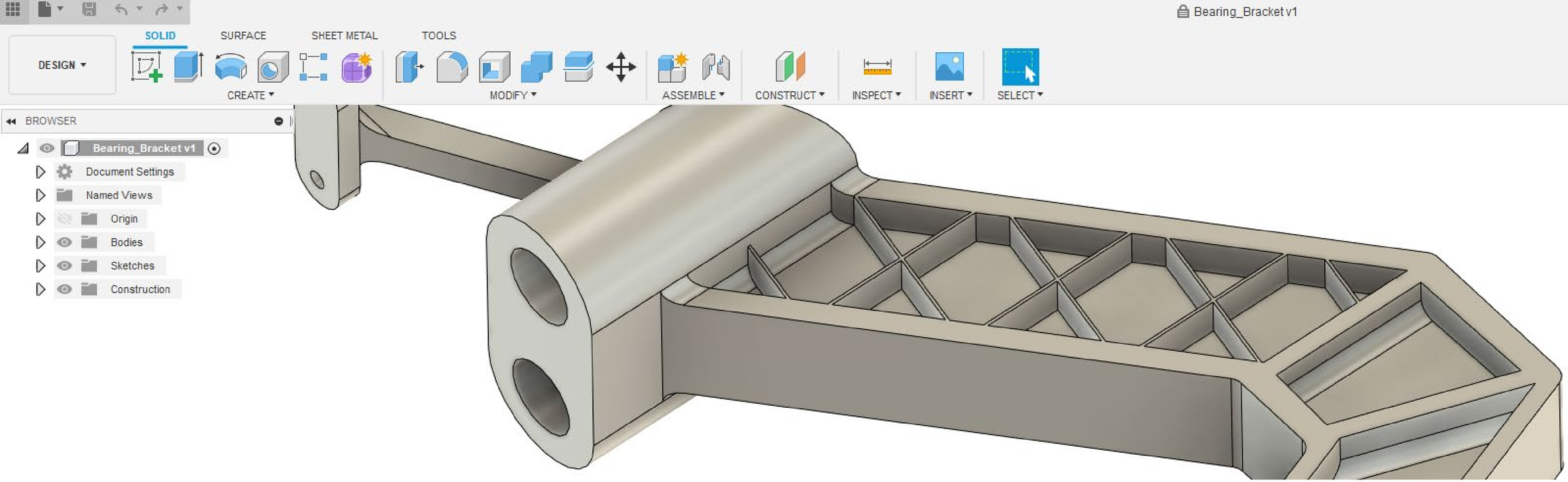
- **As of 2018 Fusion 360 used for instruction.**
- **90 minutes per week in person training.**
- **With 40 students, providing feedback to all students every week is challenging.**
- **Automated feedback may be able to help here!**

CAD and CAM instruction

- Taught through example-based learning
- Students would continue to practice in their own time using these example models.
- Getting feedback outside of contact time tutorials was difficult.
- By creating an app, feedback could be provided at any time!

What makes a “good” CAD model?





What Makes a Good CAD Model?

- **More than just getting the geometry correct.**
- **Simple to understand and quickly editable by other engineers.**

What Makes a Good CAD Model?

MODEL VOLUME

Perhaps the most important. If the volume of the student model doesn’t match the ideal, then the student has created some incorrect geometry.

NUMBER OF BODIES

For completed single component models, there should ideally be only one model body. There are some exceptions to this rule, but all the student exercises require only one body.

MODEL MASS

By also checking the mass we can determine if the student has applied the correct material to their model.

CONSTRAINED SKETCHES

While this is becoming less important in modern CAD packages, it is still best practice to ensure all sketches are fully defined and constrained.

What Makes a Good CAD Model?

FAILED FEATURES

No failed features should exist in the model history tree as this is bad practice.

MINIMUM NUMBER OF DIMENSIONS

A minimum number of features and dimensions should be used to build the model, as simple models are easier to understand and edit.

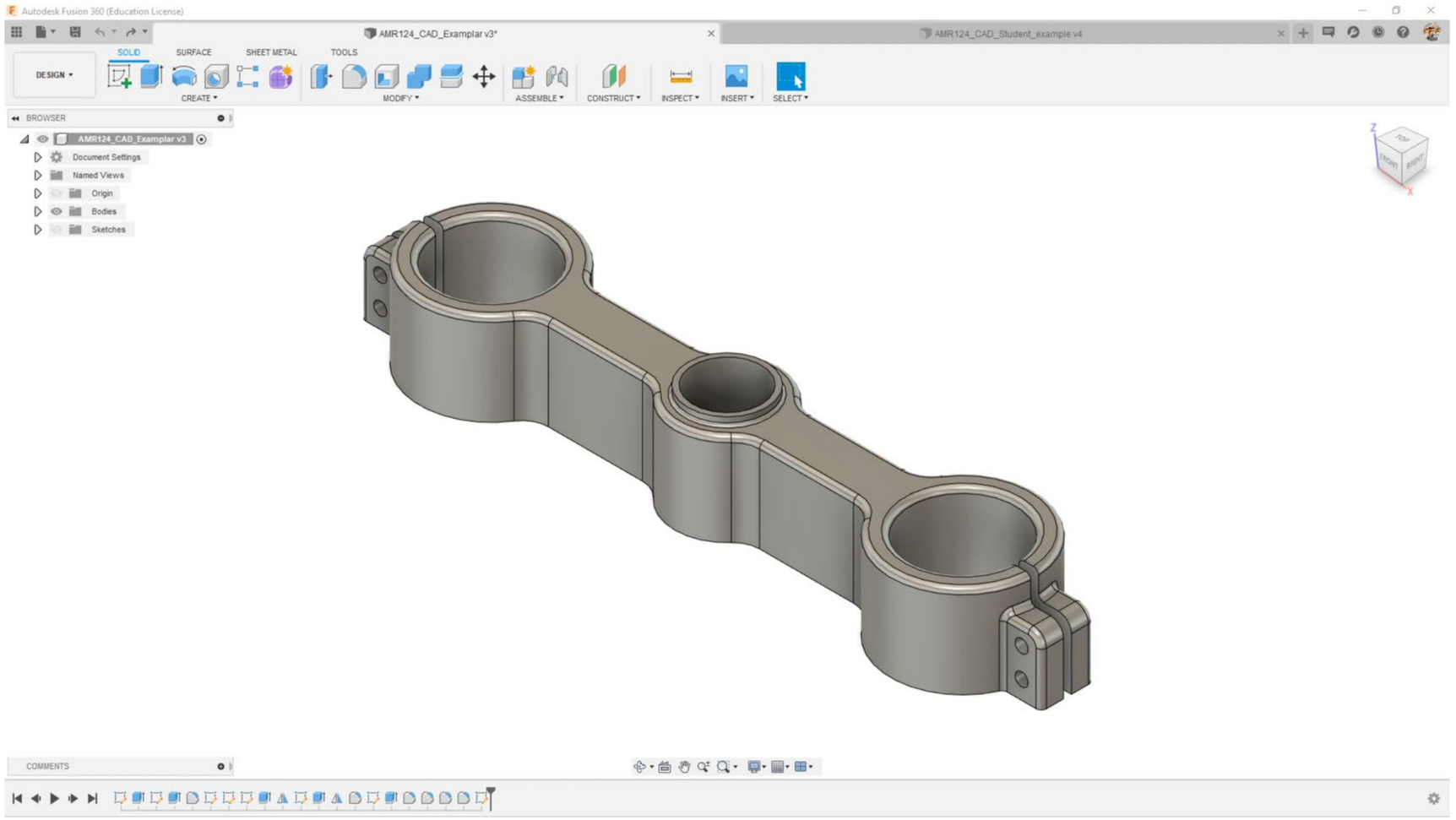
CONSTRUCTION GEOMETRY

Students should be making use of construction geometry (planes, axes, points) to build model features where possible.

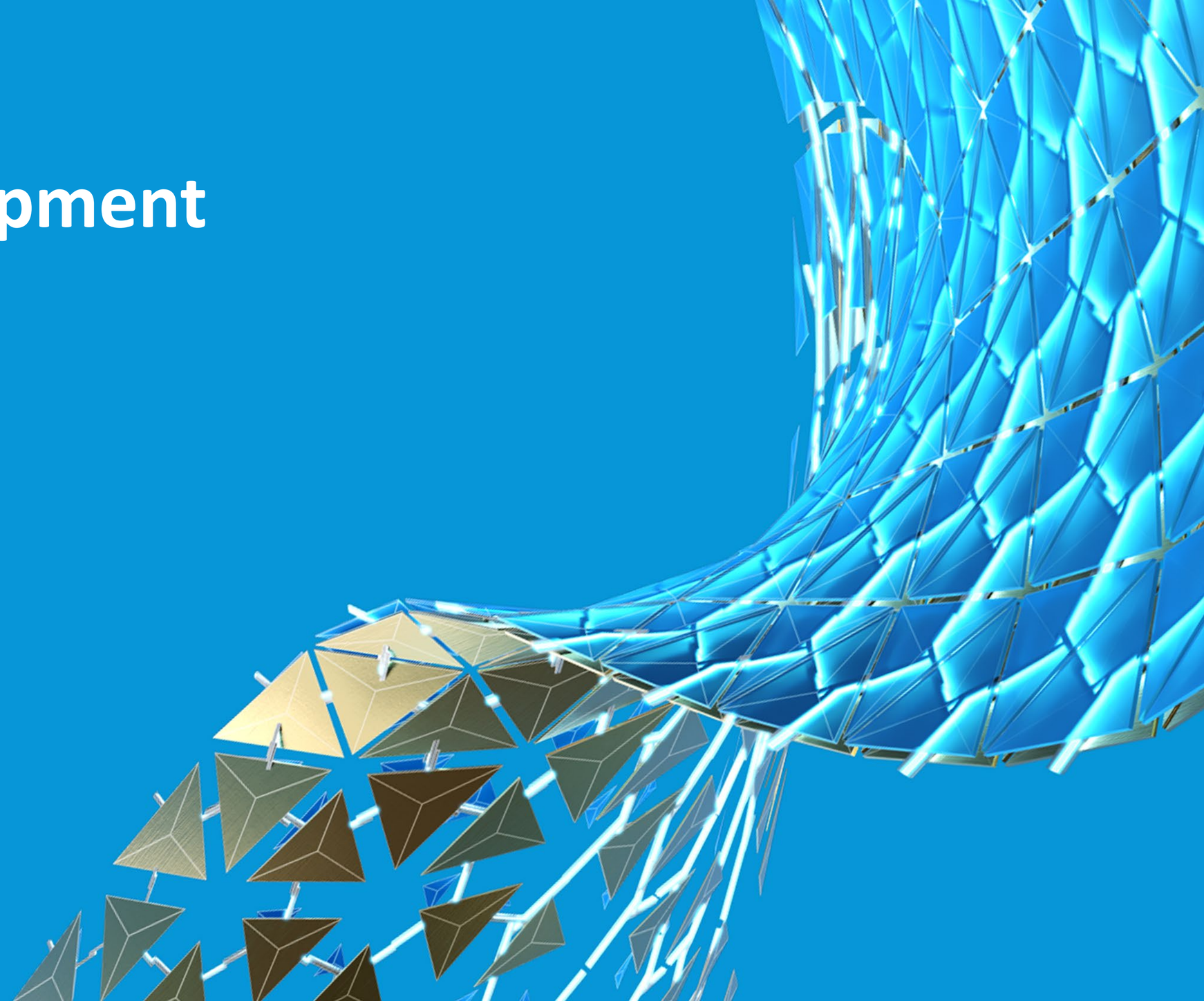
USER PARAMETERS

To further minimise the number of dimensions in the model, student should create user parameters where possible.

What happens when students don’t get it quite right?


Autodesk Fusion 360 (Education License)
AMR124_CAD_Examplar v3*
AMR124_CAD_Student_example v4
DESIGN
SOLID
SURFACE
SHEET METAL
TOOLS
CREATE
MODIFY
ASSEMBLE
CONSTRUCT
INSPECT
INSERT
SELECT
BROWSER
AMR124_CAD_Examplar v3
Document Settings
Named Views
Origin
Bodies
Sketches
COMMENTS

Initial Development



Model Checker Utility

Intended as an initial prototype and as a means of gauging student perceptions of automating feedback in this way.

- **Coding began in summer 2019.**
- **Several ways of “scoring” student models were trialed but proved difficult to implement.**
- **Key model metrics were provided to students, they could then compare against ideal values.**
- **Released under the name “AMR124 model checker utility", installed on all PC’s in the Training Centre.**
- **Students were also provided with instructions for home installation.**

AMR124 AUTOMATED MARKING SCRIPT

Instructions | Model Data | About

AMRC TRAINING CENTRE

This tool has been provided to allow for the quick checking of CAD model quality.

You may need to resize this window, do this by clicking in the bottom right corner.

This tool will report on a number of aspects of your model, please see specific guidance notes below.

Data for your specific CAD model can be found on the "Model Data" tab.

Component Volume:	The total material volume of your component will be reported here, this needs to match example component to be correct.
Component Mass:	The mass of your component will be reported here, this needs to match example component to be correct.
Number of Bodies :	The number of bodies in your component, for complete singular components this should be no more than 1.
Constrained Sketches:	The percentage of sketches which are fully constrained, this should be 100%.
Feature Health:	The percentage of healthy features, this should be 100%.
Construction Datums:	The number of constructions features, these should be included and used to build your component.
Number of Dimensions:	The number of dimensions used, this should be a minimum.
Number of user parameters:	The number of user parameters used, key part parameters should be included as user parameters.

OK Cancel

AMR124 AUTOMATED MARKING SCRIPT

Instructions | Model Data | About

AMRC TRAINING CENTRE

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Feature Health:	The percentage of healthy features, this should be 100%.
Construction Datums:	The number of constructions features, these should be included and used to build your component.
Number of Dimensions:	The number of dimen
Number of user parameters:	The number of user p

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Component Mass:	The mass of your component will be reported here, this needs to match example component to be correct.

AMR124 AUTOMATED MARKING SCRIPT

Instructions | Model Data | About

Component Volume:	1410177.77 mm^3
Component Mass:	110698.96 g
Number of Bodies :	1
Constrained Sketches:	83 %
Feature Health:	100 %
Construction Datums:	0
Number of Dimensions:	23
Number of user parameters:	1

AMR124 AUTOMATED MARKING SCRIPT

Instructions | Model Data | About

Program developed by Joe Palmer for AMRC Training Centre's AMR124 module.

Made possible by the assistance provided by Autodesk's Melissa Kaner

OK Cancel

AUTODESK® Fusion 360 API Object Model

AUTODESK.

Application

ApplicationEvent
CustomEvent
Data
DataHubs
DataHub
DataProjects
DataProject
DataFolder
DataFolders
DataFolder
DataFiles
DataFile
FavoriteAppearances
FavoriteMaterials
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ImportOptions [CC]
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ProfilePlaneStartDefinition [L]
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ToEntityExtentDefinition [L]
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ConstantRadiusFilletEdgeSet [Y]
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HoleFeature [K]
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LoftCenterLineOrRail
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LoftDirectionEndCondition [EE]
LoftFreeEndCondition [EE]
LoftPointSharpEndCondition [EE]
LoftPointTangentEndCondition [EE]
LoftSmoothEndCondition [EE]
LoftTangentEndCondition [EE]
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TwoSideAngleExtentDefinition [L]
TwoSideToExtentDefinition [L]
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SilhouetteSplitFeature [K]
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BRepLump
BRepShells
BRepShell
BRepFaces
BRepFace
SurfaceEvaluator
MeshManager
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BRepEdges
BRepEdge
BRepVertices
BRepVertex
CurveEvaluator3D
BRepLoop
BRepCoEdges
BRepCoEdge
CurveEvaluator2D

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AsBuiltJointInput
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PinSlotJointMotion (BB)
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PlanarJointMotion (BB)
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RevoluteJointMotion (BB)
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SketchCircle (R)
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SketchEllipses
SketchEllipse (R)
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SketchEllipticalArc (R)
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SketchLine (R)
SketchPoints
SketchPoint (Q)
SketchEntityList
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SketchTextInput
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SketchDimension [T]
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SketchConcentricCircleDimension (T)
SketchDiameterDimension (T)
SketchEllipseMajorRadiusDimension (T)
SketchEllipseMinorRadiusDimension (T)
SketchLinearDimension (T)
SketchOffsetCurvesDimension (T)
SketchOffsetDimension (T)
SketchRadialDimension (T)
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GeometricConstraint [S]
CircularPatternConstraint (S)
CoincidentConstraint (S)
CollinearConstraint (S)
ConcentricConstraint (S)
EqualConstraint (S)
HorizontalConstraint (S)
HorizontalPointsConstraint (S)
MidPointConstraint (S)
ParallelConstraint (S)
PerpendicularConstraint (S)
PolygonConstraint (S)
RectangularPatternConstraint (S)
SmoothConstraint (S)
SymmetryConstraint (S)
TangentConstraint (S)
VerticalConstraint (S)
VerticalPointsConstraint (S)

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ConstructionAxisByLineDefinition (E)
ConstructionAxisCircularFaceDefinition (E)
ConstructionAxisEdgeDefinition (E)
ConstructionAxisNormalToFaceAtPointDefinition (E)
ConstructionAxisPerpendicularAtPointDefinition (E)
ConstructionAxisTwoPlaneDefinition (E)
ConstructionAxisTwoPointDefinition (E)
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ConstructionPlaneDefinition [D]
ConstructionPlaneAtAngleDefinition (D)
ConstructionPlaneDistanceOnPathDefinition (D)
ConstructionPlaneMidplaneDefinition (D)
ConstructionPlaneByPlaneDefinition (D)
ConstructionPlaneOffsetDefinition (D)
ConstructionPlaneTangentAtPointDefinition (D)
ConstructionPlaneTangentDefinition (D)
ConstructionPlaneThreePointsDefinition (D)
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ConstructionPointThreePlanesDefinition (F)
ConstructionPointTwoEdgesDefinition (F)

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CustomGraphicsBasicMaterialColorEffect (HH)
CustomGraphicsSolidColorEffect (HH)
CustomGraphicsVertexColorEffect (HH)
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CustomGraphicsViewScale
CustomGraphicsViewPlacement
CustomGraphicsBRepBody [GG]
CustomGraphicsGroup [GG]
CustomGraphicsLines [GG]
CustomGraphicsMesh [GG]
CustomGraphicsPointSet [GG]
CustomGraphicsCurve [GG]

3D Math
BoundingBox3D
Matrix3D
Vector3D

2D Math
BoundingBox2D
Matrix2D
Vector2D

Surface Geometry
Surface [J]
SurfaceEvaluator
Cone (J)
Cylinder (J)
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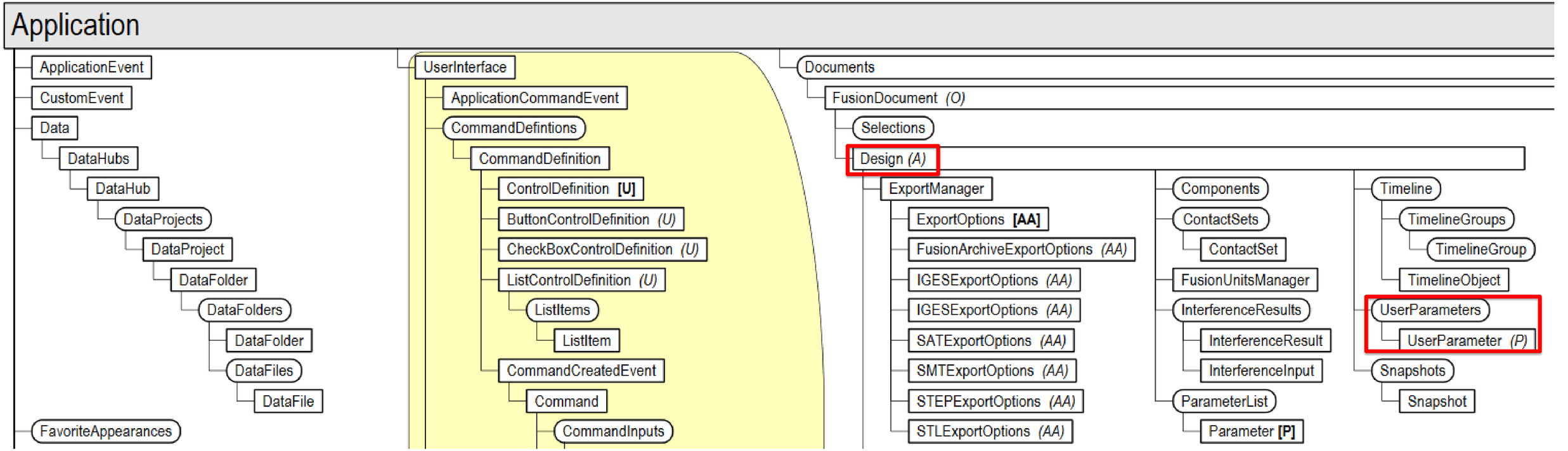
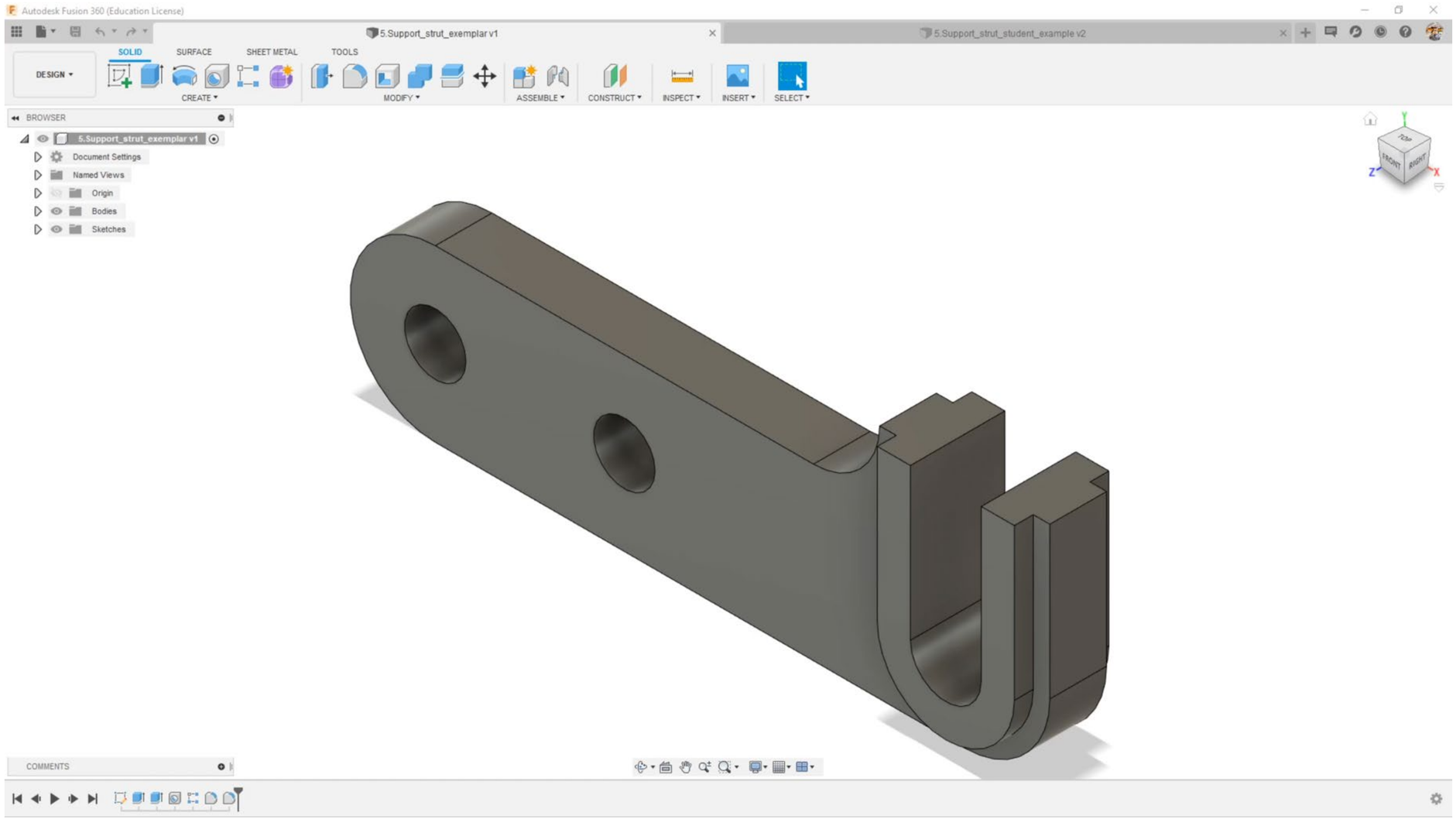
Body Related Objects:
Sketch Related Objects:

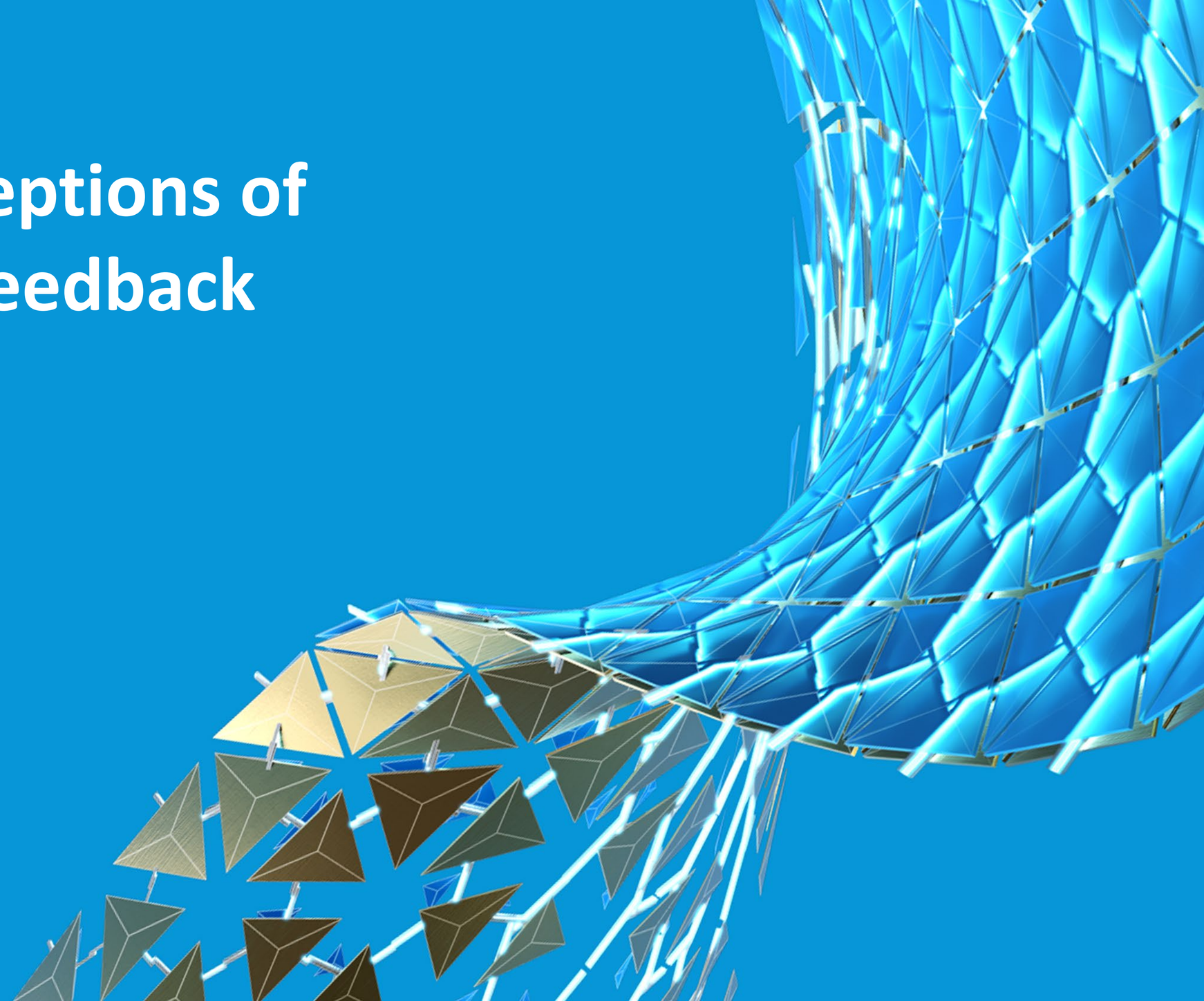
AUTODESK® Fusion 360 API Object Model




```
#report number of user parameters
user_params = design.userParameters.count
```


Autodesk Fusion 360 (Education License)
5.Support_strut_exemplar v1
5.Support_strut_student_example v2
DESIGN
SOLID
SURFACE
SHEET METAL
TOOLS
CREATE
MODIFY
ASSEMBLE
CONSTRUCT
INSPECT
INSERT
SELECT
BROWSER
5.Support_strut_exemplar v1
Document Settings
Named Views
Origin
Bodies
Sketches
FRONT
RIGHT
COMMENTS

Student perceptions of Automated Feedback



Student Perceptions Survey

41
TOTAL SURVEY RESPONDENTS

From two cohorts (2018 and 2019). Respondents represent 45% of the population.

18
RESPONDENTS

From the 2018 cohort. These students did not have access to the model checker tool.

23
RESPONDENTS

From the 2019 cohort. These students did have access to the model checker utility.

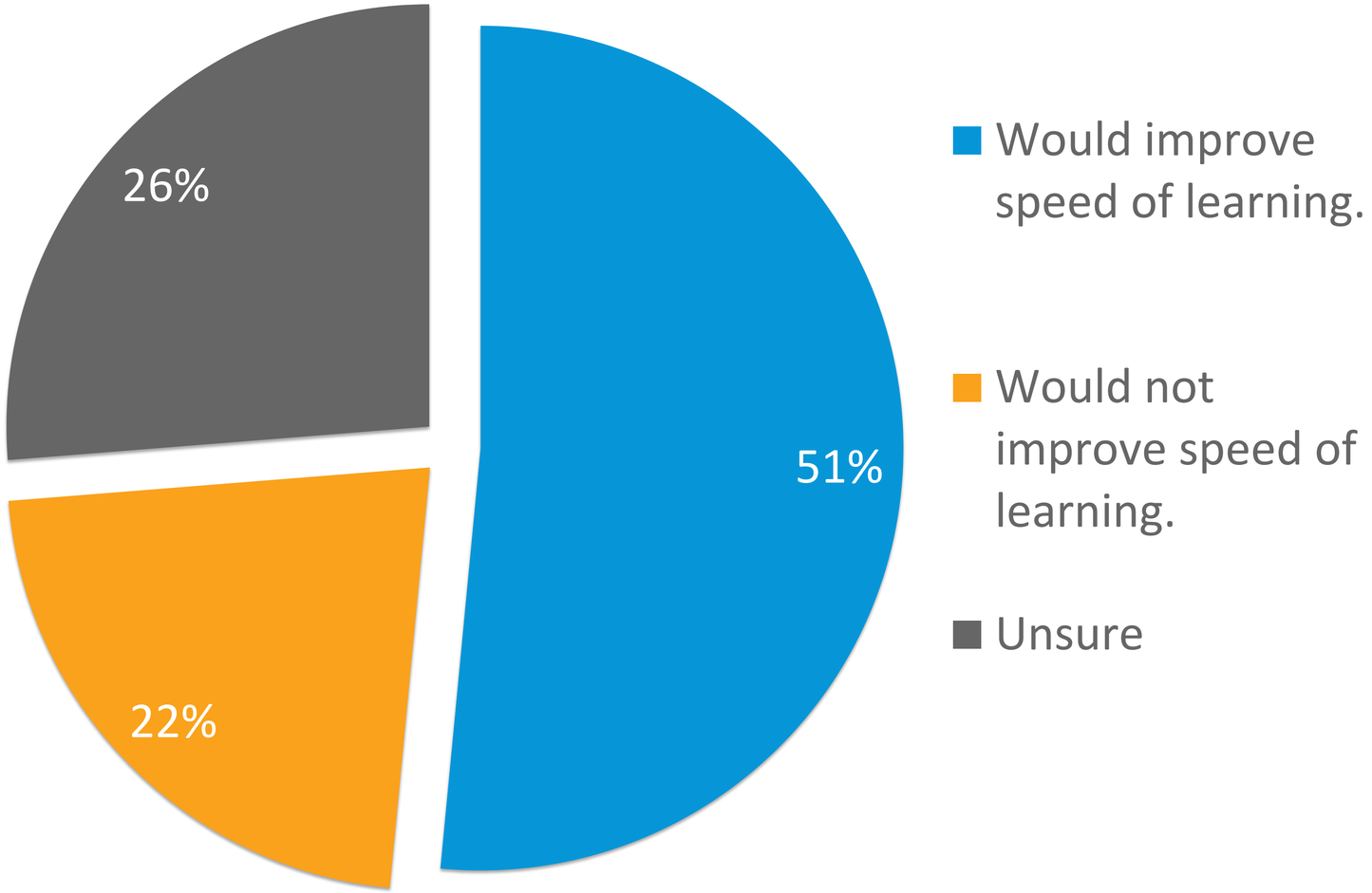
90
STUDENTS

Total number of students in both cohorts.

Survey Results

Q.

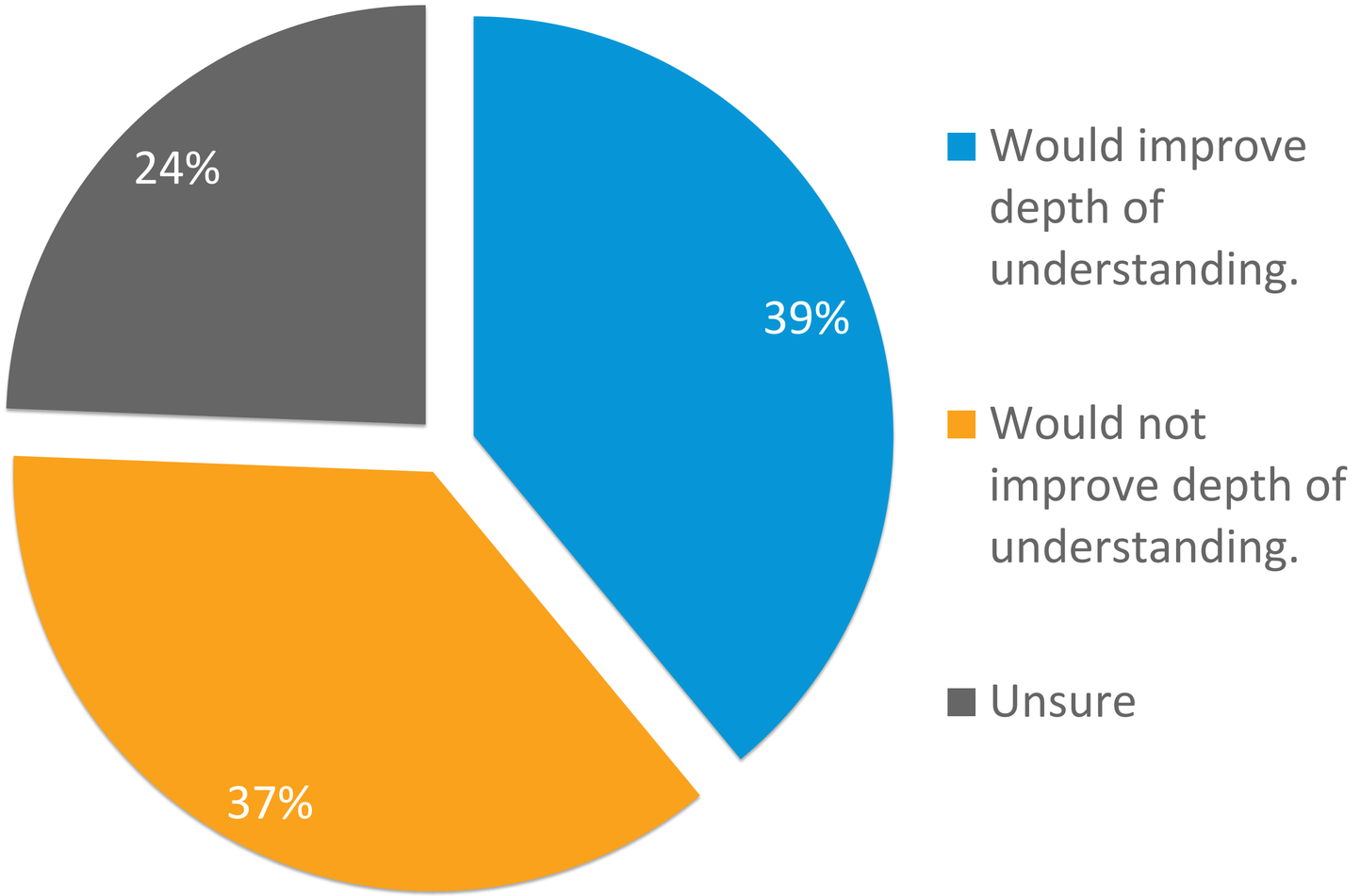
Do you think the model checker tool did or would have improved the speed at which you learnt Fusion 360?



Survey Results

Q.

Do you think the model checker tool did or would have improved your depth of understanding with Fusion 360?



“The tool allowed me to check my sketches and models without needing tutor assistance.”

“I didn't have to wait around for feedback from tutor, it also doesn't 'spoon feed' information so promotes more in-depth analysis.”

“Allows you to see where mistakes may have been made, making it quicker to resolve them.”

“It is quicker than checking each property of the model every time.”

Student quotes about the model checker utility.

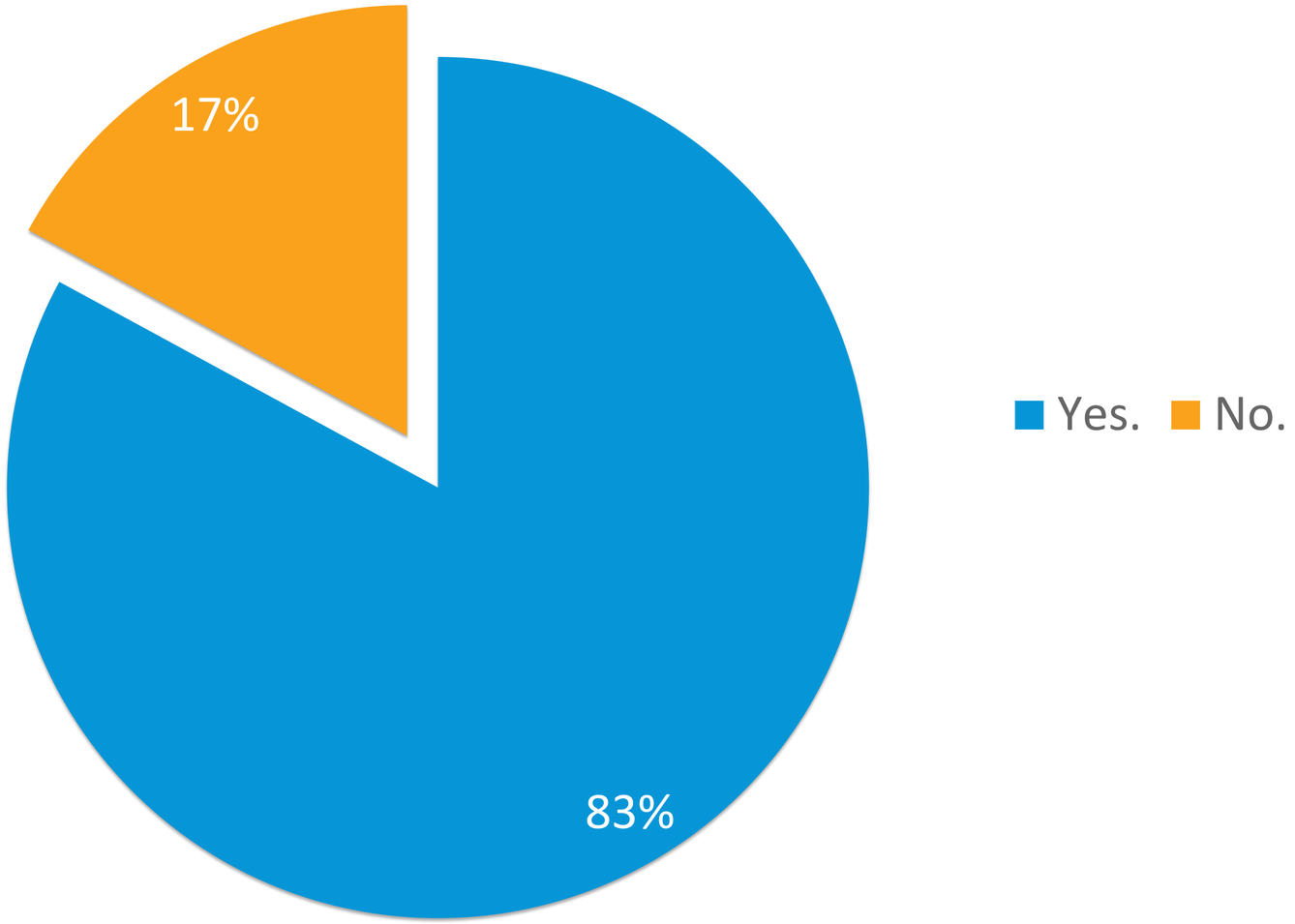
Future Developments

Students were then shown visual mock-ups for a potential future development of the tool codenamed “FOCUS”, they were then asked how they felt about this new tool.

Survey Results

Q.

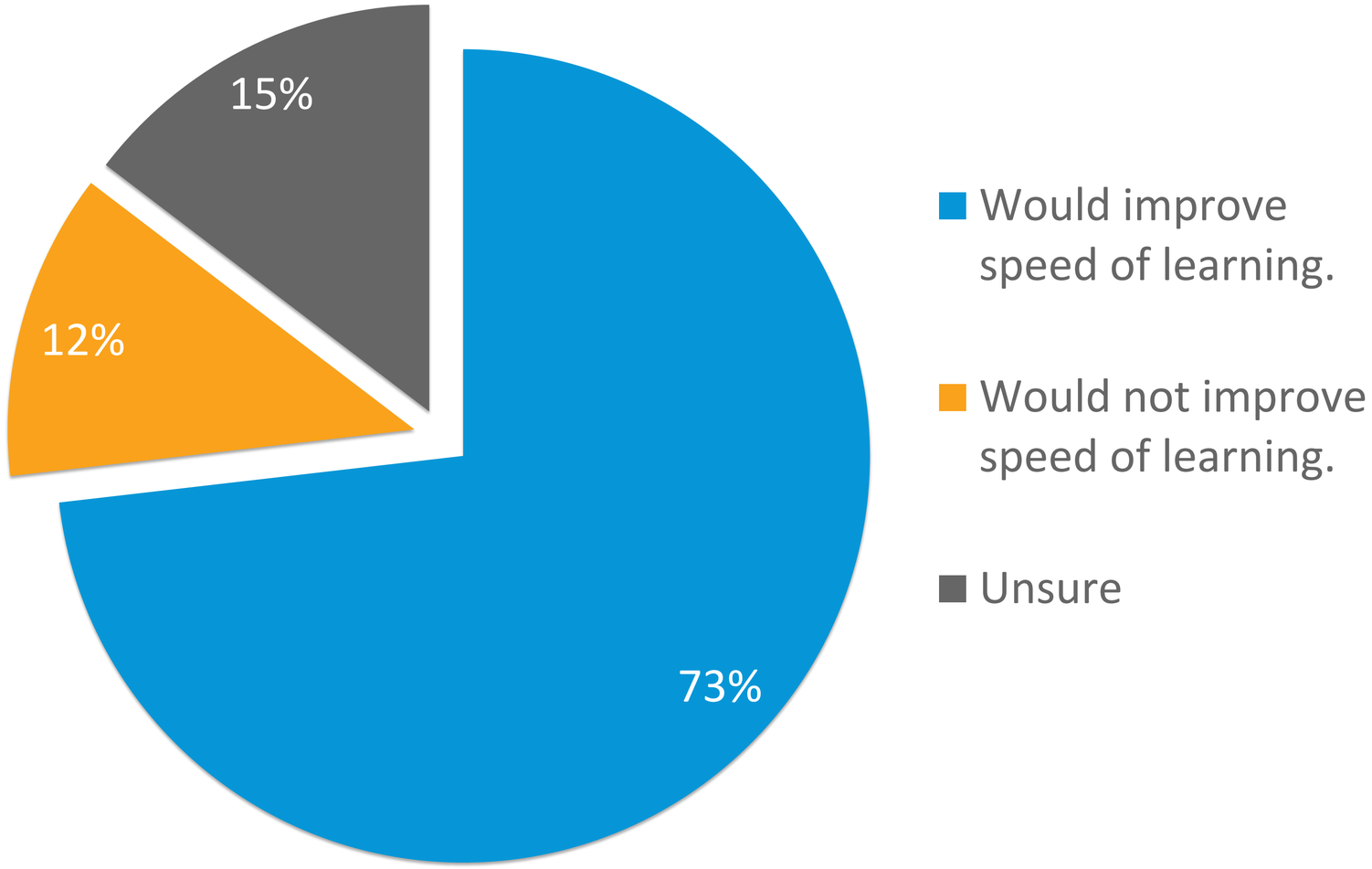
If you were learning Fusion 360 again for the first time, would you make use of the FOCUS tool?



Survey Results

Q.

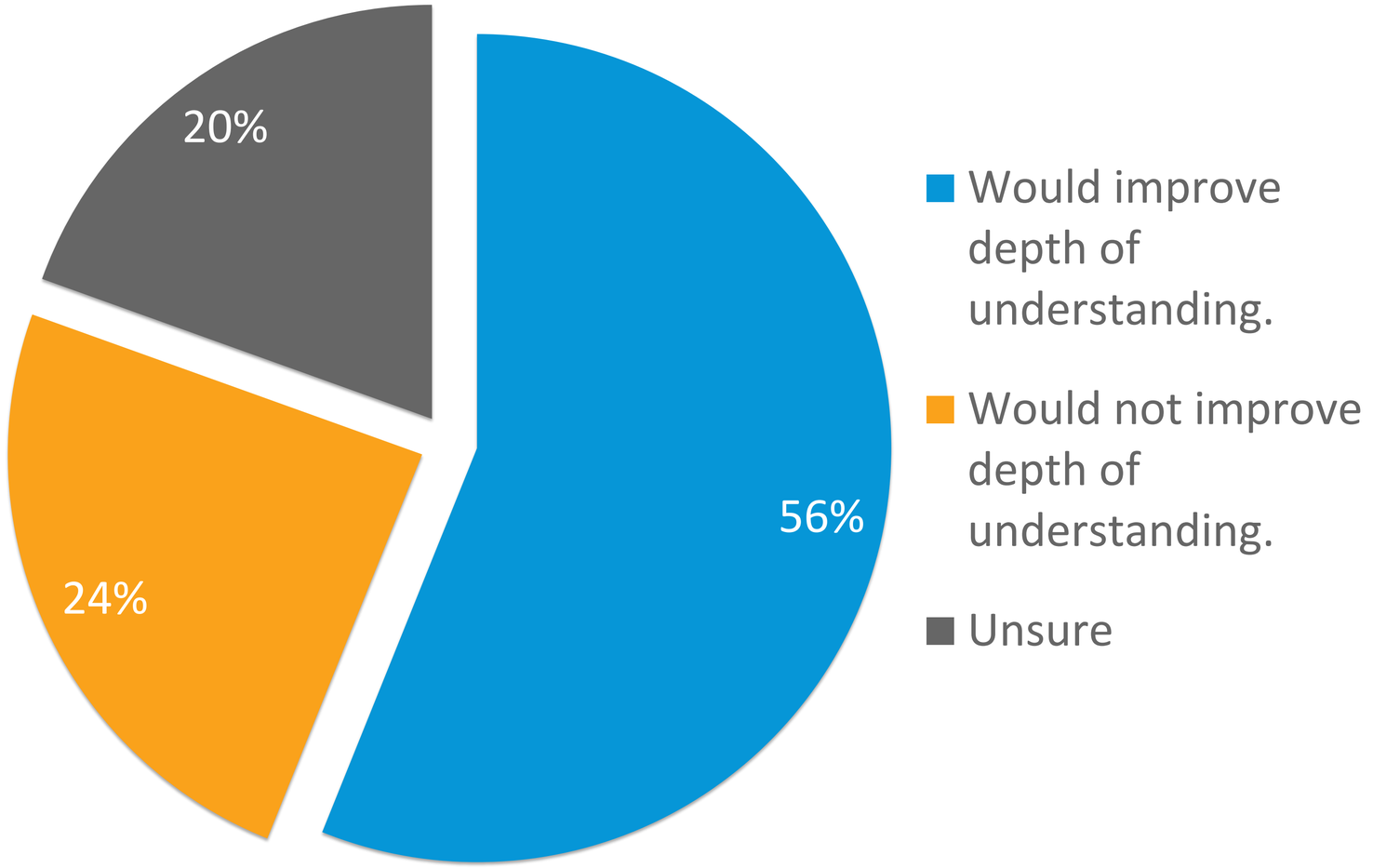
Do you think the FOCUS tool would improved the speed at which you learnt Fusion 360?



Survey Results

Q.

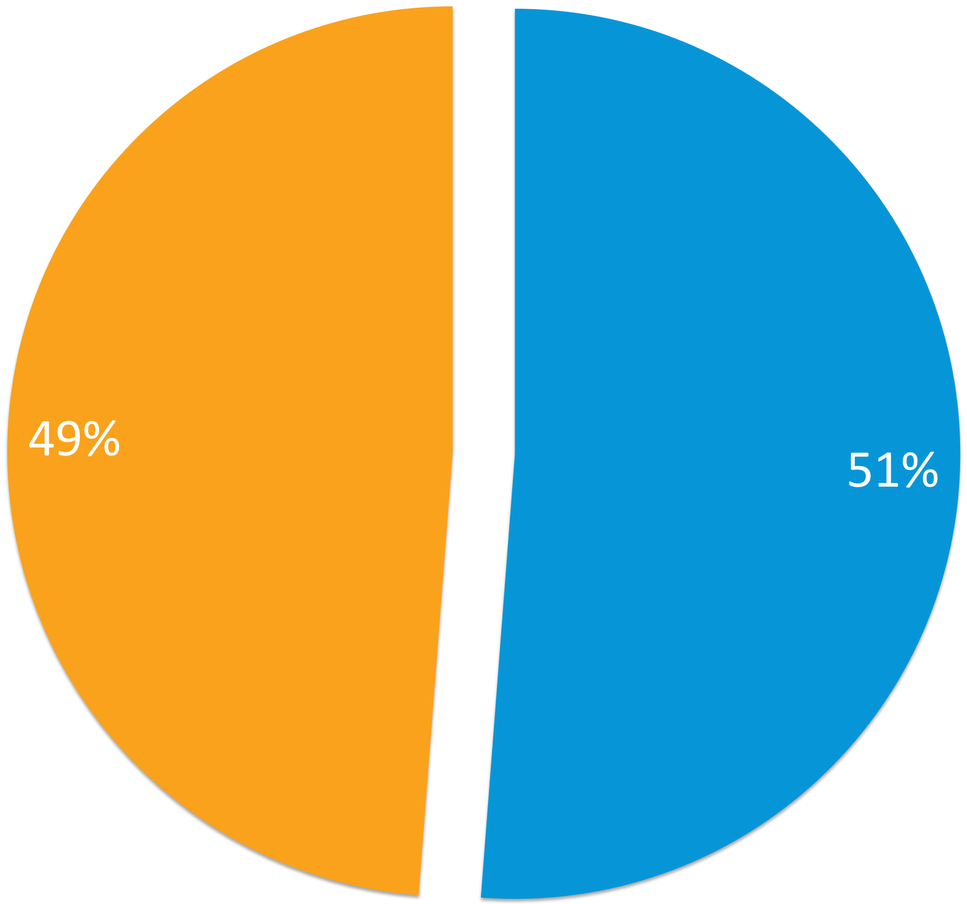
Do you think the FOCUS tool would improve your depth of understanding with Fusion 360?



Survey Results

Q.

If you were learning Fusion 360 again for the first time, which of the two following scenarios do you believe would be most beneficial to your learning?



- Individually tailored feedback is available from the course tutor, but only for a few minutes once per week.
- Automated feedback, similar to that shown in the FOCUS tool is available whenever you wish.

“I like that you can see how close you are to completion and that it ensures you know exactly what needs doing at a given time.”

“It seems quite graphical, a good way of displaying information. This gives a quick way to get information rather than reading through lines of numbers and data.”

“Display is effective in showing all the different features which should improved. It also highlights areas which students may be consistently scoring low in which can be used for further development”

Student quotes about the FOCUS tool.

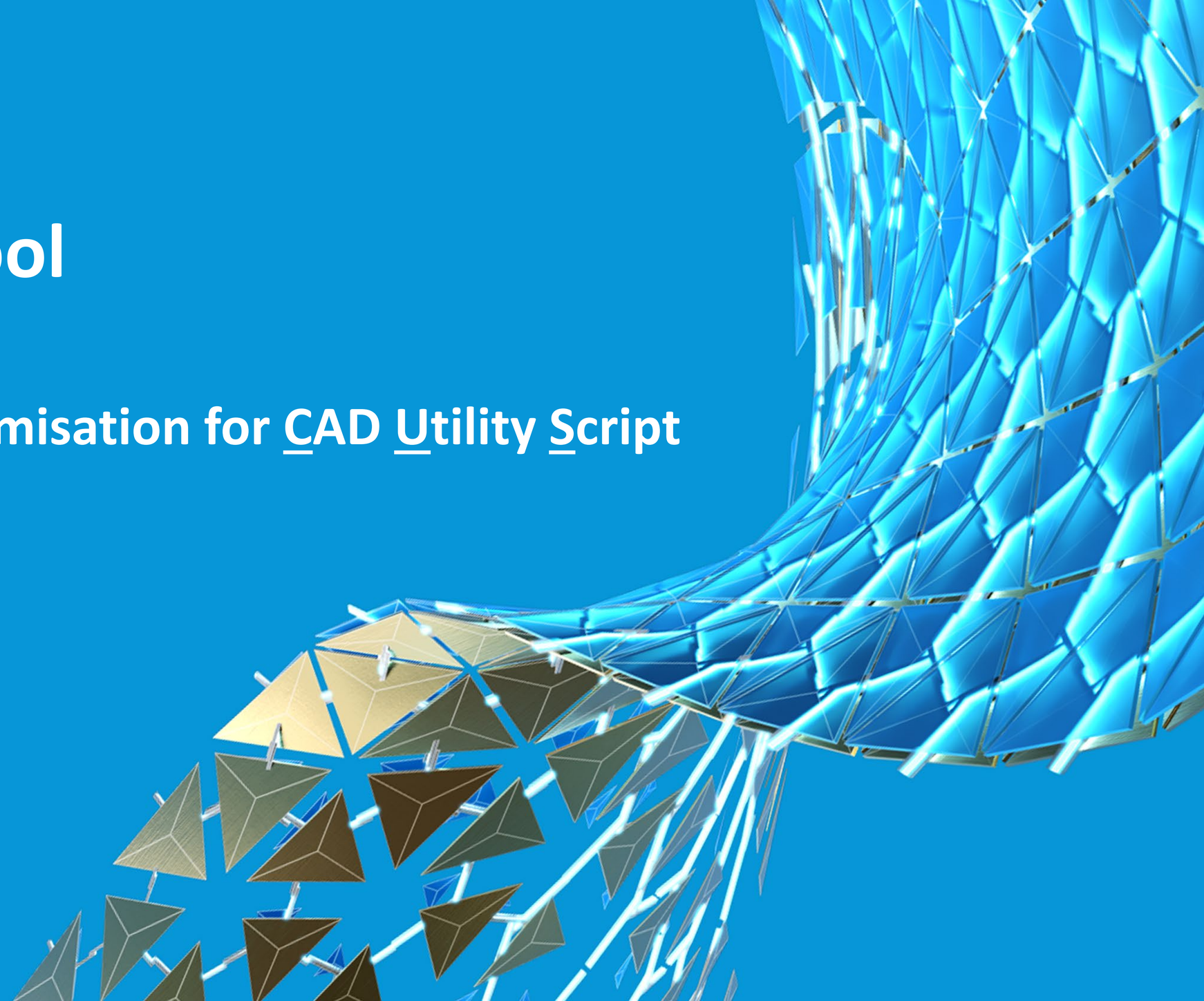
Summary of Student Feedback

The following conclusions were drawn from the student feedback survey:

- **Model checker utility provided a benefit to students.**
- **FOCUS tool would offer an improved experience.**
- **Students were split almost 50/50 on whether automated feedback or tutor feedback was the most effective.**

The FOCUS tool

Feedback and Optimisation for CAD Utility Script



FOCUS TOOL

Model Data | Further Information | About

The University Of Sheffield.

This is an automated feedback tool for the AMR124 module. Please select the practise component that you are attempting to model from the drop down list. Scores for your model, in key categories, will then be displayed below along with a total score for your model. For further information about how your model is scored, please see the information tabs to the right.

Which component are you attempting to model? 8. Stepped Shaft

Model Mass	1171.48 g	81%
Model Volume	149232.51 mm^3	81%
Number of Bodies	1	100%
Constrained Sketches	100 %	100%
Feature Health	75 %	17%
Construction Datums	1	100%
Number of Dimensions	8	100%
Number of User Parameters	1	100%

Total Score	78%

Overall this looks like a good model, well done! The volume of your model is close to ideal but improvements can still be made. Double check all of your feature sizes. The applied material type for this component appears to be correct. If you wish to log your score on the e-learning system please enter the code below:

LIQUID-DRILL-MAGNET-CARROT

OK Cancel

FOCUS TOOL

Model Data | Further Information | About

If you would like some more information about how your model has been scored then please see the table below. For each scoring metric and explanation of what the metric is has been given along with tips on how to improve your models score in this area.

Model Mass	The mass of your component will be reported here, this needs to match example component to be correct.
Model Volume	The total material volume of your component will be reported here, this needs to match example component to be correct.
Number of Bodies	The number of bodies in your component, for complete singular components this should be no more than 1.
Constrained Sketches	The percentage of sketches which are fully constrained, this should be 100%.
Feature Health	The percentage of healthy features, this should be 100%.
Construction Datums	The number of constructions features, these should be included and used to build your component.
Number of Dimensions	The number of dimensions used, this should be a minimum.
Number of User Parameters	The number of user parameters used, key part parameters should be included as user parameters.

OK | Cancel

FOCUS TOOL

Model Data | Further Information | About

FOCUS

FEEDBACK and OPTIMISATION for CAD UTILITY SCRIPT

Program developed by Joe Palmer for AMRC Training Centre's AMR124 module. Made possible by the assistance provided by Autodesk's Melissa Kaner.

OK | Cancel

Basics of the FOCUS Algorithm

- **As well as reporting the same key metrics and the model checker utility, a percentage score is assigned.**
- **The progress bars show students how close they are to an “ideal” model.**
- **Students receive a 100% score for getting a parameter correct, with marks reducing as deviation from the ideal increases.**

FOCUS

FEEDBACK and OPTIMISATION for CAD UTILITY SCRIPT

Basics of the FOCUS Algorithm

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- The progress bars show students how close they are to an “ideal” model.
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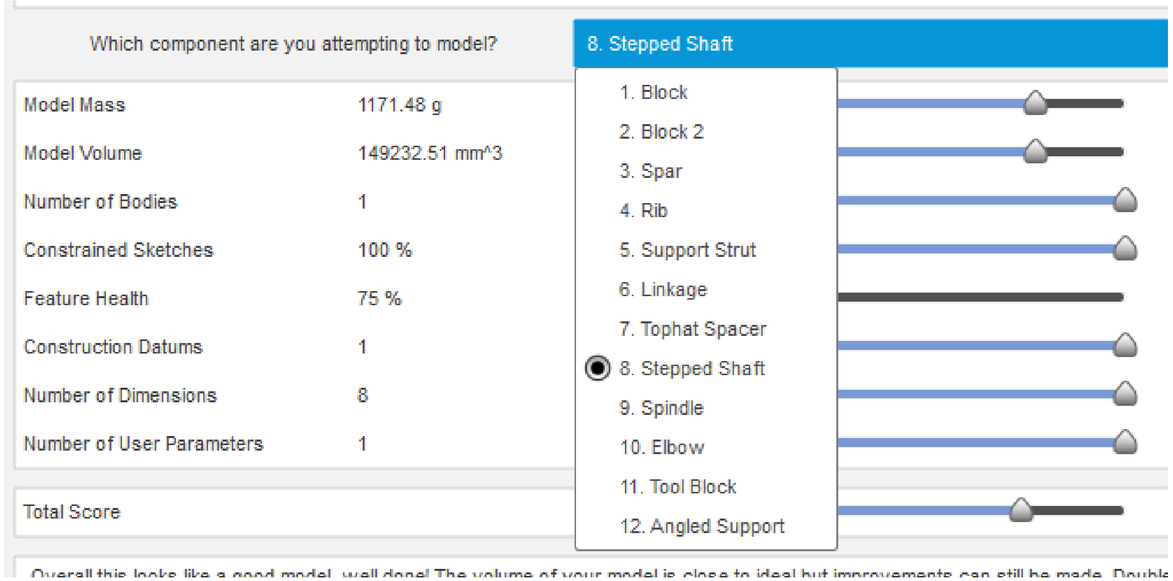
	A	B	C	D	E	F
1	Block	16980	133.258	1	11	7
2	Block 2	11590	90.974	1	16	14
3	Spar	28010	219.873	1	11	10
4	Rib	30906	243.045	1	11	12
5	Support Strut	63500	498.467	1	14	7
6	Linkage	18320	143.837	1	20	9
7	Tophat Spacer	14060	110.385	1	6	3
8	Stepped Shaft	153600	1205.426	1	12	4
9	Spindle	188900	1482.99	1	28	12
10	Elbow	14200	111.465	1	8	11
11	Tool Block	194100	1524.032	1	16	14
12	Angled Support	1069000	8389.358	1	19	16



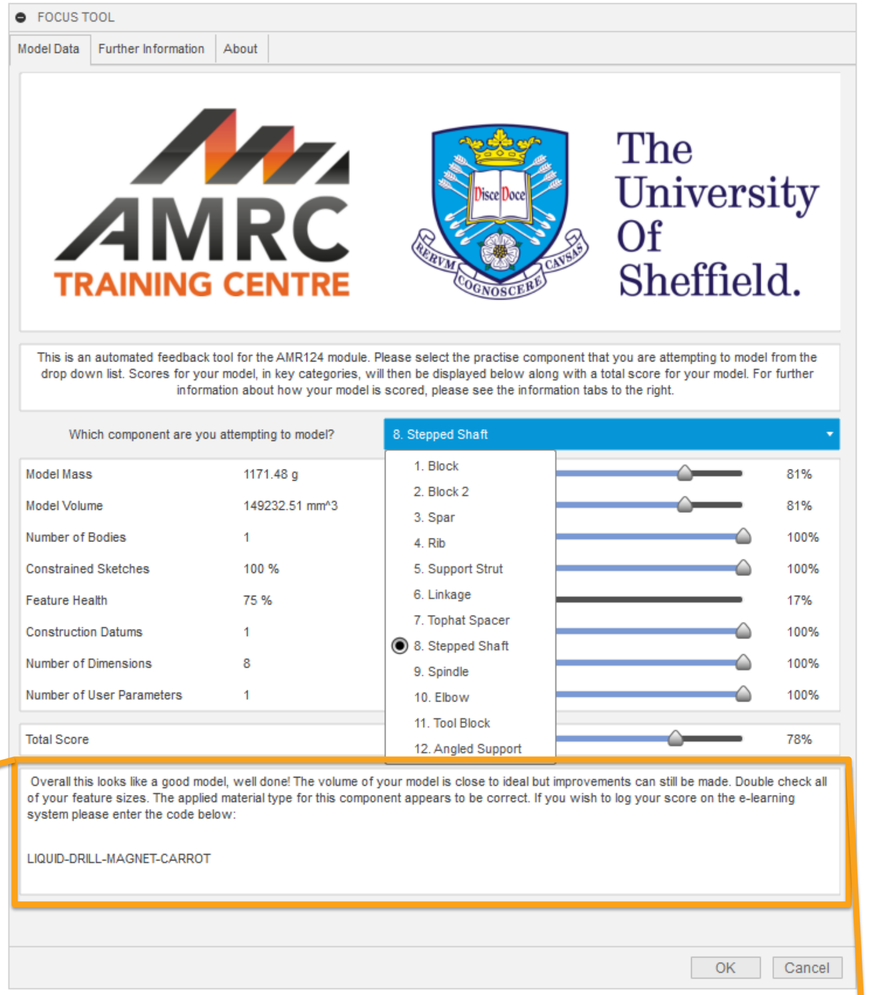
Where does the ideal model data come from?

- **Initially, ideal model values were hard-coded into the app.**
- **The app now imports ideal mode values from an excel file.**

Word Bank Feedback

As well as providing students with data and scores they are given feedback in plain text, this is generated from a word bank.

For each category score, a sentence of feedback is pulled from the word bank. These are then combined with sentences relating to other categories. The result is typically a small paragraph of feedback which guides the student on how to improve their model.



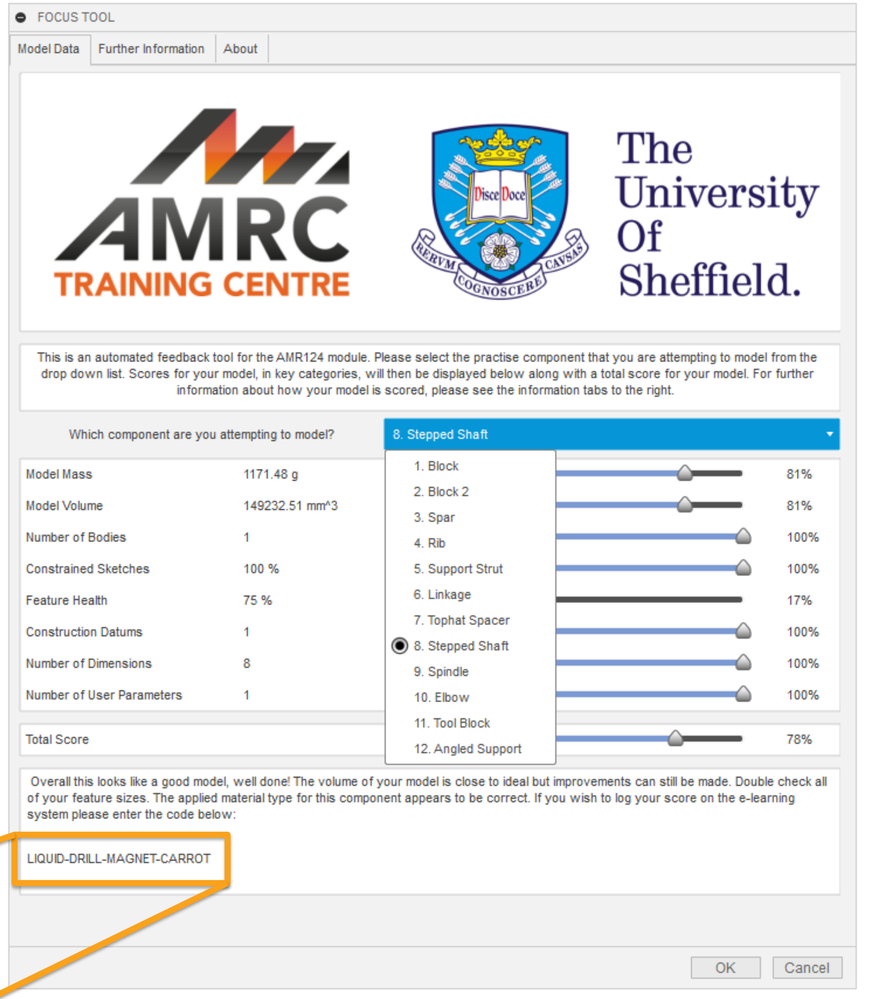
Overall this looks like a good model, well done! The volume of your model is close to ideal but improvements can still be made. Double check all of your feature sizes. The applied material type for this component appears to be correct. If you wish to log your score on the e-learning system please enter the code below:

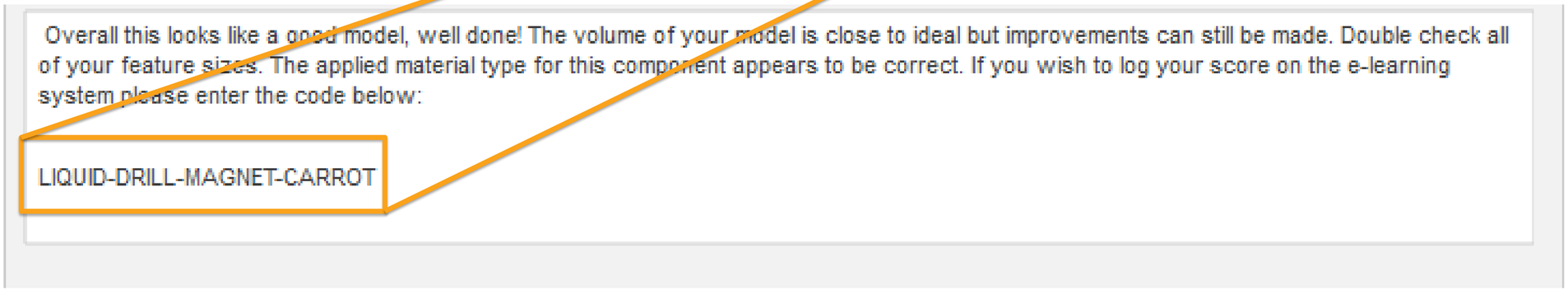
LIQUID-DRILL-MAGNET-CARROT

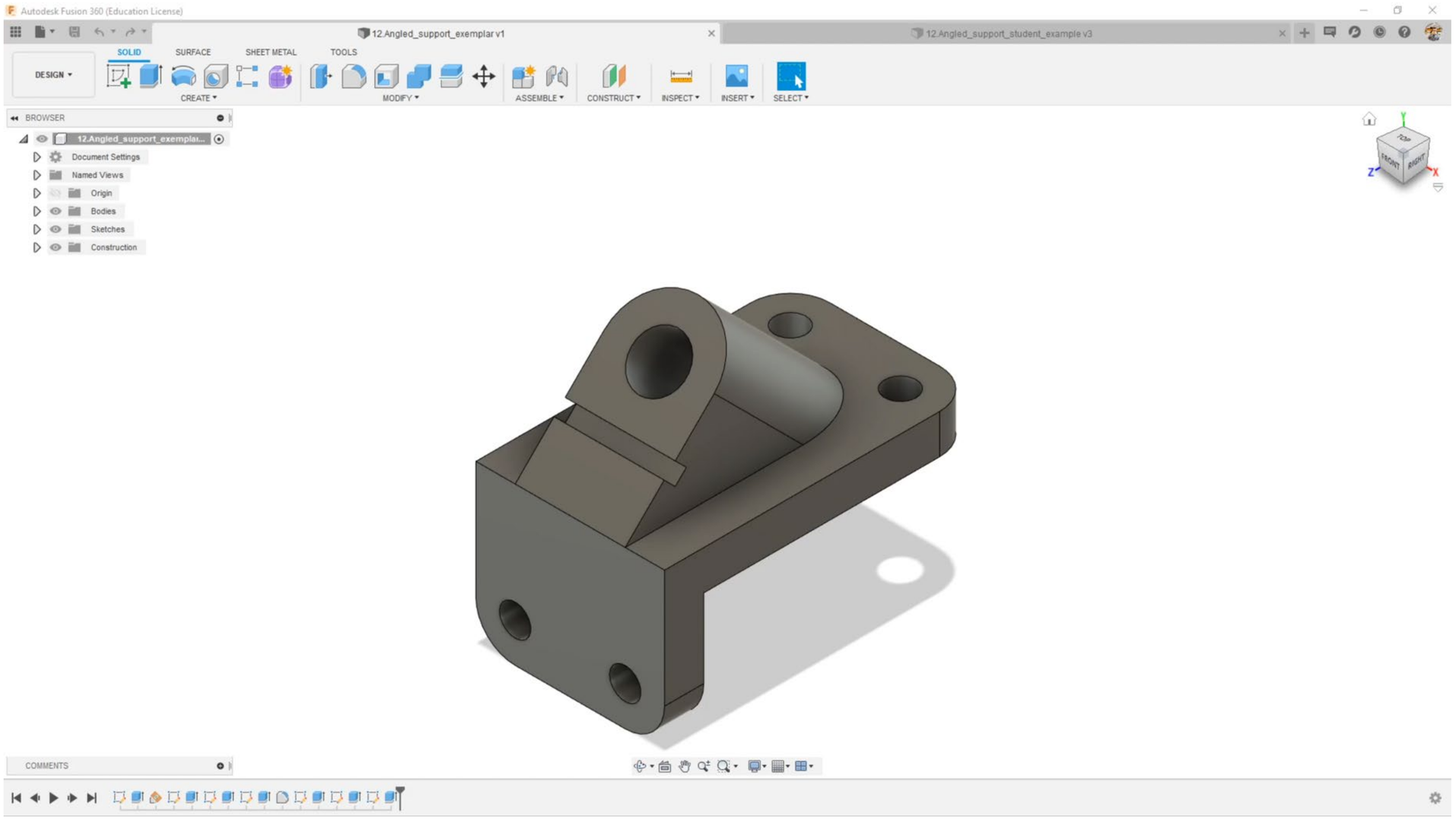
Codeword for interface with VLE

One feature that is desired by many teachers is to interface with their Virtual Learning Environment (VLE). Universal compatibility would require separate plugins to be written for each VLE on the market.

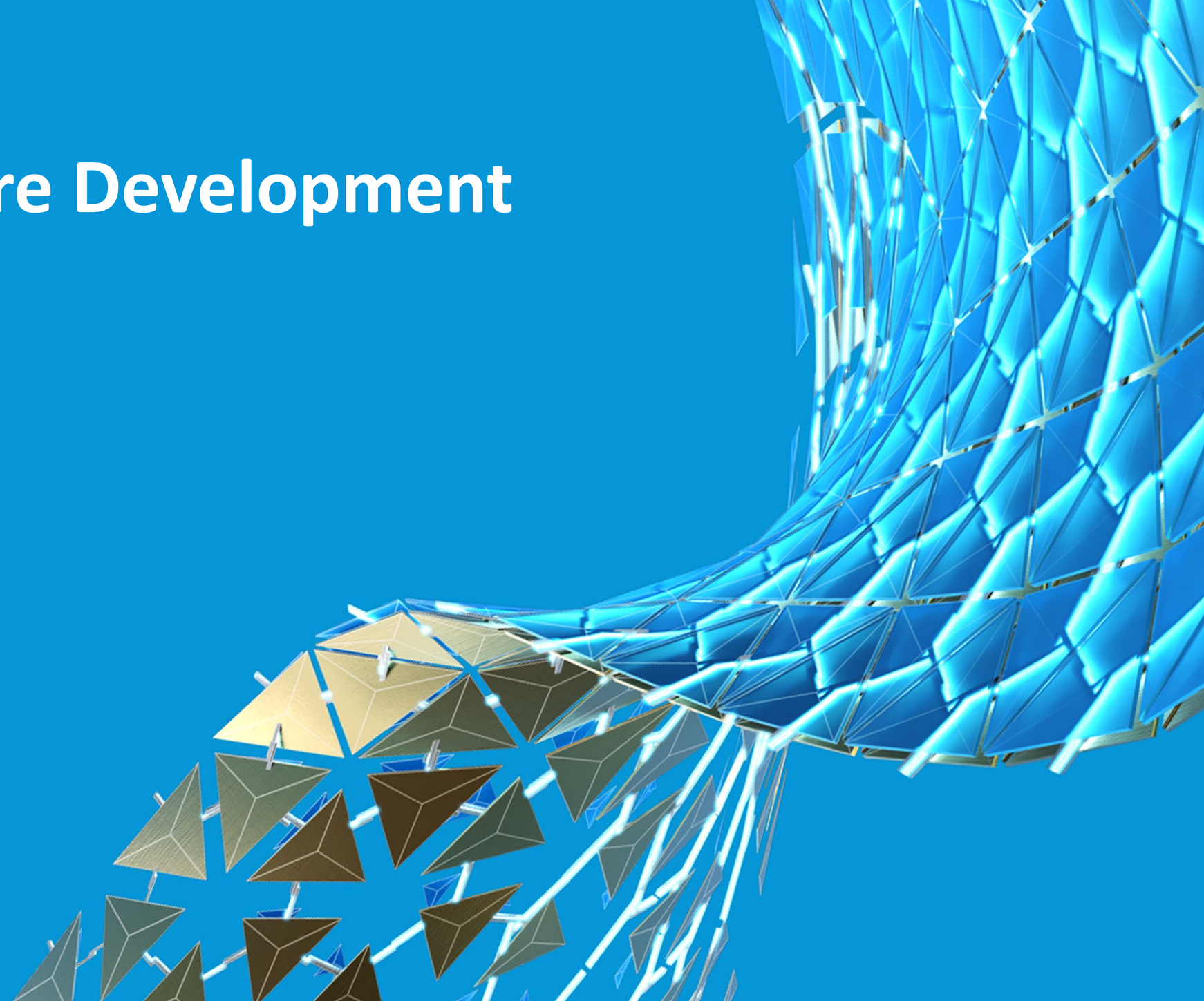
A simple way to solve this problem is to generate a code, in this case a collection of four dissimilar words which is unique to both the student and their particular score. This prevents students sharing codes and ensures that students honestly report their scores to the VLE.






Autodesk Fusion 360 (Education License)
12.Angled_support_exemplar v1
12.Angled_support_student_example v3
SOLID
SURFACE
SHEET METAL
TOOLS
DESIGN
CREATE
MODIFY
ASSEMBLE
CONSTRUCT
INSPECT
INSERT
SELECT
BROWSER
12.Angled_support_exemplar...
Document Settings
Named Views
Origin
Bodies
Sketches
Construction
TOP
FRONT
RIGHT
COMMENTS

FOCUS - Future Development and Release

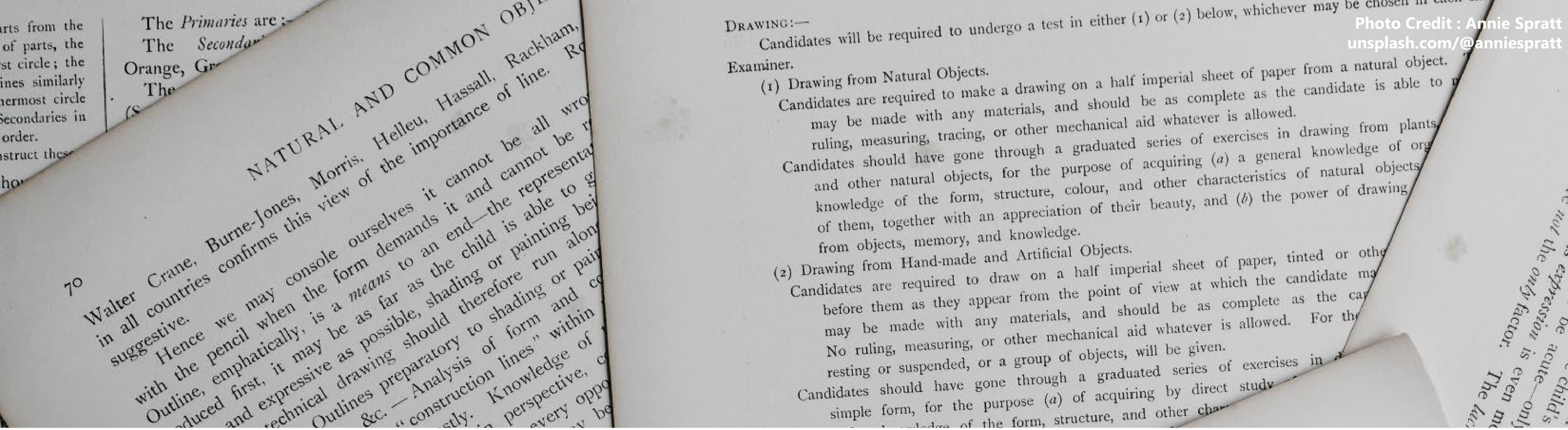


FOCUS Tool – Future Work

- **At present all parameters are assessed independently and a total score is calculated using category weightings. It is possible to score 25% with a component which does not resemble the example component. This is below pass mark so not too much of an issue, but the algorithm is still being tweaked here.**
- **Word Bank feedback requires more differentiation and depth.**
- **Codeword compatibility with a range of VLE systems needs to be assessed further.**

FOCUS tool will be available in the App Store soon

- **To sign up for updates on this please follow me on twitter [@JoePalmer55]**

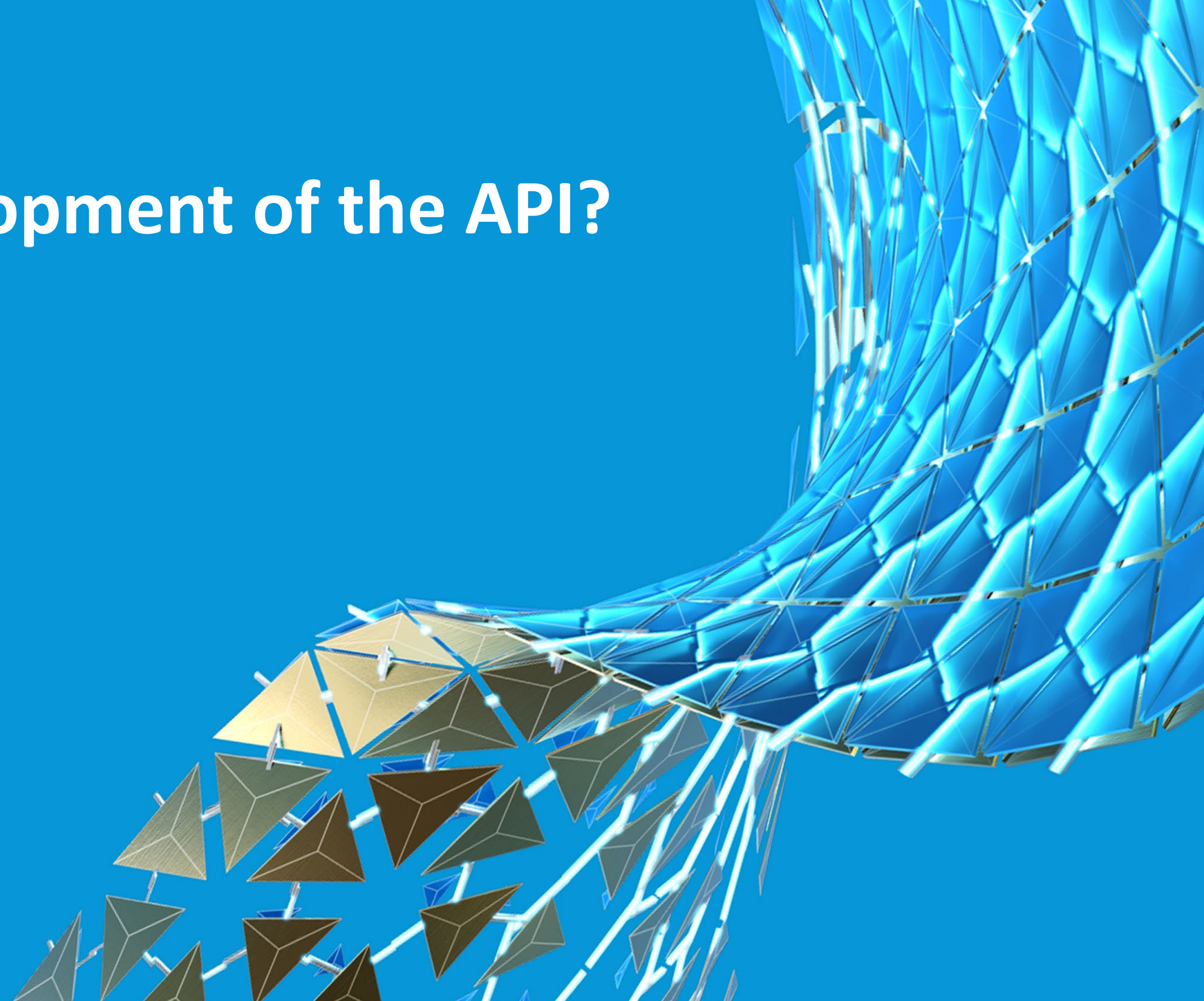


Student Perceptions of Automated Feedback in CAD

- **Data and research relating to student perceptions of these tools, and their effect upon learning is also currently being written up in a research paper.**

- **Updates on this will be posted on Twitter, @JoePalmer55**

Future Development of the API?



The API is currently in (very) active development

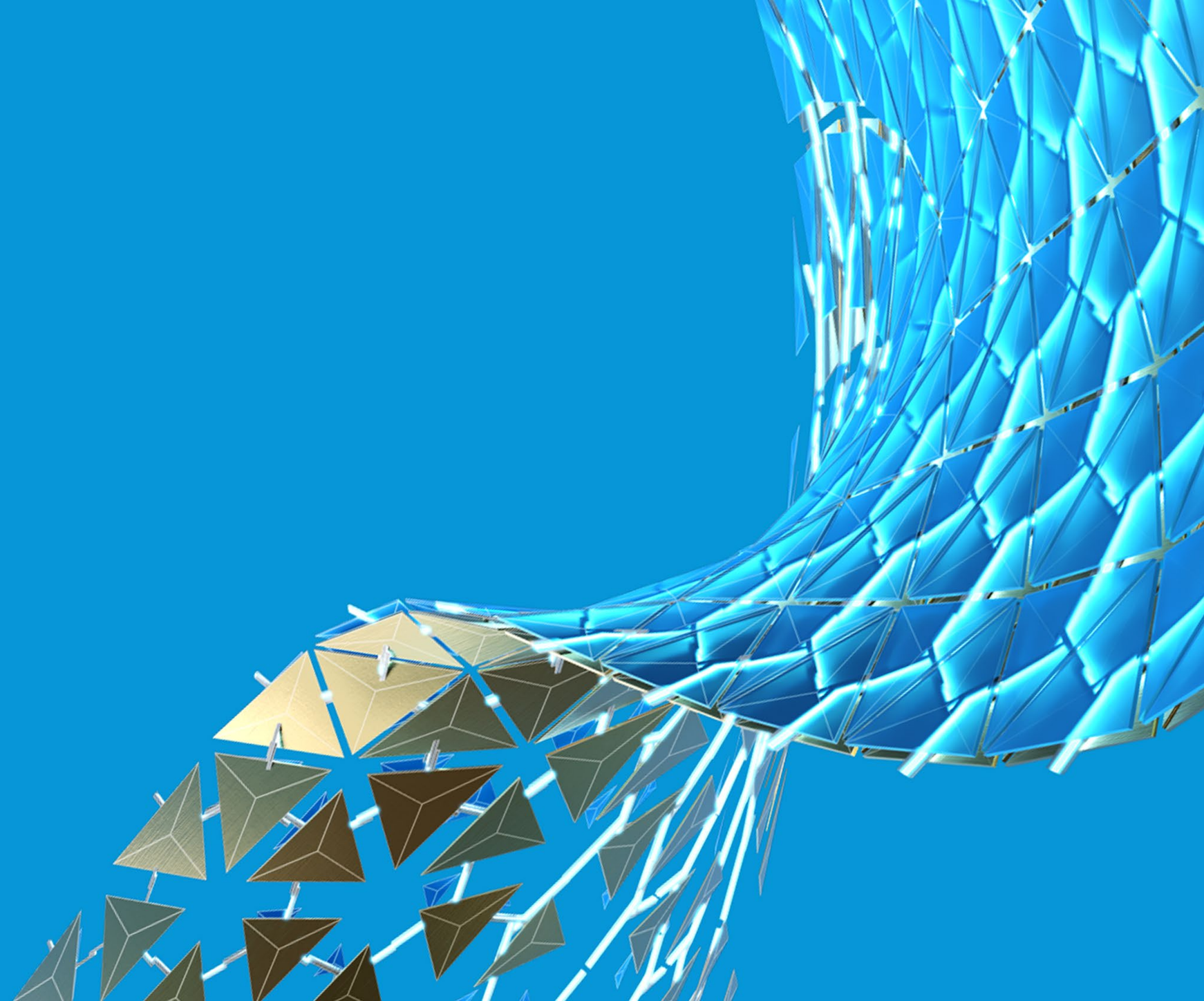
RECENT ENHANCEMENTS

- **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.**

API DEVELOPMENT PRIORITIES

- **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.**

Summary



Learning Objectives

LEARNING OBJECTIVE 1

Recall that Fusion 360 includes a comprehensive API which can be used as an automation and data insights tool.

LEARNING OBJECTIVE 2

Understand that the API can be used in ways that will enhance the effectiveness of teaching and learning.

LEARNING OBJECTIVE 3

Be able to locate the user documentation for the Fusion 360 API and have an awareness of some of its capabilities.

LEARNING OBJECTIVE 4

Recall the possible future development plans for the API and how to learn more.

Give the API a try today. You won't know what is possible until you develop something!