# ‘Zero-to-Hero’: self-assessing, scaleable, microcredential-style modules for engineering ‘maker’ skills

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**ABSTRACT**

### CONTEXT

Practical engineering ‘maker’ skills are highly valued by industry, where engineering graduates who possess hands-on experience are sought-after for their ability to prototype, troubleshoot, design-for-manufacture, and integrate with tradespeople. Industry demand for these and other skills also extends to practicing engineers, with many universities beginning to offer ‘microcredential’ courses to provide a-la-carte learning opportunities to professionals. Modularisation of course content has emerged as a potential avenue, allowing institutions to package learning materials into standalone, online blocks that can be deployed across multiple units with a program, as revision resources, to support extracurricular projects, or as microcredentials. Modularisation is particularly challenging for ‘maker’ topics, where access to physical equipment and practical demonstration are essential for developing these skills.

### PURPOSE OR GOAL

This practice paper aims to provide a blueprint for self-assessing, asynchronous, and standalone microcredential-style modules for hands-on/maker engineering topics.

### APPROACH OR METHODOLOGY/METHODS

This practice paper details and analyses the design, production, and distribution of Zero-to-Hero modules, with references to an open-sourced example we provide - *Arduino Zero-to-Hero* - throughout for concreteness. Hard-won lessons from the design of several such modules are provided to scaffold and support new producers, especially around the more ‘mechanical’ aspects of module production - including:

1. segmenting/structuring of content,
2. video structure/filming/editing, and,
3. design of self-assessing capstone projects.

### ACTUAL OR ANTICIPATED OUTCOMES

This blueprint detailed in this work and open-sourced example provides a template for the development and distribution of future modules.

### CONCLUSIONS/RECOMMENDATIONS/SUMMARY

The “Zero-to-Hero” formula has already been applied across five modules, supporting extra- and in-curricular undergraduate engineering activities across two universities. These have enabled the asynchronous uptake of maker skills by young, diverse, and multidisciplinary cohorts as a stepping stone to practical engineering projects.

### KEYWORDS

microcredential; module; online; asynchronous

# INTRODUCTION

‘Maker’ skills encompass a range of practical engineering capabilities, including CAD, fabrication, circuit/PCB design, additive manufacturing, etc. Graduates proficient in maker skills are highly sought after by industry - their ability to prototype, troubleshoot, and design-for-manufacture being essential for application of engineering theory to real-world problems.

While in the past, provision of hands-on skills training has been viewed as the purview of TAFE/VET/Trade-schools, or even of industry, there is increasing demand for universities to explicitly develop these skills in engineering graduates. Naturally, this poses a resourcing challenge to institutions. Practical elements of maker education typically demand access to specialised equipment, materials, spaces, and trainers.

Alongside this, and to meet the growing industry demand for flexible, targeted learning opportunities for professionals, universities are increasingly exploring the modularisation of course content and the deployment of microcredentials - a-la-carte learning options that cater to individual career goals and industry needs. A trend towards microcredentialing is gaining momentum - even being recommended in the recent Universities Accord (O'Kane et al., 2024) . Modularisation of course content also has applications beyond professional development: enabling deployment of content across courses and degree programs, serving as revision resources and supporting extracurricular projects such as student teams (e.g. Formula-SAE).

# OBJECTIVES

This practice paper provides a blueprint for bespoke and tailored ‘maker modules’, which target the following five objectives:

1. **Accessibility:** available asynchronously and online to accommodate diverse learner schedules and locations, and promote learner autonomy - including for revision.
2. **High Engagement:** utilising professionally-produced content and hands-on assessment to maintain interest and motivate uptake by volunteer cohorts (e.g. student teams).
3. **Scalability:** suitable for deployment to small and large cohorts with minimal instructor intervention, leveraging self-assessing projects with bespoke demonstration hardware.
4. **Practicality and Relevance:** hosted by experienced practitioners/industry experts, and grounded in real-world applications and challenges.
5. **Modularity:** structured as segmented blocks that scaffold learning, minimise extraneous cognitive load, and ensure logical progression through skills, as well as enabling potential distribution as microcredentials.

In the following sections, a blueprint for these modules, which we refer to as *Zero-to-Hero Modules*, is provided. Practical considerations toward the design and production of modules are also discussed.

# ARDUINO ZERO-TO-HERO

For concreteness, the coming sections will reference and analyse an open-sourced example we provide, *Arduino Zero-to-Hero,* designed to introduce learners to the fundamentals of microcontrollers.

> **Concrete Example:** Throughout this paper, callouts like this describe how *Arduino Zero-to-Hero* approaches various aspects of production. This module has been open-sourced, and can be viewed at https://tinyurl.com/arduinozerotohero.

# MODULE DESIGN

## Topic Selection

Zero-to-Hero modules target broadly applicable topics, empowering learners to seek out and manage application/extension of module content to their specific applications. Good candidate topics focus on introductory concepts related to a single maker skill, minimise prerequisite knowledge, and bound resources required for an end-of-module, hands-on ‘capstone’ assessment.

> **Concrete Example:** *Arduino Zero-to-Hero* introduces learners to microcontrollers, via the low-cost, beginner-friendly, and well-documented *Arduino* platform. Learners can then extend this knowledge to more involved microcontrollers, e.g. STM32, Teensy, etc.

## Delivery Mode

Zero-to-Hero modules are designed for *asynchronous and online* delivery. To enable optional deployment of a module within ~1 week of structured coursework, they typically involve up-to 3 learning hours of content delivery, and 3 subsequent hours of independent work completing homework problems and/or the capstone assessment.

> **Concrete Example:** *Arduino Zero-to-Hero* is an asynchronous/flipped module. It entails ~2.5 hours of online content delivery, and a ~2 hour, hands-on, capstone project.

## Host Selection

Zero-to-Hero video hosts are selected for their extensive practical experience utilising the maker skill being taught. A host can add significant value to the discussion of key concepts by referencing real-world examples and challenges they’ve encountered in their practice. Industry experts can be particularly effective hosts - their authentic experience lending authority to the module. To maximise engagement, choose hosts who can demonstrate high enthusiasm on camera. Finding and engaging suitable hosts can be challenging - especially considering the business-hours professional commitments of industry partners. Leveraging university or bespoke microstudio facilities can enable industry hosts to film after-hours with minimal supervision and training.

> **Concrete Example:** *Arduino Zero-to-Hero* is hosted by the university advisor of a student Formula-SAE team, who use microcontrollers extensively in their project work.

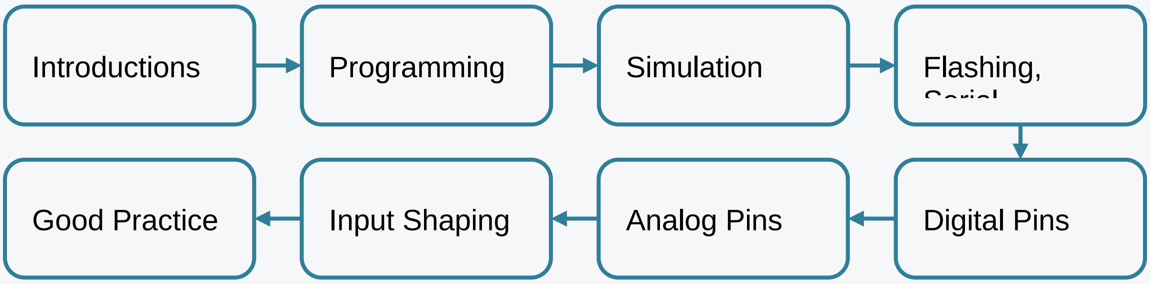
## Content Segmenting and Structuring

Zero-to-Hero modules are delivered as a sequence of carefully and intentionally ‘chunked’ content segments. Each segment focuses on a single concept/skill, and entails:

1. an engaging, short, *Concept Introduction Video* - designed for first-time consumption, and,
2. associated *Written Supporting Material* - designed for revision/review/lookup.

Segmenting and sequencing content provides a number of pedagogical benefits, including reduction of simultaneous learning burden to mitigate extraneous cognitive load, scaffolding to ensure that new concepts remain within learners zone of proximal development and improved accessibility/searchability enabling autonomy and easing revision (Brame, 2015). These efforts can significantly improve engagement with and retention of module content. Segmenting can be time-consuming: pre-production planning efforts may equal or exceed those required to film the module videos. This preparation is essential for maximising engagement (Guo et al., 2014). When sequencing, care should be taken to minimise acausal prerequisites (i.e. a segment relying on knowledge covered later in the sequence), and scaffold increased complexity and integration of concepts throughout the sequence. Preparing *Written Support Material* before filming videos can be a low-risk way to verify the flow of a sequence, helping to minimise costly reshoots.

**Concrete Example:** *Arduino Zero-to-Hero* delivers core skills over ~20 segments. Each entails 5-7 minutes of video content, and ~500 words of written/revision material. Segments are sequenced to minimise acausal prerequisites - e.g. learners are introduced to constant-power output pins before programmable output pins.




### Assessment

Zero-to-Hero modules conclude with a 'capstone' assessment. Depending on how a module is deployed, this may serve a purely formative purpose - for students to verify their own understanding - or as substantive assessment for coursework. In all cases, capstone assessments are designed to be hands-on, competency based, untimed, and available for students to complete at their own pace. Well-designed capstones test most, if not all, of the module 'skills', in a scaffolded way - one at a time - with tasks increasing in complexity and culminating in an integration exercise that brings module skills together.

**Concrete Example:** The *Arduino Zero-to-Hero* capstone assessment involves (successively) using the serial monitor, writing and flashing code, wiring sensors, and reading/writing analog & digital signals, before integrating these skills to drive an RGB LED, with brightness controlled by a potentiometer and push-button.

## PRODUCTION AND DISTRIBUTION

### Concept Introduction Videos

*Length*

Zero-to-Hero videos are short (5-10 minutes) to maximise engagement. Short videos ease rewatch/searchability/scrubbability, and appeal to the shorter attention span of modern learners. If required to be longer, videos employ other strategies to drive engagement - e.g. continuous visual flow via b-roll of hands-on activities, coding, khan-style hand working, etc. (Guo et al., 2014).

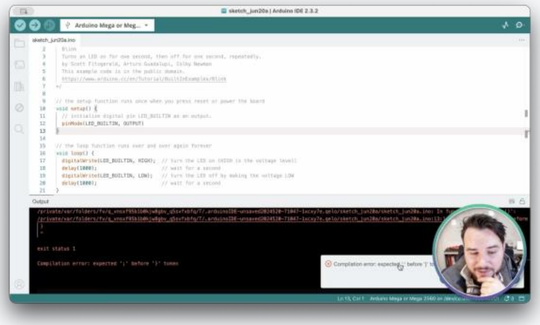
*Composition / Format*

Zero-to-Hero videos incorporate a mixture of 'scenes' to maximise engagement.

'Talking head' scenes are used for primary content delivery. These typically involve the host full-screen and centre-frame, from the chest-up, with some room left in the upper corners of the frame for overlay of images/b-roll in editing as needed. Here, the camera should be positioned at- or slightly-above-eyeline for approachability, as talking head scenes can feel confronting if the host is 'staring down' at the viewer. There is no need to set up a clinical space for filming - shooting in the host's normal work environment can mimic in-office consultation and promote a 'personal feel', improving engagement (Guo et al., 2014). While an effort should be made to limit cognitive load (e.g. by filming in front of a static background, rather than a busy shared space), maintaining some ‘academic mess’ (e.g. stacks of books) and/or personal belongings (e.g. a football scarf, or model car) in the background can help humanise the host and endear them to their audience.

‘Activity’ scenes typically involve some level of continuous visual flow, and are good drivers for engagement. These include computer simulations, programming, construction of schematics, CAD modelling, khan-style hand-working, manufacture, wiring, soldering, etc.

**Concrete Example:** *Arduino Zero-to-Hero* uses two primary “scenes” - full-screen “talking head” for content introductions/discussions (left), and a “picture-in-picture” screencast for coding and tinkerCAD simulation demonstrations (right).



*Stage Presence*

Host ‘stage presence’ is essential for engagement. Hosts should speak relatively fast and with high enthusiasm (Dart & Gregg, 2021), and focus on clarity of presentation - enunciating clearly and projecting. This can be challenging for new hosts, who tend to speak slower and quieter to camera than they would otherwise. Eye contact with the camera lens (not the confidence monitor, computer screen, or a script), a slight forward lean, ‘talking with hands’, and smiling can contribute to a positive and informal feel that drives engagement and endears the host to the viewer. In short, hosts should speak to the camera as they would a student. It is unreasonable to expect a host to deliver a 5 minute video in a single shot, and attempting to do so will lead to excessively long shoot times. Instead, a high-quality result (i.e. exclusion of errors or tangents) can be achieved by ‘steering into the skid’ and embracing the ‘jump cut’ nature of modern video. If required, hosts can even deliver one sentence at a time. Provided a host ends each sentence on a downward inflection, and starts the next on an upward one, the result will feel natural when cut together.

*Lighting*

Deliberate lighting is essential for high quality video, both in controlling shadows and improving signal-to-noise - allowing reduced camera sensor sensitivity (ISO) and a better image. Natural light can be fickle - varying with weather/time and introducing continuity challenges for edits/pick-up shots. 3-point lighting (Aldredge, 2021), where the subject is illuminated from the front (called a ‘key light’, ~100% brightness), 45º (‘fill light’, ~50%) and behind (‘back light’, ~20%) provides the best separation from the background and mitigation of shadows. In combination with overhead office lights, 2-point lighting (at ±45º) is also sufficient. In this case, beware of overhead light flickering, particularly under fluorescents. This may not always be perceptible in-person: test footage should be reviewed and camera shutter speed adjusted before ‘principal photography’. Expensive lights are not required. Adjustable-brightness and -temperature LED panel lights are now relatively affordable, given the recent surge in video game streaming as a hobby.

**Concrete Example:** *Arduino Zero-to-Hero* was filmed in an office space, with (uncontrolled) overhead lights, and two-point forward lighting provided by cheap (<$100), dimmable Amazon LED panels, ~20º above and at ±45º horizontally to eyeline.

*Film*

High quality footage contributes to the production value of Zero-to-Hero videos, which lends authority to the modules. That being said, expensive camera equipment is not necessary to achieve a good result. Modern webcams provide a quality image when paired with good lighting and composition. While natural camera background blur (Bokeh) arising from a large aperture can enhance the aesthetic of a shot, software subject masking/blurring is usually poor, can be distracting, and is best avoided. While not essential, a large increase in image quality is possible with relatively little investment. Via HDMI-out and an inexpensive (~$20 AUD) USB capture card, high quality video can be ingested from entry-level/old and inexpensive point-and-shoot, mirrorless, or DSLR cameras. Alternatively, modern mobile phone cameras can provide a substantial quality increase compared to webcams, and can be integrated via USB with free software - some even natively (i.e. iPhones with Mac computers).

> **Concrete Example:** *Arduino Zero-to-Hero* was filmed on an entry-level point-and-shoot camera via HDMI-out, with a cheap (<$20) USB-HDMI capture card, a fast aperture (ƒ 1.8) and low ISO (200) to maximise image quality and background blur.

*Audio*

Poor audio quality is widely accepted to harm engagement with video content. For spoken word, and as with lighting, high quality audio is largely dominated by signal/noise. Where possible, hosts should film in a quiet environment, and be mindful of ambient noise - computer fans, other people, squeaky furniture, etc. Use of an external microphone can help to isolate/eliminate computer noises, and these are now widely accessible and affordable. Where possible, dynamic microphones are better for this noise isolation, compared to condenser mics. Hosts should position their microphone close to their face to reduce the recording gain - though some care should be taken to avoid annoying *ess*, or *pop* sounds. One need not aim to exclude their microphone from the frame, as its presence lends visibility to the efforts made toward high audio quality.

*Capture*

Zero-to-Hero videos are recorded direct-to-disk on a computer via screencasting software. In this software, virtual 'scenes' can be constructed to e.g. overlay a presenter in the corner of a screen recording, apply filters, or make the host a full-screen 'talking-head' to focus on important points. While footage can be captured via a camera SD card and later imported/edited, 'baking in' these effects in the capture stage reduces double-handling, ingest risks, and editing workload.

*Editing*

Zero-to-Hero videos are tightly edited for conciseness, pruning (Brame, 2015) unnecessary tangents and removing dead space between sentences/phrases. Leaning into this intentional 'jump cut' style - popularised by Youtubers like Vlogbrothers, is considered normal (and perhaps even expected) by modern viewers. Aiming for a ~0.2 second air-gap between clips sounds natural.

This level of editing is time consuming - typically ~30-45 minutes for a 5-10 minute video for experienced users. Editing time can be substantially reduced by:

1. enlarging audio waveforms while a-roll trimming to quickly find phrase start/end points,
2. leaving 'breadcrumbs' when filming - written timecodes of good/bad takes and/or easy-to-spot markers in the footage (e.g. full-frame colour cards or audio spikes), and,
3. mapping hotkeys for common actions, including: 'Split at playhead' to split a clip, 'Ripple delete' to remove a segment and bring forward the next, and, 'Trim to playhead', to perform a combination of the above actions.

Modle producers need not pay for expensive editing software or powerful computers, with numerous free, resource-efficient, and well-documented options available. Blackmagic *DaVinci Resolve* is one such option, currently popular amongst the YouTube community. If editing many videos, producers should invest time reviewing free, online tutorials for efficient editing.

*Reshoots/Pick-up Shots*

Invariably, when producing tens of videos, continuity and/or structural issues will be discovered in the editing process, and reshoots/pick-up shots may be required to fill in these gaps. To ease this process, the camera and lighting setup should be rigidly attached and remain in-place through the filming process, and changes to the background should be avoided. Where possible, the host should also maintain a consistent 'costume' (e.g. a jacket) throughout filming. Where structural problems do arise, cutaway/b-roll footage can be laid over host audio to help hide pick-up shots.

*Distribution Platform*

Zero-to-Hero modules are hosted primarily through open platforms (e.g. YouTube) to minimise barrier-to-entry and enable broad distribution of modules across units/courses, faculties, and even universities. Distribution platform can be a key factor in engagement, with students reporting higher engagement with open platforms (e.g. YouTube) for the ease of content access, features, service quality and ease of use they offer, compared to internal platforms (Giesen et al., 2022).
Module producers should consider that use of such platforms may be at odds with institutional policies concerning privacy, IP leakage, and copyright, and may expose students to interruptions to their learning experience (i.e. ads). These considerations should be balanced against the potential engagement benefits, and alternative/kosher access to the video files provided (e.g. via an LMS).

> **Concrete Example:** *Arduino Zero-to-Hero* is distributed via YouTube to improve access and engagement. Videos are collated into a playlist for optional binge-watching, and copies are also provided to students via the university LMS for policy compliance.

## Written Supporting Materials

To support revision/quick lookup of module content, Zero-to-Hero videos are supplemented by written supporting material. Written material should be segmented identically, and be standalone, addressing the key video concepts.

Deployment of written content is typically through a dedicated website. Static site generators designed for this purpose (e.g. *Read the Docs*, or *Gitbook*) provide easy access to content and capability for rich media inclusion - e.g. GIFs, embedded videos, code blocks, callouts, links between pages, etc. Some platforms provide powerful search features, including natural language processing/AI indexing, and other free educational plans for small classes/projects.

> **Concrete Example:** *Arduino Zero-to-Hero* is hosted on the *Gitbook* platform, which at the time of writing, provides a free educational plan and supports rich media inclusion.

## Capstone Assessment Projects

*Scaffolding and Self-Assessment*

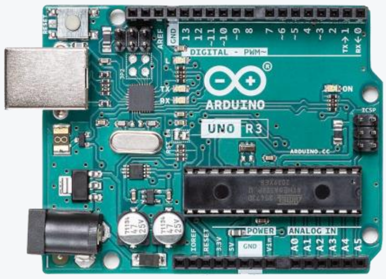
Capstone assessments are designed to be self-evaluating, for scaleability and learner autonomy. Good assessments require minimal/no intervention from teaching staff, owing to careful scaffolding of complexity throughout the assessment. A typical capstone individually tests each of the skills taught in the module, before integrating these to achieve a more complex outcome.

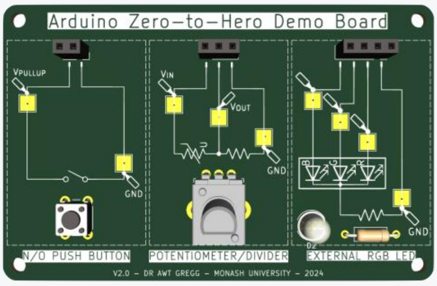
*Bespoke Demonstration Hardware*

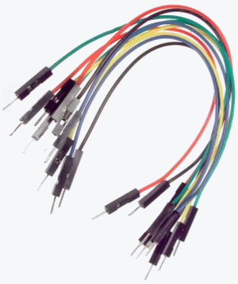
To enable unsupervised and large scale assessment, many Zero-to-Hero modules utilise bespoke capstone demonstration hardware kits. Demonstration hardware should be designed for low cost and manufacturing time, to enable bulk provision of kits to a cohort and mitigate risk of damage/loss/theft in providing easy access. This is typically achieved using bulk/cheap manufacturing techniques (e.g. acrylic laser cutting, PCB manufacture, 3D Printing, etc.).

**Concrete Example:** The *Arduino Zero-to-Hero* capstone tests student ability to wire-up and utilise a push-button, potentiometer, and RGB LED. To provide robust and consistent access to these components, the module provides a custom “demo board” PCB and jumper wires, with onboard wiring diagrams for intuitive interaction.







*Viva Verification*

To verify understanding and combat plagiarism - especially where modules are deployed as coursework in the age of AI - final certification is usually gated upon a short (1-2 minute) viva. The tone of the assessment should be curious, not judgemental, and should focus on prompting additional learning - e.g. “How else might you have written your code to the same result in fewer lines?”. Where an instructor doubts the integrity of the submission, they can prompt for a short extension task to be completed under supervision, e.g. “Could you quickly show me how you would change the hue of this RGB LED?”.

*Completion Badges*

Zero-to-Hero modules award a ‘certification badge’ upon completion of the module capstone project. This kind of gamification has been shown to increase engagement and performance (Dicheva et al., 2020).

**Concrete Example:** Zero-to-Hero Modules currently award pressed-metal, enamel-filled pins made by https://www.thepinfactory.com.au/. Artwork was made using the vector-graphics program InkScape. Pins cost ~$2.50 each, with a 3-4 week manufacture lead time. Left: two Zero-to-Hero pins. Right: a typical pin artwork proof.


Award of badges has been seen to strongly incentivise knowledge transfer - especially amongst volunteer cohorts (e.g. student teams). This semi-organic knowledge transfer benefits the entire cohort - improving the baseline fluency with various topics, developing T-shaped engineers, and creating ‘informal peer tutors’ amongst the student body. Badge quality appears to be a factor in module interest. Zero-to-Hero modules provide enamel-filled, pressed-metal badges, which students proudly display on their bags, hats, etc.

Student feedback suggests that digital badges/stickers may be less desirable. While there is a cost involved in provision of badges (~$2.50 AUD/each at 3-500 scale order quantities), this represents a relatively minor spend compared to the value added by widespread uptake of module knowledge and reduction in demonstrator hours that is achieved with these flipped classroom modules.

# CONCLUSIONS AND RECOMMENDATIONS

This practice paper provided a blueprint for the construction of *Zero-to-Hero* modules - bespoke tutorials for maker skills. Through a combination of high-production-quality and short pre-recorded videos, rich written revision content, and hands-on capstone assessments, Zero-to-Hero modules have now introduced many students to a range of maker topics across multiple institutions. This paper provided an open-sourced example module, *Arduino Zero-to-Hero*, for concrete reference.

This module is available for use/download at https://tinyurl.com/arduinozerotohero.

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