Improving Student Success Rate Through Linking Virtual, Physical and Digital Prototyping

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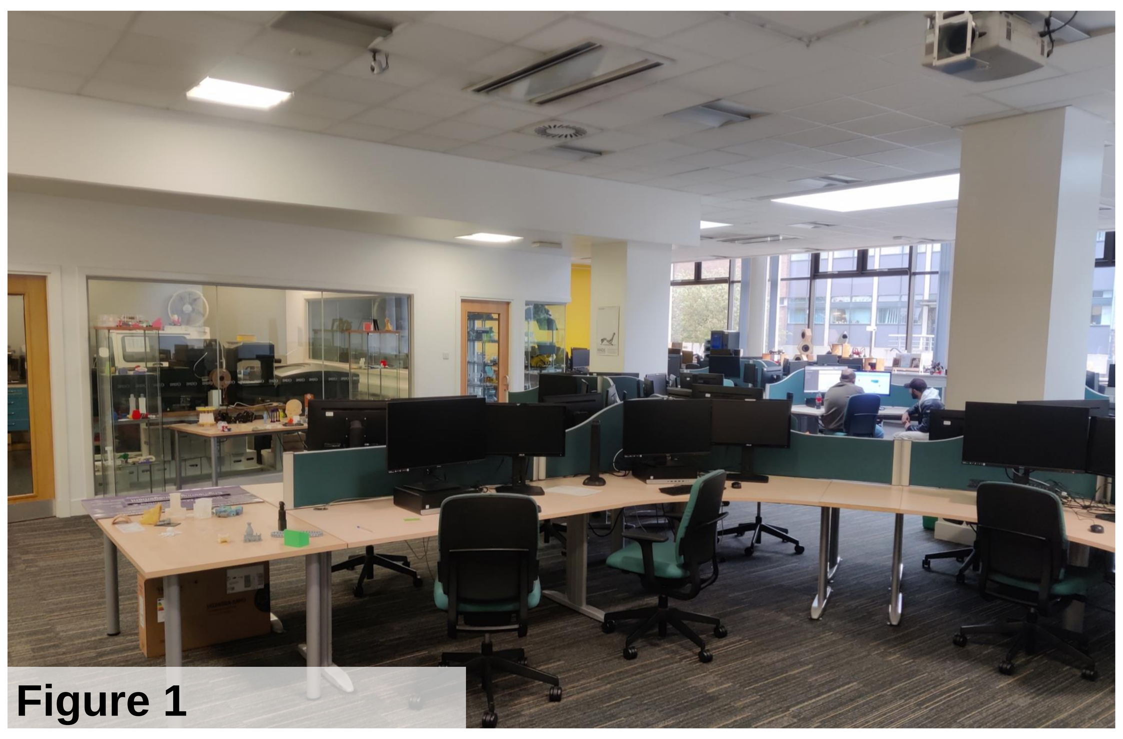
Figure 1


Figure 2

Figure 3

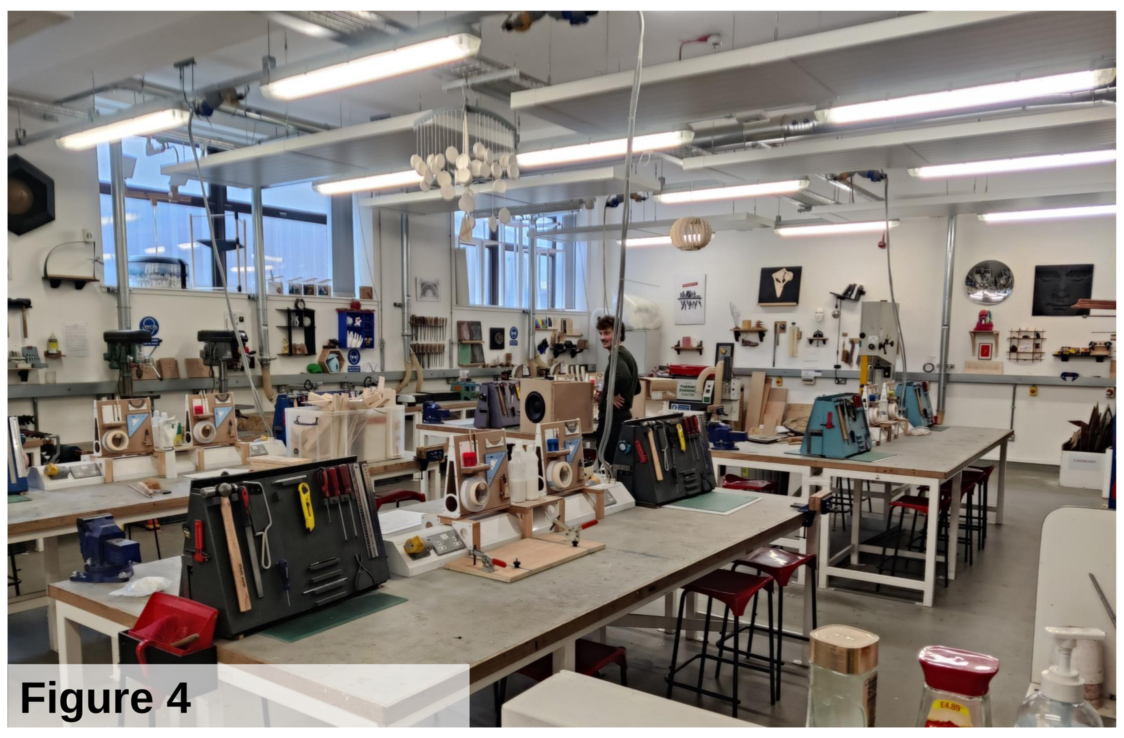
Figure 4

Background

Year 2 undergraduate Design Engineering students (n=86) undertake a ‘locomotor’ design and build project [1]. The brief is open to any design; unique or a modification of a classic mechanism design like Shigley’s 4 bar linkage [2] or Jensen’s strandbeest [3] and students are given a 3 V gearmotor kit with real and virtual parts (Fig. 6). Devices compete to travel as far as possible in 30 s also graded on novelty, complexity, robustness and aesthetics.

3 hours per week is timetabled in the Digital Design and Manufacture Suite (DDMS, Fig. 1) accessing 3D printers (Fig. 2), Universal Laser Systems cutters (Fig. 3) and hand tools in the collocated Product Design workshop (Fig. 4).

“Novelty” assessment criteria can create a period of procrastination causing inadequate prototype iteration. Many students are not using prototyping facilities until they have developed a CAD model failing to produce a refined device; around 20% of the class produce locomotors travelling greater than 1 m (up to 6 m). There is ambiguity over whether students are learning from planning errors when reviewing prototyping proficiency later in the course.

Continuous Improvement Goals

1. Improve student success rates; **2.** Create efficiency for supporting staff and machine use; **3.** Work towards more sustainable material usage.

Approach

Our approach (Table 1) has been to increase guided activity, with more milestones, integrating concept sketching, CAD and early card based prototyping, increasing student access to laser cutting. We limited acrylic availability to a 400 x 300 mm sheet per student presenting a “nesting challenge” (Fig. 8) and prompting early consideration of part sizing. Prototyping iteration is promoted [4] (Figs. 7 & 8) by allowing unlimited card sheet use in a new laser cutter to test CAD designs. Virtual prototyping techniques are also demonstrated to enable more iteration cycles (Fig. 9).

Weeks	1	2	3	4	5	6	7	8	9	10
Supported DDMS time	Lecture	Lecture	Lecture	Lecture	♦	♦			♦	
Mechanism research					A	B			C	
Concept generation										
Design detailing										
Build gearbox	Tutorial									
Build prototype leg		Tutorial								
Develop sketch into CAD			Tutorial							
Develop CAD into physical				Tutorial						
Virtual prototyping skills							Tutorial			
Engineering drawing										
CAD tutorials										

A = commitment to design concept, **B** = Interim critique, **C** = Acrylic laser cutting deadline.

Table 1 – Class Timeline Overview

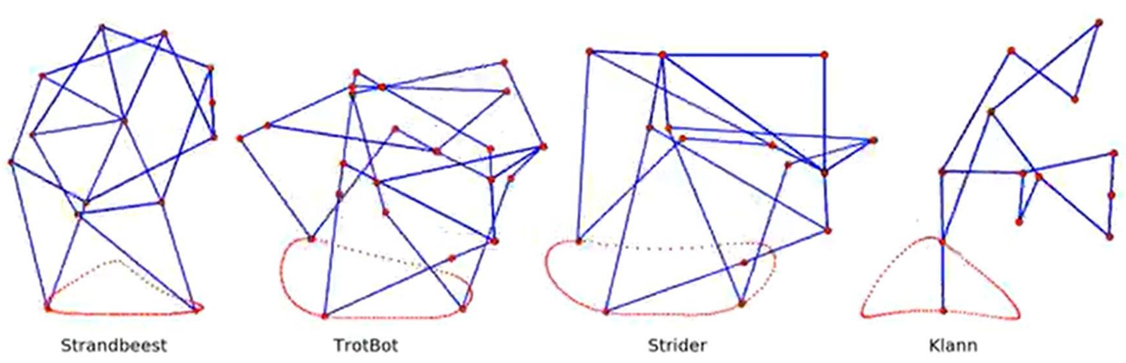

Figure 5. Weeks 1-4 [5]


Figure 8. Weeks 3 & 4

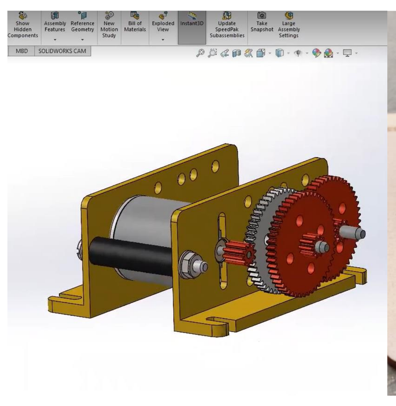
Figure 6. Week 1

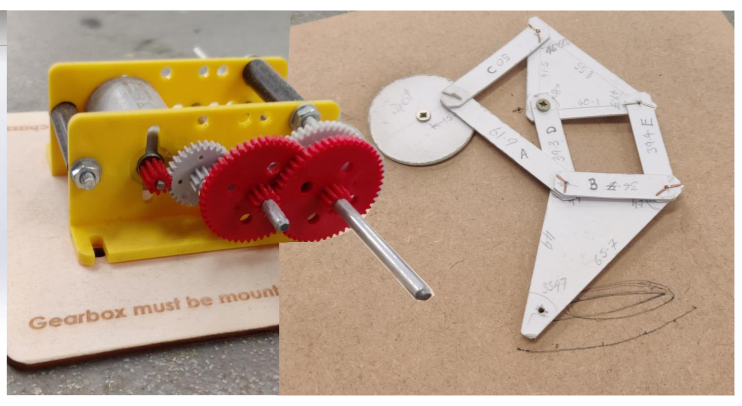
Figure 7. Week 2

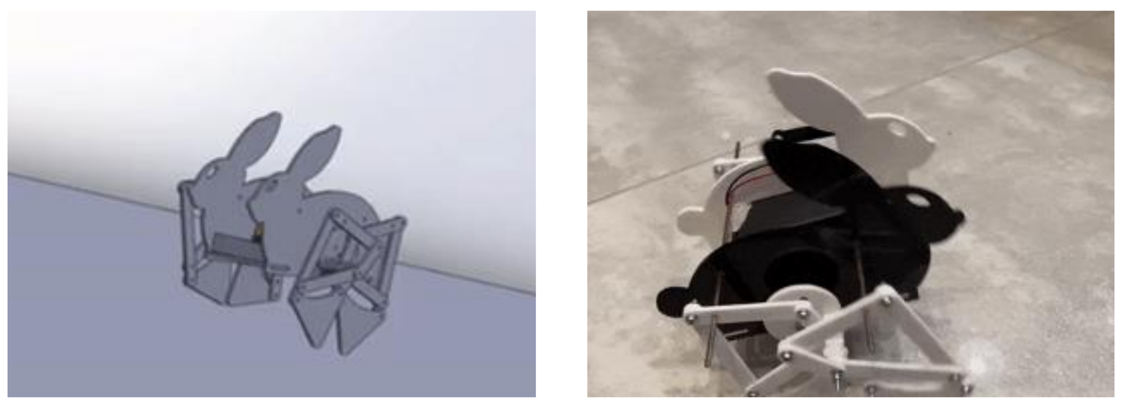
Figure 9. Week 7

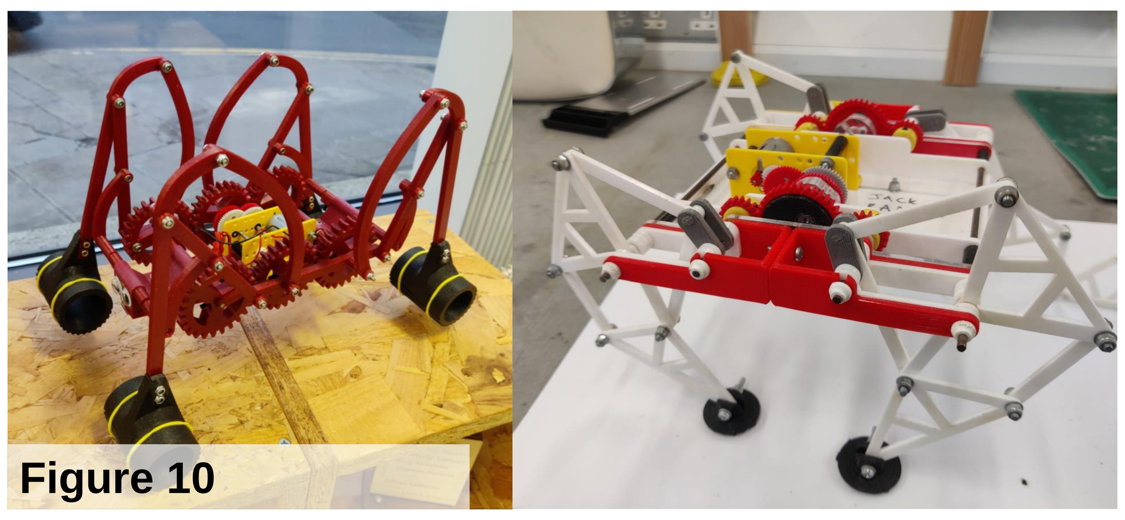
Figure 10

Results

- Build quality and detail novelty (Fig. 10) have increased.
- Many more submissions are using a mix of 3D printing and laser cutting (Fig. 10).
- The number of walking locomotors has not significantly increased.
- Technical staff workload and machine bottlenecks (re-cuts) are reduced.
- Significantly less acrylic used (no top-up order was required which was 120 sheets of 800 x 600 mm = £560 in the previous year.

References

[1] J. M. McCarthy, K. Chen. “Design of Mechanical Walking Robots”. “2021
[2] Shigley JE. The mechanics of walking vehicles. Army Ordnance Tank-Automotive Command; 1960
[3] Lin BH, Chen YH. On the Design of an Innovative Eight-Bar Linkage Walking Machine. In International Design Engineering Technical Conferences and Computers and Information in Engineering Conference 2020 Aug 17 (Vol. 83990, p. V010T10A025). American Society of Mechanical Engineers.
[4] Real R, Snider C, Goudswaard M, Hicks B. “How do prototypes change? Characterising quantitative and qualitative changes between prototype iterations”. Proceedings of the Design Society. 2023 Jul;3:2105-14.
[5] Ben vagle, Wade Vagle, https://www.diywalkers.com/ (Accessed 17/06/24)