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SURGICAL APPLIANCE DESIGN THROUGH STUDENT CO-CREATION AT PAL-WEEK

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ABSTRACT
PAL-Week has been developed out of the desire to transition 1st year UG Design Engineering student's learning responsibility and frame the expectation of their University experience through engagement in the first academic week of the year. A novel blend of Peer Assisted Learning (PAL) and Project Based Learning (PBL) techniques provides a rapid learning process with 1st year expectations formed directly through working with their 2nd year colleagues.
For their brief, mixed groups of 1st and 2nd year students were asked to design a left radial arm support to assist Interventional Cardiologists from the Cardiac Intervention Unit (CIU) at Royal Bournemouth Hospital (RBH) when conducting Transradial Coronary Angioplasty. The surgical procedure is generally conducted from the right side of the operating table and where the catheter is inserted through the right arm this falls naturally for the procedure.
Students researched, analysed and designed viable solutions for the radial arm support and presented solutions at key intervals to staff and peers. The final presentation was submitted as a narrated YouTube video and scaled prototype with all group members questioned.
Success can be framed from four perspectives: Firstly, student expectation has been set at the outset of their academic careers. Second, students understand their responsibilities within the transition from taught lessons to student managed learning. Third, students have been introduced to new technology and appropriate methodologies. Forth, the practical outcomes, from the work they have done, are currently informing the development of a working prototype device in partnership with the CIU.

Keywords: PAL, PBL, design.

1 INTRODUCTION
In common with many institutions, there has been a drive to enhance the student experience within our University Faculties through the integration of Research, Professional Practice and Education under a formal theme. For our University this is known as Fusion and is fundamental to the strategic plan [1] with funding streams available to encourage projects that embody this concept [2]. Funding typically support three streams: Student co-creation, staff mobility & networking and study leave. For this project co-creation funding provided equipment and materials in support of a PAL-Week design project in conjunction with the Cardiac Intervention Unit at the Royal Bournemouth Hospital.

1.1 PAL
A recent Higher Education Academy report [3] examined 150 separate PAL schemes from 55 HE institutions. Despite the wide range of PAL-type programmes discussed the underlying guidelines, principles and benefits remain the same and can be distilled to: Support student learning; cross-year student support; enhanced University experience; participative and collaborative; addressing what and how students learn; insight into lecturers' expectations; of benefit to all students. Ody [4] in [3] supplements with the promotion of academic and social communities, while Hilsdon [5] identifies the community of practice providing *"greater emphasis on legitimate participation and critique"*.

1.2 PAL-Week
PAL-Week was originally devised to bridge the gap in educational engagement with Sustainable Development relative to that found in some of the more pragmatic business sectors [6]. The underlying structure was informed through international best practice identified at Delft University [7] including

their “Boat-Week” activity [8], Cambridge University [9] and Manchester University [10] as well as our own programmes. The key objective was to promote students understanding of Sustainable Development and the impact upon the work they do as Designers and Engineers [11-13]. Despite the focus upon Sustainable Development, it is the learning methodology that emerged from these programmes that defines PAL-Week, rather than the subject matter delivered.

1.3 PAL-Week Method

PAL-Week has developed into a means to transition 1st year UG Design Engineering student’s learning responsibility and frame expectations of their University experience through project engagement in the first academic week of the year. A novel blend of Peer Assisted Learning (PAL) and Project Based Learning (PBL) techniques provides a rapid learning process; here the students’ transition from dependency of taught to the personal responsibility of self-directed learning is the key to success. Students receive no formal teaching or didactic elements during PAL-Week, instead they receive guidance through their presentations’ feedback and daily briefings. Students are, however, introduced to the design process (Figure 1) described in BS8887 [14] and BS7000 [15].

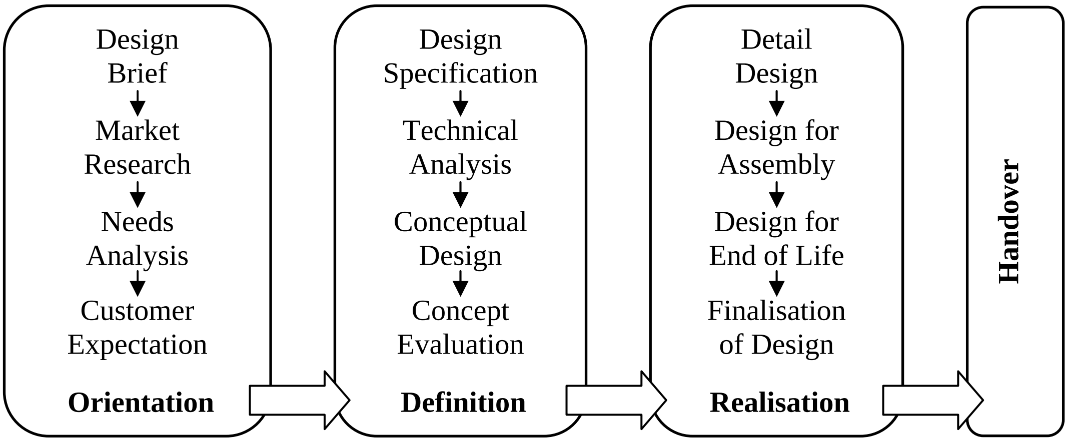

Figure 1. The Design Process, adapted from [14]

For some, this is their first time presenting to a critical audience and provides a direct method for students to measure the importance of their contribution. All students are expected to contribute to the group and for 1st years, it provides the opportunity to integrate and adapt to university learning during the first academic week rather than over the course of the first academic year. For 2nd year students, it provides an opportunity to mentor their peers in the use of facilities, design process, work ethic and university expectation. For the Academic, PAL-Week provides an opportunity to trial new techniques, promote unfamiliar topics and gain valuable insight into Student understanding of academic endeavour.

1.4 PAL-Week Objectives

PAL-Week objectives can be categorised in three distinct ways:

1. Project Objectives: Practical outputs generated by the students and represent the project goal.
2. Student Objectives: These are directly related to the guidelines in 1.1 and can be sub-divided: *Student Learning*: develop their broader knowledge of the design process applied to a real problem; *Student Experience*: develop working relationships with their peers and an understanding of how to manage the learning process; *Student Expectation*: working with their 2nd year colleagues, students understand the work ethic and academic endeavour that is expected of them at University.
3. Academic Objectives: These outcomes represent the goals of the academic team. They include evaluation of new learning methods and the application of untried technologies.

2 PAL-WEEK PROJECT

For their brief, mixed groups of 1st and 2nd year Design Engineering undergraduate students were asked to design a left radial arm support to assist Interventional Cardiologists from the Cardiac Intervention Unit (CIU) at Royal Bournemouth Hospital (RBH). When conducting Transradial

Coronary Angiography (CA) and Percutaneous Coronary Intervention (PCI) procedure it is generally conducted from the right side of the patient and, where the catheter is inserted through the right radial artery (RRA), this falls naturally for the procedure. However, clinical factors can occlude the RRA such that the left radial artery (LRA) is preferred although the layout of the catheter laboratory and monitoring systems dictates that the LRA is accessed from the right side of the patient (Figure 2). The LRA procedure is hindered by difficulty in securing the arm in place, across the body, for insertion and manipulation of catheter, stents and ancillary devices. When the Cardiologist and surgical team work across the patient to perform the left arm procedure they become susceptible to fatigue and injury to the lower back, knees and calf muscles. Fatigue is greatly compounded by wearing lead lined protective tunics and neck bands to shield against harmful emissions of ionising radiation which is necessary to visualise the coronary arteries and perform angioplasty. Left radial artery access is also more uncomfortable for the patient with the lack of arm support currently available.

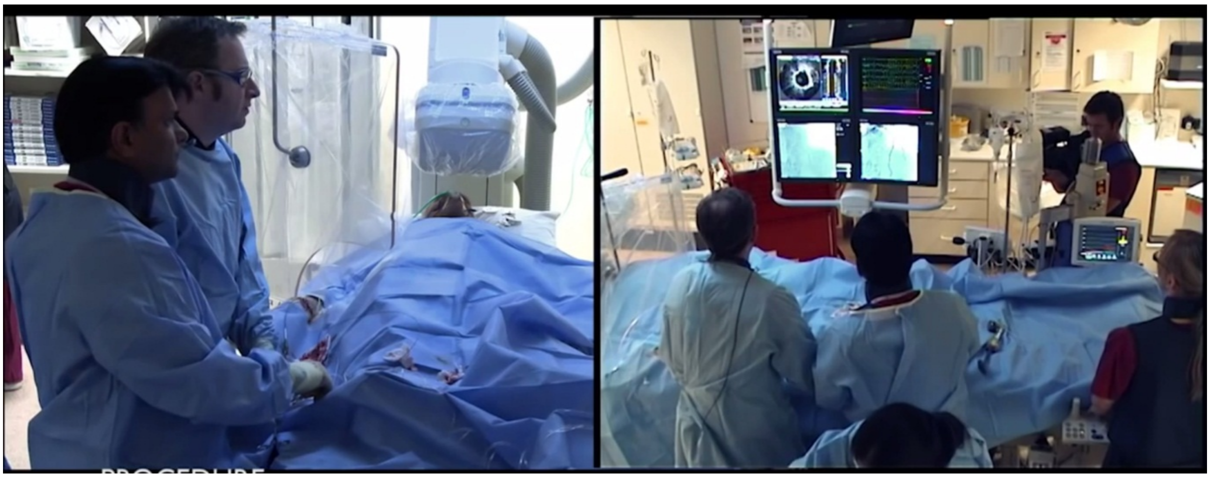

Figure 2. Catheter Lab, Bournemouth CIU [16]

2.1 Wider Objectives

For the practical development of a viable technical solution the students needed to expand their repertoire of skills and technical understanding through the practical application of ergonomics. To achieve this, students were asked to use 3D laser scanning devices to capture data of shape and form from each other’s bodies. This required students manipulating each other in a prone position to simulate the patient’s position prior to data capture. The groups were also asked to create a physical scaled model using rapid prototyping techniques and present using Youtube video rather than the customary Powerpoint to deliver their findings at key stages.

None of the students had used video before as a presentation medium and the use of laser scanners and rapid prototyping was also new. In the case of Video presentation, no workflow method or training was provided. In the case of rapid prototyping, the Makebot Replicator machines were new, untried and there was no established workflow in place. For the 3D Laser Scanners, three Cubify Sense 3D scanners were purchased specifically to support the project and, again, were untested prior to PAL-Week and no workflow established.

2.2 Ethical considerations

For Fusion Funded projects it usual to conduct an ethical review of the project; the involvement of students and the nature of data collection led to a review by the University Ethics Panel where the project was approved. A participant information sheet (PIS) and informed consent were required prior to any photographic or electronic data collection.

3 DELIVERY

PAL-Week was delivered over the course of the first formal teaching week of the academic year with 1st and 2nd year Design Engineering students distributed into mixed groups comprising 7-8 members. The programme was divided into four parts of defined duration with their own distinct objectives; each part began with reflection upon the previous outcomes, refocusing of specific objectives and concluded with student presentation of findings.

3.1 Objectives

For the first part of the programme students were provided with a short overview and asked to formulate a development plan for oral presentation to their peers within two hours.

For the second part they were asked to refine their work plan develop a technical solution delivering their oral presentation over a four minute Youtube video and specifically asked to consider:

- Function; a functional description of the technology what the product will do and how it does it. The operational performance quantified and the technology deployed should be described.
- Material; identify materials used in the product and the processes used for production.
- Anthropometric variation; variations of human form; provided with hand held 3D laser scanners.

For the third part they were asked to consider material compatibility, technology transfer and prototyping. Presenting the following day in the same format as before and specifically to consider:

- How similar solutions are used in other industries or products.
- Whether prototypes should be for the full product or key elements and relevant scale.

For the fourth part of the programme, students were asked to optimise the product's design for ease of use, decontamination, service and disposal. They were also provided access to Rapid Prototyping machines and brief instruction on lay-up criteria. Each group was provided a consultation to discuss the project with members of the Academic team. Final presentations were delivered as video with audio narration and questions from the Academic team. Assessment of student work was based upon the final presentation & questions with weighting given to student contribution within each group.

4 OUTCOMES

Student output can be evaluated through the review and quantification of content from their final Youtube Presentations. Each video was previewed to formulate a matrix of both common and relevant content before quantifying to key characteristics (Table 1). Formal academic assessment of the work was toward the satisfaction of the bulleted objectives above and is not the subject of this paper.

Table 1. Output matrix from Final Student Presentations

	Output / Group	1	2	3	4	5	6	7
Orientation	Expert Consultation				Yes		Yes	
	Market Data	Yes	Yes		Yes			
	Competitive Products							Yes
	Anthropogenic/metric data	Yes	Yes	Yes	Yes		Yes	
	Patient Orientation	Yes	Yes	Yes		Yes		
	Scan Capture	Yes			Yes	Yes		Yes
	Scan Examples	Yes						
Definition	Materials	Yes	Yes		Yes	Yes		Yes
	Analogy	Yes						Yes
	Concept Sketches	Yes	Yes		Yes	Yes		Yes
	CAD Models	Yes	Yes	Yes		Yes	Yes	Yes
	Other Models				Foam	Yes		
	Full Design		Yes		Yes	Yes		
	Context					Yes		
Realisation	Makerbot layup/output	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Right / Left hand mounting		LHS	LHS	LHS	LHS	LHS	LHS
	Floor or Table mounting	Table	Table		Table	Floor		
	Articulation	Yes	Yes		Yes			Yes
	Telescopic Adjustment	Yes	Yes		Yes			Yes
	Whole Arm or Forearm		Whole	Whole	Whole	Fore	Whole	Whole
	Wrist Orientation	Yes	Yes					Yes
	Length of Video	04:10	3:35	2:48	3:18	3:34	3:54	3:23

4.1 Project Outcomes

For their presentations, students described their work within the three key stages of the design process. Most groups provided a good description of the inputs to the orientation phase, in other words how they gathered their research data, but failed to distil this to a product design specification or statement of need. Although all student groups used the 3D laser scanners and most showed the process only one group used the output of this tool within their final presentation (Figure 3).

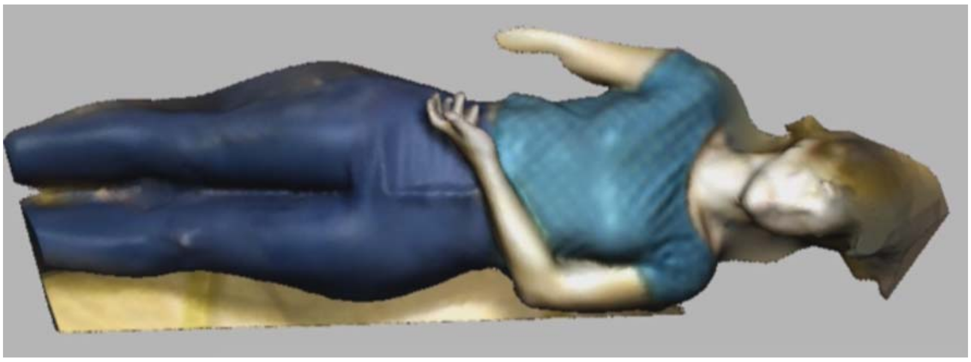

Figure 3. 3D Scan Data Capture

For the definition phase, students again focused their video presentations upon the inputs, the idea generation processes, rather than the outputs of that work. Most showed the development and selection processes but the design was not shown in detail and only one in context. For the realisation phase, students failed to present a clear final design proposal; they focused instead upon the design and production of their Makerbot rapid prototype output. Most, if not all of the supports were designed to mount the operating table or floor to the left hand side of the patient; this despite the wrist needing to support and orientation to the right. One group proposed a floor mounted support, even though the operating table needed to move during the operation for effective visualisation of the procedure.

4.2 Wider Objectives

All of the groups adopted a “hands on” approach to using the laser scanners, even if they did not use the results in their final presentations. Each manipulated their subjects into representative positions to ascertain patient comfort, flexibility and solution viability. Although initial attempts were poor and the application haphazard, each of the groups developed a working procedure for data capture.

All groups succeeded in producing from rapid prototyping, however the results were variable with problems relating to orientation on the build bed, support material and component design.

All groups developed successful workflow for creating their video presentations. Some had minor issues with sound quality, primarily related to the existing sound track prior to over-dubbing.

5 DISCUSSION

The Academic team wanted students to develop a solution that would benefit both the CIU at RBH as well as themselves through personal development. The team also wanted to trial new technologies and methods, in the form of laser scanners, rapid prototyping and video presentations.

With regard to the project objective, development of a viable technical solution, the results were mixed with some good design and development but with only a partial satisfaction of the original brief. This aspect can be tied directly to two key points: 1, failure to translate a sound PDS from the Orientation phase; 2, too much of the limited time resources directed towards the RP design rather than a viable final design. These weaknesses may be due to student’s failure to reflect adequately on feedback and a desire to push on with the next stage of the project. However, the outcomes from the student work have helped to understand the practical design constraints and the academic team are currently exploring the development of a commercially viable design solution.

The project was more successful with regard to “student objectives” (1.4) or personal development through student learning, student experience and student expectation elements. Students developed a basic understanding of the design process and how to manage their personal learning. First year students learnt, through working with their second year peers, how to manage a project, meet deadlines and distil a body of work for presentation of key facts. By working directly with their peers

they have developed a good understanding of the universities expectation of work ethic and academic endeavour required for success as an undergraduate Design Engineer within the first academic week.
In discussion with 2nd year students they found, as 1st and later 2nd years, the process to be inclusive with all students free to contribute. They also felt that as 1st years they had to mix and work with the 2nd years, the relationships they established here benefiting the whole academic year. They felt, as 2nd years, it was their responsibility to get the 1st years *"..out of fresher's mode"*.
The Academic team also used PAL-Week for the trialling of new technologies; here the project was successful and students developed their video presentation workflow throughout the project. Experience gained has led to video presentations becoming the default method within the 2nd year Design Projects and 1st year Technological Principles units. From the use of 3D scanners the most interesting aspect was how the tools enabled students to become "hands-on" with physical contact and interaction between students rather than falling upon the comfort of Anthropometric data sets.
In discussion with 2nd year students they felt the scanners were *"temperamental"*, workflow time consuming and too technical to achieve good results. However, they did conclude use of the tool as a prop freed them to physically interact with each other in a way that would otherwise be uncomfortable or intimidating. They felt they *"would not have done the ergonomics"* without the scanners.

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