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INDUSTRIAL DESIGN EXECUTION & ACADEMIC REFLECTION IN A THREE-WEEK-PACKAGE

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ABSTRACT
One of the structural challenges of educating industrial designers in a university setting is bridging the gap between the rigor of science in academia and the execution-oriented practice. In general, exemplary dives and conceptual proposals are completely acceptable within a project in the university. So how can the reality of product development and execution emphasis be introduced in an academic setting with low risk, while maintaining the academic requirement for knowledge creation and reflection? To accommodate the academic framework, the academic assignment was a short paper with reflections on methods and approached comparing the 'new' process to design and entrepreneurship methods, theories and practice. Then a simple but hard challenge was given: At the end of week three a "Designers Market" was to be arranged at campus. Each student (or pair of students) should design and manufacture 20 units of a product to be promoted and sold at the market.
The experiment turned out to yield more benefits and effect than anticipated. The observed challenges faced by students during the approximately 10 working days were a small-scale version of the real challenges of defining, designing, manufacturing and marketing a product. The combination of informal and formal evaluation using theoretical reflection on practice-oriented execution seems to be useful model for introducing the full version of product development with very low risk and still adhering to knowledge creation of academia.

Keywords: Execution oriented, theoretical reflection, motivation, formal assessment, informal assessment

1 INTRODUCTION
Industrial design is very profession oriented, so when educating designers in a university context, with expected scientific rigor is poses some challenges on how to combine execution-oriented practice for generating a 'finished design with a scientific approach. One way of mitigating the expectation of execution of the design is to limit the detailing of a product proposal to a few exemplary dives on how components, functionality, etc. would be solved in detail and leave the rest of the proposal on a conceptual level. In a non-artistic educational setting, the evaluation of proposals for new products is usually revolving around the relative relation between criteria for solution, proposal and the approach to problem solving and definition of wicked problems. This is partly due to the absence of objective criteria for "good design", with the design of products the aesthetic aspect cannot be ignored, but at the same time there are no objective way of measuring the level of aesthetics and therefore difficult to incorporate into learning objectives and evaluation. It is also partly due to the nature of the design field being so broad and diverse that design students cannot learn to design all the different type of products that exist, but need to learn "how to design", i.e. the tools, methods, skills, competencies etc. [1, 2] One can argue that this focus does not provide design students with enough practical skills to engage with the profession of design when graduating. Compared to the practice of design that graduates will face outside the university, this is a relatively slow and partially artificial process due to the ability to scope and delimit the assignment and problem. For a practicing designer in a design-studio or R&D department, the focus will be on the ability to execute design proposals within a short time period and creating real products that customers will buy. With manufacturability, available technology and low cost may have higher priority than problem definition and user-oriented research. There are different strategies that universities can deploy to prepare students for the constraints, pace and demands in practicing the profession. Some of them are already widely used like internship and collaboration with

companies to make the assignments more authentic [2]. But the intrinsic dichotomy between rehearsing and evaluating the execution skills and the academic, theoretical competencies still remains. In education theory [3] there is a very close link between the learning focus of the students and the object of assessment. So, if the assessment is process or methods oriented, the execution skills and actual design of product may not receive as much attention. However, there may be large intrinsic motivation from students to perform well, even if they are in a learning environment [4] but this is not necessarily the case. So, when developing course and project modules, there is always a struggle to reach a balance between setting a stage for execution and at the same time maintaining a focus on learning methods, processes and building students' knowledge and competencies at an academic level. This balance between practice and academia is especially explicit within a creative profession as design, where one has to learn how to deal with wicked problems and create a holistic design proposal that integrates human aspects (use, aesthetics, meaning, etc.), business aspects (market, price point, value proposition, supply chain, etc.) and technical aspects (technologies, manufacturing, materials, etc.). Dealing with this complexity can be overwhelming in itself, adding theoretical reflections on approach, methods and processes makes it an even more daunting task. This leads to the research question of this paper: How can the reality of product development and execution emphasis be introduced in an academic setting with low risk, while maintaining the academic requirement for knowledge creation and reflection?

2 METHOD

In the spring of 2018 a revision of a three-week five ECTS course module presented an opportunity for experimenting with a new setup that could introduce a reality-factor and execution emphasis on delivering a final, real product. At the same time the university has learning objectives in the curriculum for each module that cannot be changed easily. These learning objectives on knowledge, skills and competencies all revolved around theory, method, process and approach to innovation and business development. The experiment needed to comply with these learning objectives, but there were not many restrictions on how students should achieve the learning, as university staff still had the freedom to choose the method of teaching. The experiment took inspiration in previous initiatives, such as a short intense workshop where the focus was balancing academic learning with rehearsing execution [5]. This setup required a pre-defined task set by the workshop organisers and the workshop ended with students pitching their business ideas in front of a panel of business experts. However, the learning objectives were evaluated by attendance (learning methods and tools to practice entrepreneurship) and thus the feedback and evaluation from business experts was not an official evaluation, but rather a feedback on the proposal itself from a pretend investor. This provided a motivation to present a reasonable proposal at the end of the workshop in order not to embarrass one-self in front of an audience. The experiment also drew inspiration from a semester with internship where students are in companies training the practice of the profession and at the same time writing an academic paper on a research topic, using the internship company as case and source of empirical data [2]. The evaluation of the learning objectives where disconnected from the concrete work the student did in the internship. This allowed the student to reflect on a higher level on the practice of the profession and at the same time avoid non-disclosure issues regarding concrete development projects. These inspirational initiatives lead to the conceptual principle of separating the execution from evaluation, with the aim of motivating the students to execute as well as reflecting on their learning. Timewise the execution and reflection was overlapping and confined to the three-week period, with the execution element finishing 3 days before handing in the reflection paper.

2.1 Academic reflection element

To accommodate the academic framework, the academic assignment for the students was a short paper with reflections on methods and approached comparing the execution process to design and entrepreneurship methods, theories and practices. This approach also provided empirical basis for reflections on actions [6] that the students had practical and personal experiences with. It also decouples a direct relation between execution success/failure from academic success/failure. If the students did not succeed with the execution, it still provided opportunity for learning and reflection that met the learning objectives. To provide students with the necessary foundation for writing the paper, the first part of the module was about the theoretical positioning of the approaches to innovation.

2.2 Execution element

The object for execution needed to be simple enough allowing students to actually execute, rather than dealing with extensive research, complex technology and manufacturing processes. But instead of detailing and outlining the specific content of the task, the framing was reversed and focused on 'ground rules' setting some simple boundaries and requirements. This would allow students the freedom to choose complexity, scale etc. depending on their skills, risk willingness and network possibilities. That is also in line with the five principles from the effectuation approach [7] and therefore in line with the objective of the academic reflection element. This led to a simple but hard challenge: near the end of week three a "Designers' Market" was to be arranged at the campus. Each student (or pair of students) should design and manufacture 20 units of a product to be promoted and sold at this market. A few ground rules were established to keep things in line, see Table 1 below.

Table 1. Ground rules for execution task

Rule	Reasoning
No food	License needed in DK to handle and sell food
Must be physical object	It relates to Industrial Design
If a service aspect is included; must be 'consumed' on the spot	No easy way out, such as selling vouchers for visualisation or 3D modelling assistance
Self-designed and manufactured components minimum 50%	No re-sell business model that evades the design and manufacturing aspects of challenge.
Don't kill people with dangerous and faulty products (e.g. be careful with electrical components, do not make them yourself)	Killing people is bad press and poor ethics.
1-2 persons pr. team	Balancing resources and experiencing the constraints of manufacturing in 'larger scale'

2.3 Data collection

The data collection is primarily based on the papers and posters the students handed in at the end of the course. Furthermore, statements from the course evaluation and informal observations and conversations during the course and the "Designers' Market" are used to supplement the quotes from the written documentation.

3 RESULTS

Looking at the work students did during the course and the strategies they deployed, four aspects are interesting to unfold and examine further. The first aspect is the type of products the students choose to design, manufacture and sell. This aspect relates to their skills, willingness to take risks and level of ambition. The second aspect is the process and activities the students went through during the course. This outlines the different aspects and challenges of developing new products that the students experienced. The third aspect is their reflection on the process and approach and relates to the academic reflection and knowledge building. The fourth aspect is the relation between motivation and evaluation.

3.1 Type of products

The products made by the 12 teams are divided into three levels of complexity. If the product is relatively complicated and/or the manufacturing process is relatively long or elaborate, the assumption is that the team exhibited a higher level of ambition and risk willingness.

Table 2. Overview of the level of complexity in product and manufacturing

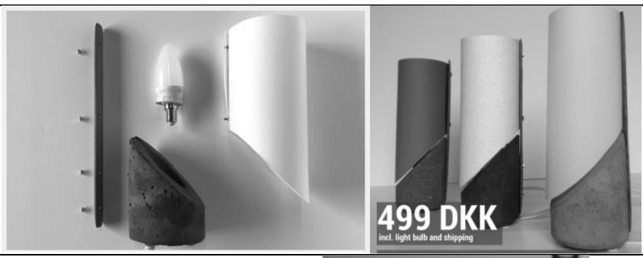
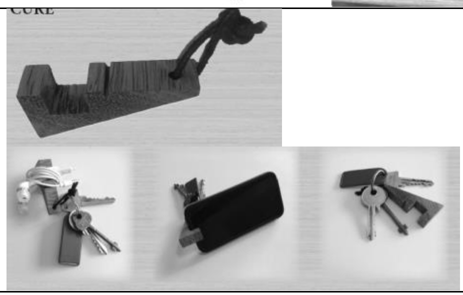
Level of Ambition & Risk	Type of product	Manufacturing processes	Team size
High	Table lamp	3D printing moulds, concrete casting.	2
	Wall clock	CNC milling, sanding.	2
	Catapult for Beer-pong game	3D printing.	2
Medium	Hydroponic flowerpot	Casting base in silicone, cutting.	2
	Laptop stand	Laser cutting and sanding wood.	2
	Flowerpot, miniature greenhouse	Assembly many components, cutting/bending plastic sticks, assembly of sticks into house structure.	1
Low	Beer game, card-based	Printing and cutting paper.	2
	Calendar with base	Cutting and colouring wood.	2
	Headphone-cord holder	Cutting and sanding wood.	1

	Keychain	Cutting and sanding wood.	1
	Keychain	Assembling pearls and parts.	1
	Posters from DK landmarks	Printing.	2

3.1.1 Examples on levels

Looking at little closer at some of the products, there is a correlation between risk, price and complexity in production. A higher complexity and more intensive manufacturing process result in products with a higher price point at the "Designers Market". Even though most teams had a difference between the actual price at the market and the suggested retail price, if the production were to be scaled and 'industrialised' using more efficient tools and techniques.

Table 3. Examples on different levels of complexity in product and manufacturing

High level: Lamp *Price at market* 129,- DKR		A (relatively) higher level of complexity in the manufacturing and assembly of the product. With a base cast in concrete in a 3D printed silicone mould, this required time, precision and knowledge on casting of small objects.
Medium level: Laptop stand *Price at market* 89,- DKR		The manufacturing process is based on laser cutting plywood and post-processing the surfaces and sides by sanding it before assembly. Both the object size and process require some time, leaving little room for iterations.
Low level: Keychain *Price at market* 50,- DKR		A Keychain is a good example of a low level of complexity and risk. Even though the manufacturing process requires some work in the wood shop, the processes and tools are relatively simple. The small size and simple product features also allow for multiple iterations.

3.2 Process and activities

With the objective of having to manufacture 20 units of a product, the *actual* production and manufacturing was a new element in comparison to other course assignment and semester projects, where a conceptual proposal is the end goal. Based on several process descriptions, supervision during the course and observation an overview is presented in Table 4, that illustrates the activities divided between phases/themes and distributed throughout the three weeks. It also shows examples on some of the activities, challenges and uncertainties students faced.

Table 4. Process, activities and challenges

Process	Activities	Challenges and uncertainties (examples)
1. Research	-Understanding potential customer groups at the sales venue (market research) -Mapping resources and skills (for manufacturing. -Defining product type -Defining Value proposition / problem -Defining budget and financial risk	-How to research a target group and value proposition without a predefined idea or product to showcase? -Calibrating risk and ambitions for unknown project -Planning a development process with a set deadline, but no certainty of time and outcome of activities.
2. Concept	-Ideation; sketching -Ideation; mock-up -Testing concept ideas on potential users -Exploring price point and value proposition relation to customer groups	-Investigating the target group through feedback on concept renderings: iterative process of understanding interdependency

	-Construction and material exploration	-Balancing materials, manufacturing techniques and investments with value proposition and price point into a coherent concept
3. Business	-Estimating sales price and production price -Budget for manufacturing and sale -Reviewing Value Proposition	-Uncertainty of customer willingness to actually buy vs. expressed interest based on 3D rendering. -Uncertainty of price point, manufacturing cost and time.
4. Production	-Sourcing materials and assistance/network -Planning production processes -Manufacturing -Assembly	-Maturing and compromising on concept and ideal version in regard to manufacturing skills and material quality. -Unforeseen manufacturing problems
5. Execution	-Marketing material; video, poster, sales pitch - Designing and building sales booth - Selling	-Facing customers and presenting key value propositions: the actual sales situation -How to attract customers to own booth?

The uncertainties and challenges students faced during the process indicates that by investing personally in the project and actually delivering working products meant that they experienced the uncertainties of product development in a more direct way. And students were challenged on their skills related to craftsmanship and operation of workshop machines that to a large extent influenced the finish of the products and therefore the price and value. Sometimes so much that the deviation from the 3D renderings used to probe the value proposition amongst potential customer was so significant that it affected the price setting before the sale at the Designers Market.

3.3 Reflection on approach

The academic reflection element in the assignment provides an opportunity to access the students' reflections on this process compared to experiences from previous projects. The more interesting reflections revolve around the approach to innovation and problem solving that diverged significantly from their previous experiences. A quote from report from the Lamp Project: "*The approach was somewhat natural, but at the same time felt uncomfortable since it is somewhat contradicting to the default AAU problem centred approach. We had to trust that effectual reasoning and our assumptions of critical design would lead to the goal, while risking failure among possible outcomes*." The lack of obvious problems to solve and the need to justify creating a new solution affected the approach and understanding. Also the students from the Wall Clock project reflected on the lack of problem and focus on aesthetic value instead: *"Testing the idea lead to yet another pivot, changing the whole perspective of the project to focus on storytelling of an ordinary clock instead of trying to cure a pain… Storytelling became the essence of the selling points, where value was added if the perspective of craftsmanship and manufacturing was presented to the customer."* Many reflections on the comparison between the Design approach and the Lean start-up helped the students to see their own approach in a larger perspective, e.g. from the Lamp project: *"During this project it has been found that there are both many similar and contradicting approached in design thinking and lean start-up approach. The iterative testing approach is somehow similar, but with a shift in the way the focus on product features are evaluated, where the lean start-up approach aims to validate customers rather than evaluating features."* This points to an internal discussion of the objective for a design shifting from the more traditional "user-oriented" approach to a customer centric approach. Simply because they had to face a customer and ask for money and not only present a concept aimed at a 'user'.

3.4 Two layers of evaluation

In spite of the many challenges that the students faced during the process, no one complained about how hard it was. On the contrary they expressed a high level of enthusiasm and excitement, only slightly worrying about if they could actually sell their final product at the Designers Market. This is a very intrinsic motivation for the execution element. On the other hand, only 1 in 20 students asked for supervision on the academic report and theoretical aspects during the course. 8 out of 20 failed at their first attempt, due to insufficient level of reflection and understanding of theory. This may be due to low or no intrinsic motivation of focus on this learning, and only extrinsic motivation for dealing with the reflection element. That was not very strong compared to the intrinsic motivation for creating and selling products. So, the two layers seems to point at two different types of motivation that are hard to balance for all students, and in this case the execution and intrinsic motivation seem to have been stronger, see Table 5.

Table 5. Double aspect of evaluation

	Informal evaluation	**Formal evaluation**
Focus	Execution	Reflection
Motivation	Intrinsic strongest	Extrinsic strongest

4 DISCUSSION AND CONCLUSION

How can the reality of product development and execution emphasis be introduced in an academic setting with low risk and while maintaining the academic requirement for knowledge creation and reflection? The data and method from this experiment indicates that there are at least two overall aspects to discuss in relation to this question. The first aspect is the content of the task was left open and thus students self-calibrated in terms of the complexity and risk willingness. In order to introduce the mass production aspect of Industrial Design, the number of units expected in this experiment was a guess. But maybe there is a balance between complexity of the product type chosen and the number of expected units to be manufactured. All of the higher-level projects had two-person teams, were many of the lower-level projects were one-person teams. So, the resources available, including manpower, skills and network capabilities will influence the self-calibration of complexity by the students and their choice of risk level. The second aspect is the structure of the course. This was more controlled and concerns the two types of evaluation and motivation created by the division of the task into the event and the hand-in. The informal evaluation relates to the sales situation, where students face the potential customers at the Designers Market. This provided an intrinsic motivation for the students to actually create and present a product that they would be proud to present or at least not embarrassed to ask people for money for something they had created themselves. This part was completely self-motivating for the students.

The formal evaluation relates to the academic hand-in, where students had to write a short report reflecting on their approach and comparing Design Thinking to Effectuation and Lean Start-up. This part was more extrinsic in the motivation because this part was subjected to grading. But the division also meant that failure to sell their products at the market had no impact on the grading, presenting a low risk for the product development but requiring them to be conscious and reflect on their actions. And as data shows, the intrinsic motivation for creating products was stronger than extrinsic motivation for reflecting. However, the combination of informal and formal evaluation using theoretical reflection on practice-oriented execution seems to be useful model for introducing the full version of product development with very low risk and still adhering to knowledge creation of academia. But an equal balance between them is somewhat challenging to achieve with this dual focus on both execution and reflection.

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