Mediterranean Journal of Basic and Applied Sciences (MJBAS)
Volume 8, Issue 1, Pages 78-100, January-March 2024

A Practical Approach on the Design of an Interdisciplinary Postgraduate Program: The Case of the "Unmanned Autonomous and Remote-Control Systems" Postgraduate Program

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DOI: https://doi.org/10.46382/MJBAS.2024.8108

Article Received: 09 December 2023 | *Article Accepted: 23 February 2024* | *Article Published: 06 March 2024*

ABSTRACT

There is a long-standing collaboration between the Department of Industrial Design and Production Engineering of the School of Engineering of the University of West Attica and the Department of Naval Studies of the Hellenic Naval Academy in the fields of research and applications. This collaboration has already led to the creation of a common interest direction in an existing Postgraduate Program. Naturally, the common interest in the subject of Unmanned Vehicles led to relevant discussions. These discussions matured quickly and led to a structured form and a specific goal: the design, production and operation of an interdisciplinary/joint Postgraduate Program. This paper presents the development process of the Curriculum for the Program and the basic assumptions about it that emerged from the combination of a review of the relevant literature and the identification of needs in the Greek and European markets.

Keywords: Curriculum design; Curriculum research; Joint postgraduate programs; Modular curricula; Blended learning curricula; Interdisciplinary postgraduate program; Unmanned vehicles.

1. Introduction

The area of research on Unmanned Vehicles is active for some time now [1]. The past two decades have seen great changes in both the vision and practical deployment of robotics and autonomous systems in defense applications [2]. The visible successes of unmanned air vehicles (UAVs), as brought originally to us daily on evening TV news but lately also by logistic solutions and even wedding and other open events video coverage, has been driving the optics. Still, ground vehicles have been employed in a variety of projects from bomb disposal, communication with trapped miners in collapsed mines or simply building surveillance, while mine-hunting underwater vehicles are deployed as standard features on ships, and mini and micro-satellites are being built by university and high-school students alike. With unmanned vehicles being interesting in both defense [3] and everyday life [4] contexts, it is no surprise that research on the subject is in an all-time high.

Commercial and tactical applications alike pose demands on vehicle design [5], cooperation [1], maintenance [6] and lawful use [7]. The said demands do not seem trivial enough to handle within existing, non-specialized, engineering or technology programs either in pre- or postgraduate levels. It is the highly interdisciplinary nature of the field, comprising of elements of mechanical engineering, electronics, communications, propulsion and logistics in the general case, even avionics and shipbuilding and stability in specific cases, but also the technological complexity of relevant problems like positioning, environment control, pattern recognition and security of communications that make sure that the subject must be dealt on its own.

On the other hand, this very demanding nature makes difficult if not impossible to handle such a program within the tight frame of a specific department of a University, perhaps even within the frame of a single University. The

Department of Industrial Design and Production Engineering of the School of Engineering, University of West Attica, and the Department of Naval Studies of the Hellenic Naval Academy have both previous experience with drones and unmanned vehicles of various configurations and have offered each other their expertise in the past, which made a cooperation in developing a relevant program straightforward. What follows is our answer, both procedure- and direction-wise to this complex, challenging, vexing but, once solved, satisfying problem.

1.1. Study Objectives

The details of the cooperation had to be planned specifically to address the intricacies mentioned above. Consequently, the objectives of this study where: (i) To identify the core subject matter for such a program of studies. (ii) To determine the skills and competencies that the program should develop to its students. (iii) To design the way to assess its success towards these goals. (iv) To decide what is to be included beyond the essentials and why was another, where the applications range from market interests [4] through the military [3] to environmental protection [8]. (v) To build syllabi for each course out of these decisions, which is quite a task, with the fast pace of development in the field posing the final challenge.

2. Design methodology stepwise

Yates and Young [9], in a somewhat different context, identified a number of curriculum design questions, some of them resonating relevance:

- How should the curriculum respond to the global economic pressures?
- To what extent (and how) can curriculum policy addresses issues of inequality and the persistent under-achievement of disadvantaged learners?
- Is it assumed that it is increasingly anachronistic to base the curriculum on subjects separated by relatively clear boundaries, and if so what alternative curriculum principles are suggested?

While our decision to develop the proposed postgraduate program was in part an answer to economic pressures produced by the fact of the sector, being one of the fastest developing globally [4], another part had to do with the direction of the curriculum; if it was to help answer the economic pressures it had to be directed towards professional/occupational requirements.

Recognizing Muller's [10] distinction between curricula with conceptual coherence – where the logic is that of the discipline – and contextual coherence – where the logic is that of the professional or occupational requirements, we decided to place our curriculum firmly in the second area. Although we do not agree with the oversimplified clear-cut distinction, we accepted the challenges that, according to him, lie in the combinations of knowledge bases that range from largely theoretical to largely practical knowledge and undertook proper conceptual refinement. In our minds, practical knowledge coincides with technological and thus applied knowledge.

On the subject of addressing issues of inequality and the persistent under-achievement of specific categories of students, that we chose not to attribute totally to them but also to curricula disabilities, our stance needed to be proactive. Failing to provide suitable professionals to cater for market needs is not a choice for either a

Department specialized in training industrial design and production engineers or a productive School of naval officers. That obviously has to do with forming the curriculum to also cater for varying student needs, and specifically those of the so called “second tier” [11].

Also, there is a matter of delivering powerful knowledge, not necessarily as in theoretical knowledge that social realist academics like Muller, Maton or Young, prefer to think but, as Shay [12] puts it, the kind that ‘enables new, as yet unimagined, ways of thinking’ and is ‘essential for innovation’. Losing theoretical knowledge altogether, as Allais [13] or Wheelaham [14] fear, is not an option either for a program addressing a field in the edge of technology still pretty much emerging. No matter how industry specific and interested in qualifying the audience of such a program is, epistemic access – as Wheelaham conceptualizes it – is necessary for practical purposes, such as accessing further relevant knowledge from disciplines after program completion, as much as for avoiding reproducing social inequality [14]. While workplace performance has been a major consideration, Barnett’s [15] worry on knowledge relegating to the shadows in tertiary vocational programs was also in our minds.

Whether it is assumed increasingly anachronistic to base the curriculum on subjects separated by relatively clear boundaries or not, in our case it was simply not a viable choice. The field, existing and vibrant, presents a multidisciplinary base and it is also of interdisciplinary interest in its range of applications. Thus, this choice is somewhat clear cut also.

But perhaps the process should be presented in historical terms, as it took place up to now and as it is planned for the near future as a result.

2.1. Preparation stage

A number of meetings, initially with members of the University of West Attica, but soon also with members of the Hellenic Naval Academy as participants, have taken place between the months of September and December of the year 2019. From the very first meetings, the possibility and desirability of combining forces and experience was evident. Early meetings have confirmed the existence of a field of study on Unmanned Vehicles and of a relevant market, the need for both credentials and certifications for practitioners in the field and a vast space of applications in related subjects. Latter ones have operated as brain storming sessions on needed knowledge and skills and what the two institutions could offer both individually and combined. By the end of the initial period it was already decided that a semi-formal development process would take place with identifiable and distinctive steps, adopting, as Rompelman and de Graaff [16] suggest, a designer’s point of view.

Also, a group of academics was established as members for the joint venture, on the basis of both previous experience in the field and interest in a related academic endeavor. A decision was made to involve these personnel in designing the curriculum, in accordance with notions supported by Johnson and more recently Alsubaie [17], assuring the involvement of at least those stakeholders that are directly involved in student instruction and are thus a vital piece in successful curriculum development.

In an article summative of the relevant literature, Shao-Wen Su [18] identifies a number of ways a researcher or designer of curricula could approach them: as a Set of Objectives, as Courses of Study or Content, as Plans, as

Documents and as Experiences. He argues that the progression is from the narrow to the broad. But for us, a Curriculum is even broader than that. It is a process: a process of organizing a knowledge field, a process of creating a Community of Practice [19] and in our case, of a Curriculum of a Masters in an emerging field, a process of Organizational Knowledge Creation in the sense that Nonaka and his colleagues introduced [20]; a process that is labor intensive, open and repetitive in nature.

2.2. Decisions on further steps

A study of curriculum regulations to determine the spectrum of acceptable choices and a feasibility study needed to be undertaken but need not be conducted in a plenary session. The group that undertook this task was more or less the group of authors of this article, due to administrative experience, previous engagement with the economics of academics or knowledge of the legal intricacies.

Proof of need belonged to the same category and, while a mission statement needed wider approval, it was largely developed in the same context. Important contributions of experienced members of the wider team did help both the mission statement and the title of the postgraduate program reach their final form.

The wider team had more to do with determining financial and technical considerations and making choices on basic characteristics of the curriculum. Once this stage was reached, it was clear that the proposed program was both ambitious and expensive.

Availability of infrastructure was again a task for the administrative team, as was the initial proposal on structural choices that were nonetheless finalized in a plenary session. Structural choices took into account the basic characteristics of the curriculum but also the multidisciplinary nature of the field.

The choices regarding ECTSs and learning outcomes were assigned to smaller groups that corresponded to teaching teams of possible courses, as was syllabi and material development. Some major decisions were made in advance, posing some restrictions in the process, while monitoring the process stayed with the administrative team, and weighing various propositions remained the prerogative of the plenary session.

The somewhat slower processing of institutional commitment for the Hellenic Naval Academy led to the decision that prototyping would take the form of a three (3) year long period of running the program as a single institution program of the University of West Attica. During this phase, the Hellenic Naval Academy would participate both as an external contributor and as an external evaluator.

Both internal and external formative evaluation, and also market and student feedback [21], were taken into account; the prototype will then be fine-tuned into final form. That way the whole of major stakeholders will, at this point, have participated in forming the curriculum. The final-form would be that of a joint/bi-institutional postgraduate program with Hellenic Naval Academy participating as a full partner.

Since no professionally oriented program can run for ever unchanged, a Re-evaluation Cycle of six (6) years, including the prototyping period in its first run, was decided, at the end of which a summative evaluation will take place for the period that will be used to inform the decision on continuance but also as formative for any major redesign of the program for the next period, should continuance be decided.

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2.3. Need and Mission Statement

The proposed postgraduate program serves the development of specialized knowledge and training in cutting-edge technology and is aimed at executives active in the areas of maritime technology and entrepreneurship, defense and civil protection. It also highlights and supports the sustainability parameter of technological, operational and business options in the above areas. Finally, it exploits and utilizes the additional know-how, infrastructure and human resources of the two institutions, providing higher education in the Attica Region, in order to create prospects for production and specialization of new knowledge [22] economic development [23] and employment [24].

The purpose of the Interdepartmental Postgraduate Program is:

- The promotion of science and research in the subject of the program.

- The preparation and training of specialized and capable scientists, researchers and professionals who will promote the development of the country and Greek companies in the field of Shipping.

- The close cooperation between the Academic Community, the Schools of the Armed Forces and the Organizations and the Companies, for the acceptance, use and dissemination of the subjects of an Inter-departmental and even Inter-institutional Postgraduate Program.

2.4. Study of curriculum regulations and Feasibility Study

A number of constraints came up from legal requirements and regulations, as for example a limitation of on-line components in no more than 30% of each syllabus in full time courses. Another limitation came from internal regulations, since in the University of West Attica a work load of more than 30 hours per week for a postgraduate student is, in general, deemed excessive and needs special dispensation to be granted, especially when the postgraduate students are expected to be at work while also studying in a full-time mode. A relevant one was that a yearlong postgraduate program is not expected to either grant more than 60 to 80 ECTS or include a thesis or project as a completion requirement.

On the other hand, research-based postgraduate programs at master’s level, while can possibly include some courses that need to be followed, are expected, by our institutions, to have far less work load allocated to directed study and far more to reviewing literature and prototyping. While such a limitation is by no means unreasonable, it is not applicable in the case of a heavily interdisciplinary field, where even experienced practitioners would benefit from extensive familiarization with contributing disciplines other than their own.

Thus, per legal and regulatory requirements, the full-time version of the program needed to be longer than a year, with less than 30 hours per week work load – lest the more complex process would have to be employed – with courses and, preferably, a semester dedicated to a postgraduate thesis or construction project.

2.5. Financial and technical considerations

The feasibility study and economic-technical report on the proposed postgraduate program are too extensive to be presented here. Nonetheless various points in them are of interest for our purposes:

1. The proposed program of studies is an "expensive" one, in the sense that to be properly operating there is a considerable cost per student per semester, especially in regards with the final semester.

2. Demands in laboratory space, classrooms and materials are, besides considerable, more or less inelastic.

3. Especially in regards with materials, economies of scale are absolutely necessary for the program's feasibility if materials are not to exclusively burden students.

4. People engagement, in terms of teaching and research personnel as much as students', needs to be high and consistent.

5. The building of a Community of Practice would demand at the same time considerable laboratory time and space availability, presentation time and space and appropriate ICT support. Internal forums, discussion rooms, relevant article lists and cloud file-space are, if not necessary, integral to the program's success.

Some restrictions were derived such as a cup of 100 students per run, maintaining current regulations and restrictions, due to availability of space in both institutions. A breakeven point for a run was determined to be 25 students at a fee of 3500 euros per program, in case the cost of materials for the final project is relegated to the students, and 40 students if materials are to be provided by the program. The last choice was considered preferable. For the fee level, financial crisis considerations were weighted against sector characteristics.

Supporting many development and construction problems at the same time would demand the engagement of research personnel besides the teaching team. Visiting professors besides the ones originating with the HNA might be beneficial in covering niche areas of the field, either within existing courses or in the form of short seminars. Financial provisions had to be put in place for such a choice to be available.

Time allocation of laboratory time also needed to be planned and provisions for testing grounds to be made. For the testing grounds a, relatively, inexpensive solution was given by the armed forces, in exchange of special provisions for a number of officers that would participate to the program.

The puzzle was more complex than usual and the possibility of seeking sponsorship from known companies in the field was entertained. While that was not excluded, a decision was made not to base operations in such a solution, so as not to compromise the academic nature of the conducted research.

While undertaking joint ventures with the private sector is not outside the program's scope and intentions, that should be determined on a case by case basis. That way, the benefits of applied research would not be drawn in expense of possible breakthrough and innovation attempts based on concept projects. Needless to say, should such cooperation occur, the breakeven point would lower considerably.

2.6. Basic characteristics and parameters

Some decisions on the basic characteristics of the program were made beforehand. Since the promotion of science and research on the field was part of the mission statement, at least a part of the program would be research directed. Yet, since the preparation and training of specialized and capable personnel, both academic and professional, was also included, further characteristics were necessary: that research would be mostly applied; that measures be taken to allow for such research to be undertaken; that a balance would be shot between formal knowledge deliverance, field specific knowledge experienced and practice.

The close cooperation with various stakeholders demands also presented the design with a challenge: academic processes are slow and comparatively inflexible. Thus an intermittent structure needed to be used to facilitate communication, while maintaining control of the academic process within the academy.

Finally, due to the many areas of interest that Unmanned Vehicles cover, the actual composition of the student population could neither be known in advance nor expected to be constant throughout the period of operations. That led to a necessity for a parametric configuration that could be adjusted to serve multiple distributions of students, according to their origin from the research community, the armed forces, the logistics and the manufacturing sectors to mention but a few possible origins or interests. One expected commonality, at least for the first couple of runs, was previous experience in the field.

In the continuum between isolated and trans-disciplinary curriculum suggested by Harden [25], the only logical choice was that of an interdisciplinary curriculum. Not sharing his fear that in the move from a multidisciplinary to an interdisciplinary approach the loss of the disciplines' perspectives might be implicit, we nonetheless wanted to safeguard our program from such a fate. Thus, a multidisciplinary section of the curriculum was deemed necessary.

On the other hand, a wholly multidisciplinary approach could on the contrary hinder the attempt by maintaining disciplinary ‘silos’ and their dire effects. Bailey-McEwan [26] thinks they fail to provide the conceptual tools required for professional practice, losing that way alignment with a major objective.

While trans-disciplinary education as reflected in learning described by McCombs [27] – ‘an individual process of constructing meaning from information and experience, filtered through each individual's unique perceptions, thoughts and feelings – seemed also alluring, such an approach would not serve the promotion of science and research in the subject of the program with the same success. Further integration might hinder instead of help our attempt to serve a field of multiple parents and hosts of aspiring progenies. Not to mention that, as with Harden’s own example, we consider a trans-disciplinary approach better suited for parts rather than the whole of the curriculum.

However, maintaining the overall interdisciplinary approach, a more trans-disciplinary section could serve well the mission of the program. Thus, it was decided to include such a section and it was deemed better to combine it with the research section of the curriculum.

In Maton’s [28] semantic terms, our curriculum was determined to be of a strong semantic gravity and also of a somewhat strong semantic density, as the terms relate to knowledge practices. Here semantic gravity is taken to mean the degree meaning relates to its context, and density the degree of condensation of meaning within symbols [29]. At this point, Muller’s [10] contextual to conceptual continuum became irrelevant because our curriculum was placed on our two-dimensional schema in a place that was not well described when collapsed in his one-dimensional space. It should be noted that, in our case, semantic density is not mediated by lack of symbolic thinking in the field but rather by the concurrent presence of multiple symbolic scientific languages; in terms of concepts, it is not their absence but their abundance that somewhat frees the field from semantic density's hold. Perhaps a better way to describe the difference is to follow Brandom [30] and talk about formal and material inferences, the former carrying mostly semantic density and the latter mostly semantic gravity.

2.7. Structural choices and availability of infrastructure

One major structural choice was that of building the curriculum around a number of learning experiences of authentic character. The appropriateness of the approach has been shown by Kolb & Kolb (Figure 1), as is the fact that experiential learning affords educators a way to design and implement teaching and learning strategies conductive to creating a learning environment beneficial to both faculty and students. Its catering for different style learners and applicability to any and all disciplines constitutes a major reason for choosing this model. Still the choice raises a number of challenges among which creating appropriate, growth promoting, learning spaces, where the process is applied not as a tool but as individualized holistic learning. Another challenge is devising appropriate assessment schemes that go beyond traditional examination formulas. The third great challenge is creating an institutional wide support system, which becomes even more difficult when the inter-institutional nature of the endeavor in its final form is taken into account.

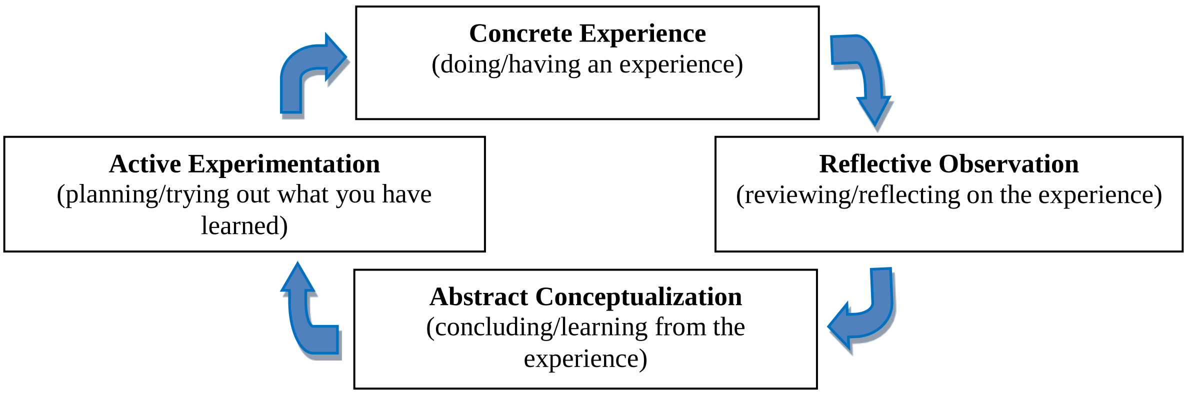

Figure 1. Kolb's Cycle of Experiential Learning (adaptation from [31])

To answer the first and third challenge and also the question of infrastructure availability, an unprecedented choice was made. The postgraduate program was to be related with the Department of Industrial Design and Production Engineering Research Laboratories. That way, the whole research infrastructure was committed to the program at the same time, ensuring support for student research by tethering funds and supervising research personnel and providing appropriate spaces for experiential learning. Furthermore, the Labs could and would be used to facilitate communication with stakeholders.

The student population was expected, at least during the first few periods of operation, to probably be more to the professional or research side rather than that of study continuance, and thus their experience was deemed to be important enough to be taken into account. Since that sounded a lot like adult education, one could assume that Knowles' [32] four major assumptions would apply to the learning process. The four major assumptions are known to be that:

1. it entails changes in self-concept;
2. there is a major role of experience;
3. there is readiness to learn; and
4. there is orientation to learning guaranteed.

Still, students were thought to need cope with disciplinary variety and possibly multiple communities of practice [33], to a point divergent from their community of origin. One also had to take into account situational learning [34] and the way in which a learner's experience would be shaped by their context and community, both original and built.

That was not far from how the context of knowledge is thought to affect knowledge itself. According to Bernstein [35], the field of production, the field of recontextualization and the field of education, all would form, reform and reshape knowledge. Here we have multiple fields of production, a multidisciplinary field of reconstruction and an interdisciplinary educational field. Even though this seemed over complicated, there was a simple systemic model able to cope with all complexities at once.

The first semester would be built around courses, representing major discipline contributions. They would be more or less traditional subject matter organizations, although provisions would be taken to secure higher level of interaction and alternative modes of assessment. This semester would serve as the multidisciplinary section of the curriculum, and the input to the next section.

The second semester would comprise more of thematic than subject constructed courses. Laboratory hours would be more than theoretical, where possible and small projects and problem-solving situations would form part of the teaching and learning process. This would be the main, interdisciplinary section of the curriculum, providing multiple learning spaces for the students to try on, opportunity for students' personal experiences to fertilize the learning process and finally research and application experiences to help form a community of practice within the programs limits. At the same time, it would prepare students for the next, mostly construction project-oriented section.

Finally, the third semester would comprise of a study and development project in place of a thesis or a literature review and a positioning paper on an important open subject in the field. This semester would also include seminars of which at least one would be mandatory, that of relevant law. This semester will represent a trans-disciplinary approach to the field, based on knowledge, experience and context acquired during the previous year and also during the project. Development would take part on one of the Research Laboratories, supported and overviewed by research personnel affiliated to that laboratory.

Had one taken into account the probably concrete and relevant, albeit limited to a segment, previous experience on the field of most students and the nature of the three semesters, might detect a wide experiential circle. Indeed, first semester courses allow for reflective observation, relating previous experience with various disciplines besides one's own, thematic courses allow for (re)conceptualization within the various strands of the field, and finally the project-based third semester allows for active experimentation. Of course, it is the smaller Kolb cycles that we intent to culture within the courses and most importantly during the project that will convey most of the experiential learning in the program.

2.8. ECTSs and learning outcomes

The design of a postgraduate curriculum within the space of the European Higher Education Area (EHEA) needs to make use of the relevant tools for making studies and courses more transparent and recognizable. At the same time, such a provision might help with later accreditation of graduates or a classification of the postgraduate title itself. The relevant tool is the European Credit Transfer and Accumulation System (ECTS) [36] and it is based on Learning Outcomes. While it has many flaws [37], it offers some kind of benchmarking for university degrees of all levels.

Learning outcomes have also been heavily criticized, especially in early applications and in relation to application in secondary education in South Africa, Australia and the U.S. [38]. Lately, and more so in regards with applications to higher education, there is a more positive stance [39] emerging. In any case, they focus on what the student needs to know and be able to do realistically in a given time, instead of describing the material to be covered or questions of the subject to be negotiated by the curriculum.

They are the basis of backward design [40] that goes from envisaged learning outcomes all the way to a Course's or Lesson's Requirement Plan and from that to a design and production process that designs and produces syllabi (Figure 2). They allow for assessment of their achievement, thus, evaluation of the syllabi and the overall program, leading to both maintenance of syllabi in year to year operations and modification of syllabi and curriculum between cycles.

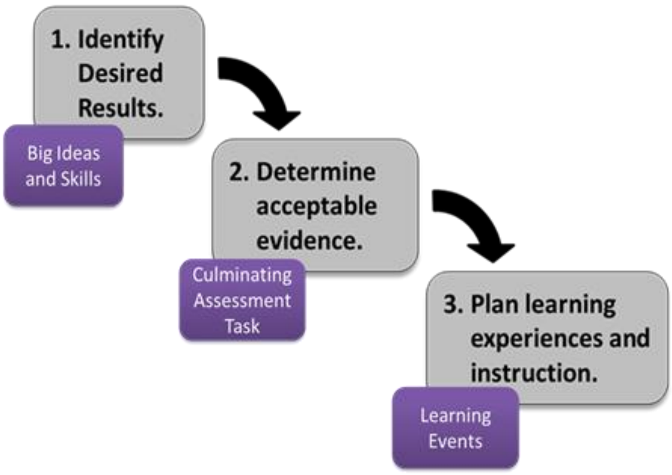

Figure 2. Backward design (adaptation from [40])

Critique and championing notwithstanding, there are four major advantages in formulating a curriculum using learning outcomes:

1. they are easily classified according to criteria in taxonomies, like Bloom's extended taxonomies [41], allowing for targeting superior forms of knowledge,

2. they serve to assist the internationalization of higher education, for example, in the case of undergraduate studies, make positioning within the framework of either the Washington1 or the Sydney2 and Dublin3 Accords, for engineer, engineering technologist and engineering technician titles recognition respectively, straight forward,

3. they are well combined with experiential learning (Figure 3) and

4. they also cooperate well with blended learning [42].

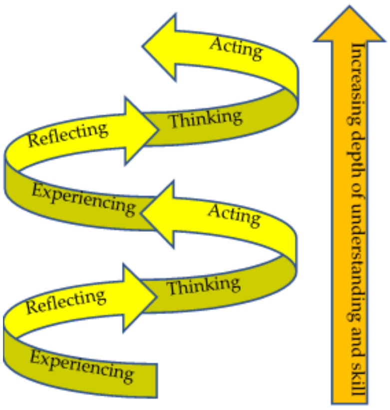

Figure 3. Experiential Spiral (adaptation from [43])

Another major advantage, specific to Europe, is that they are necessary for recognition within the European Higher Education Space. Many other, minor, advantages that are nonetheless important in our case include:

- their focus on the application and integration of the course content,
- their ability to indicate useful evaluation methods,
- the fact that they allow instructors to clearly define the standards by which course success will be assessed,
- the fact that the learning context is emphasized,
- that they help to focus on the knowledge and skills that will be valuable to the student in the context of their possible applications,
- that they provide structures from which courses and programs can be evaluated; and
- that they prevent the treatment of courses, syllabi and curricula as autonomous units that operate in a vacuum and without continuity.

There were a few restrictions made, a direct result of choices and restrictions on workload. That was that each semester could not include more than thirty (30) ECTSs and that the overall number would reach ninety (90) ECTSs. While according to regulations only 30% of the course is allowed to be online, it has been decided that it would be utilized to the extent possible and, after the latest experience with COVID-19 home confinement experience, the possibility of further facilitation of online components would be sought after.

All other decisions, including what will be incorporated in the various syllabi, what material will be provided online and the manner of assessing and evaluation for each course, were left to the relevant groups. These groups

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were comprised per course by participants with particular interest in this course. They were relatively small compared to the plenary session and, being far more flexible, they produced skeleton syllabi by June 2020. They would have produced stratified learning outcomes by the end of summer – covering all levels of the extended Bloom's taxonomy. Suggestions on ECTS allocation for each course and where common material will be allocated, had been also made by them but final decisions were left to the wider group.

2.9. Syllabi and material development

The same groups from the previous paragraph were responsible for building particular courses' final syllabi, based on the stratified learning outcomes. Syllabi maintenance, revisions and material development, for each and every course, were their responsibility for the first run but also for all consecutive maintenance and modification circles. The time horizon for the first syllabi was that of October 2020.

A few decisions have been made in advance and constitute what Rompelman and de Graaff [16] would call hard boundary conditions for all our syllabi:

• The syllabi will be modular [44]. That choice allows for adaptability, reusability and a variety of approaches both within and outside a competence-based syllabus. It is also suggested that modular structure is quite appropriate for advanced laboratorial courses. Modularity certainly helps, with constant maintenance and periodic modification of syllabi and the curriculum.

• They will be built systemically [45], as quasi open interrelated systems. A major reason for that is the powerful influence of a new, shaping, field. Another is that feedback and adjustment have to be incorporated in the maintenance/modification process. It is also the best configuration to handle redundancy and surplus.

Redundancy [46] and surplus matter will exist in the curriculum. Helpful redundancy serves educational purposes, allows for small experiential cycles to enhance learning experiences, more traditional educational benefits when in the form of repetition is used with the purpose of reinforcement, some autonomy between courses and units, and infusion of material across content areas. It also exists vertically between semesters. Surplus matter is the choice to include a substantial percentage more material than what the hours available for the course suggest, in our case a 20%, in order to allow for some choice on the part of the teaching team on what will be taught each year. This way, the course plan can take into account the actual composition of the student population (of the run) and adjust without the need of major review processes, like changing the course outline, which in Greece are centralized and thus exceedingly slow.

The syllabi will be supported by both synchronous and asynchronous online material with the purpose of flexibility. There is an intention of gradually producing full blended learning lessons, supported throughout their theoretical part online and leaving the choice of which 30% will be taken online, if so decoded, to the student. Also, there is some reflection, leaning towards allowing, on possible expansion of the percentage allocated for the online dimension should that be allowed, thus answering current challenges and pressures from inside and outside the academic space [39]. An additional consideration being significantly lowering the breakeven point, especially for consecutive runs, should that happen, while in the same time allowing for greater student enrollment.

Course material will be built in the same manner allowing for infusion of material from across content areas and also for constant revision of minor experiential cycles designed and included with the purpose of supporting specific learning building and progression.

With syllabi and material, student assessment schemes will be devised appropriately for the course's category. Indicatively, formal academic written work (such as reviews and essays), shorter oral presentations, self-reflective essays, internship proposals and reports on internships regarding the participation in Research Laboratories, project proposals for planning design and production of deliverables, design and construction projects have been proposed and graduation of problem and project-based learning follows semester progression. Final choices will be made internally with the teaching and research teams that form and deliver each course.

2.10. Prototyping and assessment

At the same time, our initial, single institution program will be ready to run. It will test all innovative elements such as the involution of Research Laboratories, the groups of academics sharing responsibility for each course and the construction project comprising the third semester. It was expected to start its operations during the summer semester of 2021. The organization of appropriate learning spaces is expected to prove quite challenging.

2.10.1. Prototype evaluation

In the first run of the postgraduate program we expect to need very extensive formative evaluation, before the courses settle. Even so, the first major milestone in the evaluation process is expected to be the one at the end of the three-year initial period. Both institutions will evaluate the prototype operation, with University of West Attica members of the team operating as internal evaluators, having taken up the whole of the administration load during that period. Hellenic Naval Academy members of the group will take up the role of external evaluators, taking advantage of their abstinence from administrative tasks during this period.

Students of the first two runs will be asked to participate in the evaluation of the program and their contribution is expected to be major. Possible approach of their employers and other stakeholders is also expected at this point.

2.10.2. Fine-tuning

In the first run of the postgraduate program we expect to need very extensive formative evaluation, before the courses settle. Even so, the first major milestone in the evaluation process is expected to be the one at the end of the three-year initial period.

Based on prototype evaluation of the curriculum, structural choices and organization of the postgraduate program will be revised and adapted. This fine-tuning will take part during the third run of the program and will be decisive for the changes from the prototype program to its final form.

2.10.3. Final form

The program will take its final form, as this will have been formulated on the basis of prototype evaluation, with the conversion of the program to a joint bi-institutional one. That is expected to happen sometime before the end of year 2024, provided that time-scheduling stays on track.

2.10.4. Re-evaluation cycles

The re-evaluation cycles after that have been set to six (6) years in the Cooperation Memorandum. Formative evaluation will take part however after every run's completion.

3. Current State

The results of stages B to I of the preceding chapter have helped form the prototype of stage J that has been submitted to, discussed and approved by the relevant academic bodies of both partnering institutions. The form of the single institution masters' program with UNIWA that will be making use of visiting professors from HNA awaited the legal procedure of publication to the Gazette of the Greek Government, to start accepting students by the summer semester of 2021.

That is to say, that in the terms of an engineering design process [47], as shown in Figure 4, we have completed our first cycle, that of concept development and evaluation, whereas our concept is the skeleton curriculum with the structural choices and infrastructure use plan that go with it, and remains to present its results, which is the purpose of this paper.

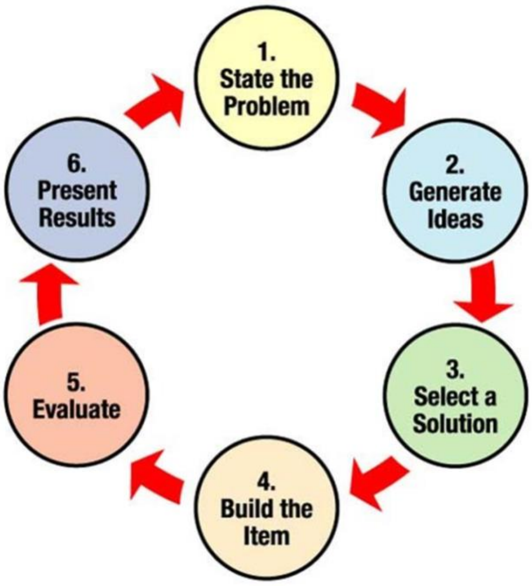

Figure 4. NASA Engineering design process (adopted from [47])

3.1. Syllabi that constitute the curriculum

The syllabi that constitute the curriculum are, for the time being, the ones related with the following courses:

First Semester (A) – disciplinary courses

A.1 Integrated Systems Programming and Sensor Arrays

A.2 Data Communications

A.3 Energy Management

A.4 Mechanical Constructions and Materials

These, first semester, courses are the more traditional within our curriculum. Even so, their structuring will have to take into account the fact that students will, in all probability, be more than less adults and possibly already practitioners in the field. Thus, some consideration of adult education and life-long learning principles [48] is due.

Second Semester (B) – thematic courses

B.1 General Issues of Networking Unmanned Systems – Autonomous Ground Vehicles

B.2 Specific Issues of Unmanned Underwater and Surface Naval Systems

B.3 Unmanned Air and Space Systems

B.4 Study and Development of an Unmanned System

B.5 Seminar (mandatory): Legislative Framework

At this point, there is even more need for adult learning principles consideration [49]. Case studies [50], but also problem-based and project-based components [51] increasing in extent, complexity and student autonomy [52] as the semester progresses, will be a major part of the second semester lessons. Towards the end of the semester, small research projects are the norm and also a part of the assessment scheme. Provisions are taken to allow for and support the students' self-regulation of learning [53].

Third Semester (C) – research thesis/construction

C.1 Short Seminar: choice from available topics

The third semester includes only one optional seminar of some special interest, related or not to the major constructionist project of the main course. Attention is given to the ways in which meanings are generated during bricolage with artefacts, influenced by the changes students make to them, also giving emphasis to ownership and production [54]. Amongst the seven essentials for project-based learning, according to Larmer and Mergendoller [55], in the sixth place one can find feedback and revision and that set one of the major demands in personnel, experienced researchers to get involved with the students' projects. There is ample bibliography to the benefits of project-based learning [56]. Our case demands an actual deliverable of either physical or digital nature and not an abstract.

4. Commentary

4.1. Reflection on the design process

The design process has been more thorough than it is customary but that only reflects the fact of the complexity of the endeavor. While the Unmanned Vehicle field is very active and productive, is still shaping. It is formed by contributions of multiple disciplines and answers a variety of problems that present inter- and sometimes trans-disciplinary nature.

Thus, a complex solution with a mix of approaches, gradually moving towards maximum integration of the curriculum elements, was chosen and thus far applied. The steps remaining are of similar complexity and need to be performed with the same precision.

Yet, it is hoped that such a burdensome choice offers enough advantages to build a unique curriculum, capable to serve a new industry integrating new science, technologies and practices into it. A curriculum that is also capable of further improvement and fine-tuning; hopefully, a curriculum flexible enough to cope with the ever-changing scenery of the sector.

4.2. Assessment and discussion

Hargreaves and Fink, as reported by van den Akker [57], find that: "Change in education is easy to propose, hard to implement, and extraordinarily difficult to sustain". He himself thinks that, arguably, curriculum change belongs to the hardest category. How then do we know that a diverging curriculum such as ours, which might very well fit to be called, in David Ackerman's terminology, an atypical form of program organization, is on track to serving the needs that created it?

There are some criteria that Plomp [58] revised from Nieveen for educational interventions. Considering a new curriculum, a major educational intervention, we revise them again and present in Table 1 along with our evaluation for this endeavor.

Table 1. Our curriculum against criteria for quality interventions

Criterion	Indicators	Elaboration	Evaluation
Relevance	(content validity)	There is a need for the intervention and its design is based on state-of-the-art (scientific) knowledge.	There is a strong need for such a program. We designed it taking into account both the latest in curriculum research and the latest in the field. √
Consistency	(construct validity)	The intervention is 'logically' designed.	It progresses from disciplinary to research focused courses. √
Practicality	Expected	The intervention is expected to be usable in the settings for which it has been designed and developed.	It has been built so. √
	Actual	The intervention is usable in the settings for which it has been designed and developed.	Remains to be seen.
Effectiveness	Expected	Using the intervention is expected to result in desired outcomes.	It has been built so. √
	Actual	Using the intervention results in desired outcomes.	Remains to be seen.

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We also wish to propose a set of criteria, based on Pamela Roberts' educational drivers [59]. While difficult to serve all five masters, at least to the same extend, we strongly believe that a postgraduate curriculum should strive to cater for all of them. A curriculum that even partly serves all or most of them is a well-rounded and due for a long life one. Our curriculum serves graduate employability, attempts to answer creatively to the question of teaching and research relationships, allows for change through teachers' collective learning [60], and has provisions for application of educational technologies and flexible delivery (see Table 2), thus making us hopeful that we have a proper base for our postgraduate study program.

Table 2. Our curriculum against criteria based on Roberts' educational drivers

Criterion	**Coverage (3 √ maximum)**
graduate employability and competence built	√√
activating teaching–research relationships	√√√
compatibility with and provocation of changing understandings about teaching and learning	√√√
educational technologies utilization	√√√
flexible delivery compatibility/ readiness	√√

While we did not involve either of our institutions in its entirety [61], the whole of the Department of Industrial Design and Production Engineering resources have been employed for the prototyping phase. A similar level of involvement we envisage for the Department of Naval Studies, once the program is turn bi-institutional.

5. Conclusion

The process of developing a living, open and systemically structured curriculum has, thus far, been successful and with minimal hindrance. While it is not, by any means, a currere [62] – forever fluid and never set –, or a lived curriculum, [63] – as in form only through experience in a transdisciplinary practice environment –, it is none the less our intention to be alive and constantly revised in a double learning loop; a curated and open process. We also address it to all our students, without bias related to discipline of origin, striving for curricular justice [64] with responsiveness to individual needs and characteristics [65].

That is not meant to suggest that no friction presented itself during even the early stages already concluded. On the contrary, we had to appoint, mid-process, a coordinator with the mission to assist the teams with negotiations of meaning [19, 66] and keeping the peace, as is always the case in multi-stakeholder systems [66]. Still, friction has been dealt with within the process of building a community of practice [67, 68] and it has not been detrimental to the process either. On the contrary, it has been deemed productive by all parties interested.

While that might be considered a good practice, there are limitations to its application: we consider the fact that our curriculum is not a core one, a major factor to the process' success. In truth, our very unconventional curriculum is of a special nature in that it only covers a specific niche in the overall activity of the two institutions, thus inviting participants into a different community of practice that is nonetheless merely one of many. It has been seen by its academic community as an educational experiment, trying on for size things that might otherwise cause riots. Several colleagues that have their reservations about some elements of the design process or relevant choices were able to contribute without second thoughts, since this was not an institutions wide change of practice. Curiosity personal and scientific was also a factor.

What is even more important is its research focus [67]. In institutions where overworked academics yearn for some time for research in interesting fields, combining teaching with research is a refreshing thought. One might be inclined to take up some design, maintenance and administrative labor to enjoy such a diversion from, one too many, teaching sessions with no research interest.

This research focus has been two levels: on one hand, we designed a curriculum that allows for research on the subject of unmanned vehicles; one may at the same time conduct research on curriculum design/development [69] to find the proper form to serve that intention in the specific case of Unmanned Vehicles. Curriculum design is after all a specimen of education design [70], and that in turn, especially when on barely treaded ground, is a specimen of education research in its function to design and develop [71]. Therefore, since this curriculum is heavily dependent on the fast evolution of technology in the studied field of Unmanned Vehicles (as in other similar cases like [72, 73]), it is recommended for the future that:

- The described herein design process could be a model one for curricula of advanced technological subjects in other field, besides Unmanned Vehicles, as well.

- The technological evolution in this field should be constantly monitored, in order to keep the syllabi of courses updated.

- The didactic practices should be also constantly assessed, in order to ascertain whether they achieve the intended teaching goals or not, and be adapted accordingly.

Declarations

Source of Funding

This research did not benefit from grant from any non-profit, public or commercial funding agency.

Competing Interests Statement

The authors have declared that no potential competing financial, professional or personal interests exist.

Consent for publication

All authors contributed to the manuscript and consented to the publication of this research work.

Acknowledgments

The authors express their thankfulness to the University of West Attica for supporting the publication of the results (through ELKE).

References

[1] Gupta, S.G., Ghonge, D., & Jawandhiya, P.M. (2013). Review of unmanned aircraft system (UAS). International Journal of Advanced Research in Computer Engineering & Technology, 2(4): 1646–1658.

[2] Campbell, S., Naeem, W., & Irwin, G.W. (2012). A review on improving the autonomy of unmanned surface vehicles through intelligent collision avoidance manoeuvres. Annual Reviews in Control, 36(2): 267–83.

[3] Schneiderman, R. (2011). Unmanned drones are flying high in the military/aerospace sector (special reports). IEEE Signal Processing Magazine, 29(1): 8–11.

[4] Lucintel Brief (2011). Growth opportunity in global UAV market. Las Colinas, USA: Lucintel.

[5] O'Mahony, N., Campbell, S., Krpalkova, L., Riordan, D., Walsh, J., Murphy, A., & Ryan, C. (2018). Deep Learning for Visual Navigation of Unmanned Ground Vehicles: A review. In 2018 29th Irish Signals and Systems Conference (ISSC), Belfast, UK.

[6] Abdullahi, H.S., Mahieddine, F., & Sheriff, R.E. (2015). Technology impact on agricultural productivity: A review of precision agriculture using unmanned aerial vehicles. In International Conference on Wireless and Satellite Systems, Pages 388–400, Cham, International: Springer.

[7] McLaughlin, R. (2012). Unmanned naval vehicles at sea: USVs, UUVs, and the adequacy of the law. J. Inf. & Sci., 21(2): 100.

[8] Verfuss, U.K., Aniceto, A.S., Harris, D.V., Gillespie, D., Fielding, S., Jiménez, G., et al. (2019). A review of unmanned vehicles for the detection and monitoring of marine fauna. Marine Pollution Bulletin, 140: 17–29.

[9] Yates, L., & Young, M. (2010). Globalization, knowledge and the curriculum. European Journal of Education, 45: 4–10.

[10] Muller, J. (2009). Forms of knowledge and curriculum coherence. Journal of Education and Work, 22: 205–226.

[11] Woods, D., Felder, R., Rugarcia, A., & Stice, J. (2000). The future of engineering education III; Developing critical skills. Chemical Engineering Education, 34(2): 108–117.

[12] Shay, S. (2012). Conceptualizing curriculum differentiation in higher education: a sociology of knowledge point of view. British Journal of Sociology of Education, 34(4): 563–582.

[13] Allais, S.M. (2007). Education service delivery: the disastrous case of outcomes-based qualifications frameworks. Progress in Development Studies, 7(1): 65–78.

[14] Wheelahan, L. (2007). Beyond the Contextual: The importance of theoretical knowledge in vocational qualifications and the implications for work. In Proceedings of the 3rd International Conference: The times they are a-changing: researching transitions in lifelong learning, University of Stirling, UK: Centre for Research in Lifelong Learning.

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[15] Barnett, M. (2006). Vocational knowledge and vocational pedagogy. In M. Young and J. Gamble (Eds.), Knowledge, curriculum and qualifications for South African further education, Pages 143–157, Cape Town, South Africa: HSRC Press.

[16] Rompelman, O., & de Graaff, E. (2006). The engineering of engineering education: curriculum development from a designer's point of view. European Journal of Engineering Education, 31(2): 215–226.

[17] Alsubaie, M.A. (2016). Curriculum Development: Teacher Involvement in Curriculum Development. Journal of Education and Practice, 7(9): 106–107.

[18] Su, S.W. (2012). The Various Concepts of Curriculum and the Factors Involved in Curricula-making. Journal of Language Teaching & Research, 3(1): 153–158. http://dx.doi.org/10.4304/jltr.3.1.153-158.

[19] Annala, J., & Mäkinen, M. (2017). Communities of practice in higher education: contradictory narratives of a university-wide curriculum reform. Studies in Higher Education, 42(11): 1941–1957.

[20] Nonaka, I., von Krogh, G., & Voelpel, S. (2006). Organizational Knowledge Creation Theory: Evolutionary Paths and Future Advances. Organization Studies, 27(8): 1179–1208.

[21] Bovill, C., & Bulley, C.J. (2011). A model of active student participation in curriculum design: exploring desirability and possibility. In C. Rust (Ed.), Improving Student Learning (ISL) 18: Global Theories and Local Practices: Institutional, Disciplinary and Cultural Variations, Pages 176–188, Oxford, UK: Oxford Brookes University, Oxford Centre for Staff and Learning Development.

[22] Malone, Y. (2002). Social Cognitive Theory and Choice Theory; Compatibility Analysis. International Journal of Therapy, 22: 10–13.

[23] Arthur, B.W. (2009). The Nature of Technology: What It Is and How It Evolves. London, UK: Penguin.

[24] Letts, W. (2019). Pursuing employability: A journey more than a destination. In J. Higgs, G. Crisp, and W. Letts (Eds.), Education for employability: Learning and future possibilities, Volume 2, Pages 82–88, Rotterdam, The Netherlands: Brill Sense.

[25] Harden, R.M. (2000). The integration ladder: a tool for curriculum planning and evaluation. Medical Education–Oxford, 34(7): 551–557.

[26] Bailey-McEwan, M. (2009). Difficulties of mechanical engineering students in developing integrated knowledge for the cross-discipline of mechatronics: A conceptual investigation. Master of Education Thesis, University of Witwatersrand, Johannesburg, South Africa.

[27] McCombs, B.L. (1992). Learner-Centred Psychological Principles. Guidelines for School Redesign and Reform. Washington, DC: American Psychological Association.

[28] Maton, K. (2011). Theories and things: The semantics of disciplinarity. In F. Christie, and K. Maton (Eds.), Disciplinarity: Systemic functional and sociological perspectives, Pages 62–84, London, UK: Continuum.

[29] Shay, S., & Steyn, D. (2016). Enabling knowledge progression in vocational curricula: Design as a case study. In K. Maton, S. Hood, and S. Shay (Eds.), Knowledge-building: Educational Studies in Legitimation Code Theory, Pages 138–157, London, UK: Routledge.

[30] Brandom, R. (2000). Articulating Reasons: An Introduction to Inferentialism. MA: Harvard University Press.

[31] Kolb, A.Y., & Kolb, D.A. (2006). Learning Styles and Learning Spaces: A review of the Multidisciplinary Application of Experiential Learning Theory in Higher Education. In R.R. Sims & S.J. Sims (Eds.), Learning Styles and Learning, Pages 45–91, Hauppauge, New York, NY: Nova Science Publishers, Inc.

[32] Knowles, M.S., Holton III, E.F., & Swanson, R.A. (2014). The adult learner: The definitive classic in adult education and human resource development. London, UK: Routledge.

[33] Land, R., et al. (2008). Threshold concepts within the disciplines. Rotterdam and Taipei: Sense Publishers.

[34] Durning, S.J., & Artino, A.R. (2011). Situativity theory: A perspective on how participants and the environment can interact: AMEE Guide no. 52. Med. Teach., 33: 188–199.

[35] Bernstein, B. (2000). Pedagogy, symbolic control and identity: Theory, research, critique. Lanham, MD: Rowman & Littlefield Publishers.

[36] Publications Office of the European Union (2015). ECTS Users' Guide. Luxembourg: Publications Office of the European Union.

[37] Grosges, T., & Barchiesi, D. (2007). European Credit Transfer and Accumulation System: An Alternative Way to Calculate the ECTS Grades. Higher Education in Europe, 32(2-3): 213–227.

[38] Carey, K. (2015). The End of College. New York, NY: Riverhead Books.

[39] Kaliannan, M., & Chandran, S.D. (2012). Empowering Students through Outcome-Based Education (OBE). Research in Education, 87(1): 50–63. https://doi.org/10.7227/RIE.87.1.4.

[40] Wiggins, G., & McTighe, J. (2005). Understanding by design. Alexandria, VA: Association for Supervision and Curriculum Development.

[41] Starr, C., Manaris, B., & Stalvey, R. (2008). Bloom's taxonomy revisited: Specifying assessable learning objectives in computer science. ACM Sigcse Bulletin, 40: 261–265.

[42] Lim, D.H., & Morris, M.L. (2009). Learner and Instructional Factors Influencing Learning Outcomes within a Blended Learning Environment. Educational Technology & Society, 12(4): 282–293.

[43] Kolb, A., & Kolb, D. (2018). Eight important things to know about the experiential learning cycle. Australian Educational Leader, 40(3): 8–14.

[44] Makrygiannis, P.S., Paradisi, A., Tsapelas, T., Papakitsos, E.C., & Piromalis, D. (2020). An Example of Designing Modular Vocational Syllabi. European Journal of Engineering Research and Science, Special Issue (CIE 2019), Pages 17–21.

[45] Papakitsos, E.C. (2016). The Application of Systems Methodology to Curriculum Development in Higher Education. Higher Education Research, 1(1): 1–9. https://doi.org/10.11648j.her.20160101.11.

[46] Zinsmeister, H. (2008). Freshmen's CL curriculum: the benefits of redundancy. In Proceedings of the Third Workshop on Issues in Teaching Computational Linguistics, Columbus, Ohio.

[47] Lucas, B., & Hanson, J. (2016). Thinking Like an Engineer: Using Engineering Habits of Mind and Signature Pedagogies to Redesign Engineering Education. International Journal of Engineering Pedagogy, 6(2): 4–13. https://doi.org/10.3991/ijep.v6i2.5366.

[48] Jarvis, P. (2004). Adult education and lifelong learning: Theory and practice. London, UK: Routledge.

[49] Tight, M. (2002). Key concepts in adult education and training. London, UK: Psychology Press.

[50] Swanborn, P. (2010). Case study research: What, why and how? Thousand Oaks, CA: Sage.

[51] Wiek, A., Xiong, A., Brundiers, K., & Van Der Leeuw, S. (2014). Integrating problem-and project-based learning into sustainability programs. International Journal of Sustainability in Higher Education, 15(4): 431–449. https://doi.org/10.1108/ijshe-02-2013-0013.

[52] Mills, J.E., & Treagust, D.F. (2003). Engineering education – Is problem-based or project-based learning the answer. Australasian Journal of Engineering Education, 3(2): 2–16.

[53] English, M.C., & Kitsantas, A. (2013). Supporting student self-regulated learning in problem-and project-based learning. Interdisciplinary Journal of Problem-Based Learning, 7(2): 6.

[54] Kynigos, C. (2015). Constructionism: Theory of learning or theory of design? In Selected regular lectures from the 12th International Congress on Mathematical Education, Pages 417–38, Cham, International: Springer.

[55] Larmer, J., & Mergendoller, J.R. (2010). Seven essentials for project-based learning. Educational Leadership, 68(1): 34–37.

[56] Kokotsaki, D., Menzies, V., & Wiggins, A. (2016). Project-based learning: A review of the literature. Improving Schools, 19(3): 267–277.

[57] Van den Akker, J. (2013). Curricular development research as specimen of educational design research. In T. Plomp & N. Nieveen (Eds.), Educational Design Research; Part A: An Introduction, Pages 52–71, Enschede, The Netherlands: SLO.

[58] Plomp, T. (2013). Educational design research: An introduction. In T. Plomp & N. Nieveen (Eds.), Educational Design Research; Part A: An Introduction, Pages 11–50, Enschede, The Netherlands: SLO.

[59] Roberts, P. (2015). Higher education curriculum orientations and the implications for institutional curriculum change. Teaching in Higher Education, 20(5): 542–555.

[60] Hoban, G.F. (2002). Teacher Learning for Educational Change. Maidenhead Berkshire, UK: Open University Press.

[61] Pinar, W.F. (2013). International handbook of curriculum research. London, UK: Routledge.

[62] Clements, D.H. (2007). Curriculum research: Toward a framework for 'research-based curricula'. Journal for Research in Mathematics Education, 38(1): 35–70.

[63] Riley, K. (2023). Researcher/Teacher/Environmental Education Worldings: Negotiating a Lived Curriculum. In (Re)Storying Human/Earth Relationships in Environmental Education, Children: Global Posthumanist Perspectives and Materialist Theories, Singapore: Springer. https://doi.org/10.1007/978-981-99-2587-2_5.

[64] Riddle, S., Mills, M., & McGregor, G. (2023). Curricular justice and contemporary schooling: Towards a rich, common curriculum for all students. Curric. Perspect., 43: 137–144.

[65] Edgar, S. (2022). The tricky concept of 'educational equity': In search of conceptual clarity. Scottish Educational Review, 54(1): 3–25.

[66] Easter, S., Murphy, M., & Brannen, M.Y. (2023). Negotiating Meaning Systems in Multi-stakeholder Partnerships Addressing Grand Challenges: Homelessness in Western Canada. J. Bus. Ethics, 183: 31–52. https://doi.org/10.1007/s10551-022-05064-7.

[67] Bertella, G. (2024). Cross-community enactive research: a relational practice-based approach to academic engagement. Current Issues in Tourism, 27(5): 819–832. https://doi.org/10.1080/13683500.2023.2185505.

[68] Akosen, L., & Asiedu, N. (2023). Communities of Practice as a Knowledge Management Tool in Ghana's Telecommunication Industry: A Systematic Review. International Journal of Management, Knowledge and Learning, 12: 21–37. https://doi.org/10.53615/2232-5697.12.21-37.

[69] Shavelson, R.J., Phillips, D.C., Towne, L., & Feuer, M.J. (2003). On the science of education design studies. Educational Researcher, 32(1): 25–28.

[70] Richey, R., & Klein, J.D. (2007). Design and development research: methods, strategies, and issues. London, UK: Routledge.

[71] McMillin, J., & Dyball, R. (2009). Developing a whole-of-university approach to educating for sustainability: Linking curriculum, research and sustainable campus operations. Journal of Education for Sustainable Development, 3(1): 55–64.

[72] Bunt, R., & Lautenbach, G. (2023). University lecturers' perceptions of communities of practice to promote ICT adoption. In T. Bastiaens (Ed.), Proceedings of EdMedia + Innovate Learning, Pages 298–307, Vienna, Austria, Association for the Advancement of Computing in Education (AACE).

[73] Noar, A.P., Jeffery, H.E., Subbiah Ponniah, H., & Jaffer, U. (2023). The aims and effectiveness of communities of practice in healthcare: A systematic review. PLoS ONE, 18(10): e0292343. https://doi.org/10.1371/journal.pone.0292343.