Reimagining and Empowering the Design of Projects: A Project-Based Learning Goals Framework

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***Abstract*—How is project-based learning (PjBL) defined and what is its purpose? What makes a "good" PjBL experience? How authentic should projects be? Who chooses the project topic or challenge? Should students work on teams, present their work to experts, or write a self-assessment? Over the years, instructional designers and educational theorists have proposed different answers to these questions, and crafted expert recommendations on what projects should do or be, and how PjBL ought to look. Our on-the-ground experience has illustrated, not surprisingly, that PjBL is quite different in theory and practice. We find that PjBL is a flexible pedagogical approach that can help instructors in a myriad of ways; but a single project cannot do everything, and instructors must grapple with difficult trade-offs to shape a compelling PjBL learning experience. In this paper, we present a goals framework that enables instructors seeking to engage with PjBL to intentionally design PjBL experiences that encourage broad competency development, and to consider the fundamental question: What are you trying to support or achieve with a project? The framework describes *broad competencies* that transcend disciplines, emphasizes learning *multiple domains* (cognitive, affective, social, and psychomotor), and encourages flexible and *non-prescriptive usage*. The goals framework offers value to instructors as a communication tool, an analytical tool, and a design tool.**

Keywords—project-based learning, learning goals, competency-based learning, active learning, Bloom's taxonomy

I. Introduction

Instructors who implement project-based learning (PjBL) experiences recognize that intentionally designed experiences can help students make progress toward many different learning goals. PjBL may thus be viewed as a flexible pedagogical approach that may take different forms based on personal or contextual factors, such as learner needs, instructor intent, program or institutional culture, broader educational trends, and course-level situational constraints. With this in mind, and drawing on existing learning goals frameworks (e.g., [1], [2], [3]) and relevant educational research (e.g., [4], [5], [6]) we developed a PjBL goals framework that enables instructors to consider a wide range of student learning goals for a project experience, in the context of a particular course. This framework enables instructors to freely explore what PjBL *might be* without getting hung up on attempting to precisely define what PjBL *is*.

The goals framework embodies several key ideas. First, the goals are competency-based and transdisciplinary, e.g., communication, critical thinking, collaboration, and self-directed learning. This enables instructors and students from any field to engage with the framework. Second, the list of goals spans multiple domains of learning, including cognitive, affective/motivational, psychomotor, and social development, thereby enabling instructors to push their designs beyond traditional course content. Third, the framework is fluid and flexible, not prescriptive, which encourages instructors to deeply consider goals that are meaningful or aspirational to their course situation and institutional context.

II. Background on Learning Goals Frameworks

Learning goals frameworks or taxonomies are not new. The project goals framework described in this paper draws on nearly 100 years of prior research and practice, which has generated learning goals frameworks that vary from high-level articulations of educational philosophies or visions, to detailed models for specific pedagogies or curricula.

A. High-Level Educational Goals Frameworks

At the higheset and most abstract levels, organizations or individuals present learning goals as foundational educational principles or models for education. For example, in the International Commision on Education for the Twenty-first Century's report, UNESCO describes four pillars of education: (i) *learning to know*, (ii) *learning to do*, (iii) *learning to be*, and (iv) *learning to live together, learning to live with others* [7]. In many ways, the UNESCO learning goals framework mirrors earlier work by Bloom et al [1]. In 1956, Bloom et al. published their now well-known taxonomy of educational objectives for the cognitive domain, which aligns with notions of *learning to know* and *learning to do*. Less recognized by many educators, however, is the affective domain taxonomy, published by Krathwohl, Bloom, and Masia [2] shortly after the cognitive domain taxonomy was in print. In *Taxonomy of Educational Objectives–Handbook 2: Affective Domain*, Krathwohl et al. describe goals that mirror UNESCO's *learning to be* and, to some extent, the *learning to live with others* categories. Krathwohl et al. also bemoan the disappearance of affective objectives from college courses. They describe the deemphasis of affective goals as an "erosion" due in part because it is "easier to teach and evaluate cognitive objectives" using traditional pedagogies and grading methods, because the affective domain feels more personal, and because interests, attitudes, and motivations may develop on different timescales compared to cognitive learning [2, p. 16]. Nonetheless, Krathwohl et al. stress that the affective

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domain must be considered in learning, as it is here that powerful forces that "determine the nature of an individual's life and ultimately the life of an entire people" are contained [2, p. 91].

Shortly after the affective domain was published, a psychomotor domain was added to Bloom's taxonomy to capture learners' motor abilities and skills interacting with the physical world [8], [9]. In the 1990s, Pacific Crest added a social domain to the cognitive, affective, and psychomotor taxonomy, to emphasize skills such as communication, interpersonal and cultural relating, management, and leadership [10]. A four component model with cognitive, affective, psychomotor, and social learning domains is reasonably well aligned with social-cognitive frameworks for learning, particularly with models presented in the self-regulated learning (SRL) literature. Zimmerman, for example, describes SRL as a "complex interactive process involving social, motivational, and behavioral components," in addition to cognititions and metacognitions [11]. Pintrich's conceptual model for SRL describes cognitive, motivational/affective, behavioral, and contextual components of learning. The *contextual* component, in this case, draws attention to how learners connect interpersonally (social interactions, collaboration, peer learning), and how they engage in the physical environment (designing projects, removing distractions, performing a task). Building on the work of Pintrich and others, Ford and Smith (2005) describe a goals taxonomy with several major categories including *task goals* such as creativity and management, *cognitive goals* such as understanding and exploration, *affective goals* such as happiness and physical sensations, *self-assertive social relationsihp goals* such as self-determination and resource acquisition, *integrative social relationship goals* such as equity and social responsibility, and *subjective organization goals* such as unity and transcendence [12].

An alternative approach to categorizing learning is presented in Fink's Taxonomy of Significant Learning [3]. Fink divides learning into *foundational knowledge, application, integration, human dimension, caring, and learning how to learn.* The foundational knowledge category deals exclusively with cognitions, e.g., understanding and remembering information and connecting ideas, while the other categories are more cross-cutting in nature. For example, the application area includes cognition (critical thinking) as well as psychomotor (operating lab equipment) and social (managing projects) skill building. Integration is described as both a cognitive (interdisciplinary thinking) and social (learning community interactions) endeavor.

A common feature of these high-level goals frameworks and learning taxonomies is that they encompass much more than low-level cognitions such as content acquisition, factual recall, and conceptual understanding. They expand cognitive learning upward, toward sophisticated skills such as evaluation, design, and metacognitive awareness; and they extend learning outward, toward learners' motivations, behaviors and interactions, and engagement with the physical world. This expansion into broader learning goals and development of more sophisticated skills influenced our project goals framework.

B. Pedagogical Frameworks

Existing pedagogical models for problem-based learning (PBL), project-based learning (PjBL), and design and studio learning provided valuable inputs to our design of the project goals framework. Not surprisingly, the models for active and student-centered pedagogies reflect a broader range of goals than those typically found in traditional learning. Barrows and Tamblyn's (1980) early PBL model for medical education emphasized knowledge application and higher-level cognitive skills such as diagnosis and clinical reasoning, along with student self-direction and positive motivational goals such as enjoyment and a sense of relevance [13]. In her description of PBL approaches, Hmelo-Silver (2004) describes the goals of PBL as helping students develop flexible knowledge, problem-solving skills, self-directed learning skills, collaboration skills, and intrinsic motivation [5]. Savin-Baden (2003) identifies several hallmarks of PBL including critical thinking, independent inquiry, social or community connections, and affective learning [14].

In a review of the history of project-based learning, de Graaff and Kolmos (2007) discuss how PjBL in engineering evolved over time, from an emphasis on the principles of learning by doing and experiential learning, to an emphasis on incorporating complex, real-world challenges that address societal needs and require interdisciplinary thinking [15]. In early conceptualizations, projects were defined as complex interdisciplinary efforts that required students to work in cross-disciplinary groups, link theory and practice, and take control of their learning process [15]. Savin-Baden (2003) describes how group/team work, student choice, self-direction, and creation of physical artifacts are common elements of PjBL [14]. Blumenfeld et al. (1991) describe how investigation of authentic problems and construction of representations and artifacts in PjBL has the potential to support both high-level cognitions and positive motivations [6].

Design and studio pedagogies also embrace a broad set of learning goals. In describing the "hidden curriculum" of the design studio, Dutton (1987) explores how studio pedagogy could enable students to think critically about broader societal issues, develop understanding of group dynamics, and explore personal goals and values [16]. Little and Cardenas (2001) emphasize studio learning goals related to design tools, interactions with people groups, project management, and communication skills [17]. Finally, more recent applications of design thinking in education emphasize collaboration, empathy, critical thinking, real-world problem solving, and hands-on prototyping, testing, and iteration [18].

C. Disciplinary or Domain-Specific Frameworks

The goals framework presented here was also influenced by recent calls for reform in technical education, and STEM learning policies and standards. For example, ABET's criteria for student outcomes include a range of high-level cognitive capacities, as well as skills in *communication, multidisciplinary teaming*, *use of techniques and tools*, *design within realistic constraints*, *lifelong learning*, and an *understanding of the impact of engineering in global, economic, environmental, and societal context* [19]. Among the key attributes for engineers

outlined in the NAE's *Engineer of 2020* vision are *analytical skills*, *creativity*, *communication*, and *lifelong learning* [20].

III. The Project Goals Framework

This section presents the project goals framework and goal definitions, the design principles used to inform the design of the tool, and an overview of the prototype testing and revision processes. The core principle underpinning this framework is the observation that there is no single way to craft an engaging and effective project. Successful projects take on a variety of forms and achieve many possible impacts. Not every learning experience involves the same focus or goals, people, resources, or constraints. As such, the process used to develop project goals needs to be human-centered and situation-specific, as opposed to a rigid pedagogical prescription.

A. Design Principles

The project goals framework was created by curriculum designers as a tool for curriculum designers. As mentioned above, projects take on many forms for different audiences. Therefore, there is not a single set of goals that applies to all projects, nor a single course design "formula" that will benefit all instructors. In developing the goals framework, we embraced several design principles:

- **Broad**. The framework should emphasize inter- or trans-disciplinary competencies that reflect holistic models for learning, and reflect student-centered pedagogical practices.
- **Simple and Transparent.** The goals framework should be easy to understand, with clear, jargon-free, and non-domain specific language. Its use should be obvious to practitioners, and instructors should be able to quickly and naturally engage with the tool.
- **Flexible, Non-Prescriptive**. The framework should support instructor intent and agency. Educators from different disciplines, and with diverse educational beliefs, should be able to use the tool. Users should feel a sense of autonomy – freedom, choice, and control – as they engage with the tool.
- **Inspiring, Future-Facing**. The framework should enable educators to imagine new opportunities for their course projects. The goals should align with calls for educational reform and progressive educational models.
- **Honest in Trade-Offs.** The framework should encourage thoughtful and intentional trade-offs in selecting project goals. It should help instructors see and avoid the "do everything" trap.

Of these design principles, the Honest in Trade-Offs concept seems to be the most challenigng for instructors to grasp. The concept of trade-offs – acknowledgement that everything has limitations and that strategic choices must be made – is fundamental to design practice. Yet when it comes to the design of project-based experiences, many educators adopt a *more is better* approach, and expect to realize *efficiencies* without any losses or costs. In practice, this translates to attempts to add new learning goals without removing, or at least adjusting, the existing goals. For example, in workshop settings we often observe instructors' attempts to add project goals such as teaming and self-directed learning, while hesitating to reduce any emphasis on content learning goals.

Some authors promote the idea that difficult choices are not necessary when it comes to curriculum design. For example, Fink argues that "teaching is no longer a zero-sum game," and that "teachers don't automatically have to give up one kind of learning to achieve another" [3, p. 37]. We disagree. Our 15+ years of designing and implementing project-based learning experiences has taught us that every learning goal takes time and resources. The problem could be that some educators conflate the concept of *synergistic connections* with the concept of *efficiency*. Fink describes different types of learning as "synergistic," but he implies that efficiency appears alongside the synergy [3]. We recognize that positive *linkages* or *interconnections* exist among different learning goals, and the educational research illustrates many correlational and causal relationships. For example, higher-level cognitions are known to be tightly coupled to students' intrinsic motivations (e.g, [21], [22]). But to suggest that these relationships somehow occur without any costs or effort is absurd. Emphasizing positive motivations in course projects requires design and implementation of specific assignments and assessments geared toward these goals. Similarly, goals such as communication or teaming and collaboration cannot be added without costs. If you want to boost a course's emphasis on communication, you need to create room for communications-related activities and assessments. If you want to emphasize teaming and collaboration in a course currently oriented toward individual learning, you have to make time for peer interactions, project-team coordination and planning, and team member evaluation. And since most courses are already filled with as many activities that instructors and students are able to handle, the addition of something new might require a subtraction or at the very least some rearranging and rethinking. In any given project, instrutors can do a lot of things, but they can't do everything – everything takes time, and trade-offs are always a part an authentic design procees.

B. Project Goals and Definitions

The current iteration of the project goals framework is shown in Figure 1. Working definitions of the goals are shown in Table I. Important visual elements of this framework include the simple icon-based representation of each goal and the low-to-high slider bar without any numerical scale or visual divisions. The slider bars are simply labeled LOW (not emphasized) to HIGH (heavily emphasized), to allow instructors to interpret the scale based on their own situation and context. In general, goals that closely connect to the course's activities, products, and assessments might receive relatively high ratings, and goals earn lower ratings when they receive less overall emphasis or are addressed in classroom activities but not assessed, e.g., students may work in project teams but the project assignments or activities may not be designed to build or evaluate specific teaming skills. The two blank lines at the bottom of the goals list send an important message to instructors about their agency and autonomy as course designers: the list is certainly not comprehensive, and instructors need to take ownership by customizing it.

Fig. 1. The project goals framework, created to support the design and analysis of project-based learning (PjBL) experiences. The blank rows at the bottom enable educators to expand the goals framework based on their specific course, program, or institutional needs or values.

TABLE I. PROJECT GOALS WITH PROPOSED DEFINITIONS.

PROJECT GOAL	DEFINITION
HANDS-ON SKILLS	Active manipulation of physical objects, use of tools, operation of equipment
DESIGN & CREATIVITY	Purposeful generation and development of original concepts, processes, or prototypes; use of divergent thinking tools and techniques
CONTENT LEARNING	Acquisition, comprehension, and application of knowledge (lower-level cognitions)
CRITICAL THINKING	Interpretation, analysis, synthesis, and evaluation of ideas (higher-level cognitions)
REAL-WORLD CONTEXT	Addressing authentic problems from outside the classroom, often with consideration of complex economic, cultural, social, and ethical issues
DISCIPLINARY INTEGRATION	Applying the skills, perspectives, and knowledge from more than one traditional academic discipline to a complex challenge
COMMUNICATION SKILLS	Effective presentation or exchange of information and ideas using written, oral, visual, or graphical means
TEAMING, COLLABORATION	Engagement and cooperation with others in defined roles towards one or more common goals
INTRINSIC MOTIVATION	Engagement in learning for reasons of personal interest, enjoyment, value, or passion
SELF-DIRECTED LEARNING	Autonomously addressing learning needs by taking control of goal setting, resource identification, process selection and implementation, and reflection and assessment

C. *Testing and Development of the Framework*

The goals framework design was prototyped, tested, and refined through direct interaction with educators in curriculum design workshops. Several hundred faculty members from a broad range of U.S. and international institutions have used the goals framework to characterize their own and others' courses, to redesign courses, and to individually or collaboratively generate new course project ideas. The goals framework has been used by college educators in engineering as well as liberal arts, medicine, and business. The tool has also been tested in a variety of K-12 educational settings, including public, private, and specialty schools.

Testing the goals framework with faculty groups led to several major changes. For example, the first iteration of the framework included two goal areas titled "Synthesis," "Skill Building," and "Hands-On Experiences." During testing of the early prototype, the faculty feedback indicated that the "Skill Building" goal was too vague, and not clearly distinguishable from the "Hands-On Experiences" goal. Faculty also suggested that "Synthesis" was too limited in scope. In later versions of the framework, "Skill Building" was changed to "Communication Skills," "Hands-On Experiences" was shifted to "Hands-On Skills," and "Synthesis" was broadened to "Critical Thinking (analysis, synthesis, evaluation)." Another significant change to the framework involved the insertion and subsequent removal of "Identity Development" goal. Despite its importance to holistic learning, we found that educators struggled to define and situate the "Identity Development" goal within the context of course-level project design. Finally, the titles of several goals were modified as a result of faculty feedback during the prototype testing process. As examples, "Understand Broader Context" was simplified to "Real-World Context," and "Interdisciplinary Thinking" was shifted to "Disciplinary Integration." These modified goal titles better reflect the language used by practitioners in course design.

In workshop settings, instructors readily engage in adding their own project goals to the framework. Common additions to the goals list include *sustainability*, *ethical understanding*, *professional identity development*, and *business and entrepreneurship*. Future versions of the goals framework may formally incorporate some of these instructor-defined learning goals.

IV. APPLICATION OF THE FRAMEWORK

We propose that instructors may apply the project goals framework in four distinct ways: (1) as a *communication* tool within faculty groups and teaching teams, or between instructors and students; (2) as an *analytical* tool for understanding existing course experiences; (3) as a *redesign* tool for expanding the focus of the course or developing a broader range of non-traditional goals; and (4) as a *generative design* tool for creating entirely new course experiences. In this section, we present examples of these application modes.

A. *Communication*

The simplest application of the project goals framework is as a tool to aid communication within faculty groups and teaching teams, or between instructors and students. The framework tests the level of shared understanding by drawing attention to basic questions such as, "What are we doing in this project?" or "What is this learning experience fundamentally about?" For example, Fig. 2 illustrates how four different instructors in the same course rate the goals of a particular hands-on project. This faculty team appears to share a common vision of how the project addresses certain skills such as Hands-on Skills and Design & Creativity; but they express different understanding of the extent to which the course emphasizes Teaming and Disciplinary Integration.

Fig. 3 shows similar alignments and misalignments in learning goal understandings between an instructor and 20 students enrolled in an introductory, project-based science course. These different rankings enable valuable discussions among different stakeholders, resulting in shared understandings of the terminology and the desired outcomes of the learning experience.

Fig. 2. Goal ratings for the final project in an introdcutory engineering course. The colored circles represent goal ratings from four different instructors in the same course. Note the close instructor agreement in some goal areas, and disagreement in other areas.

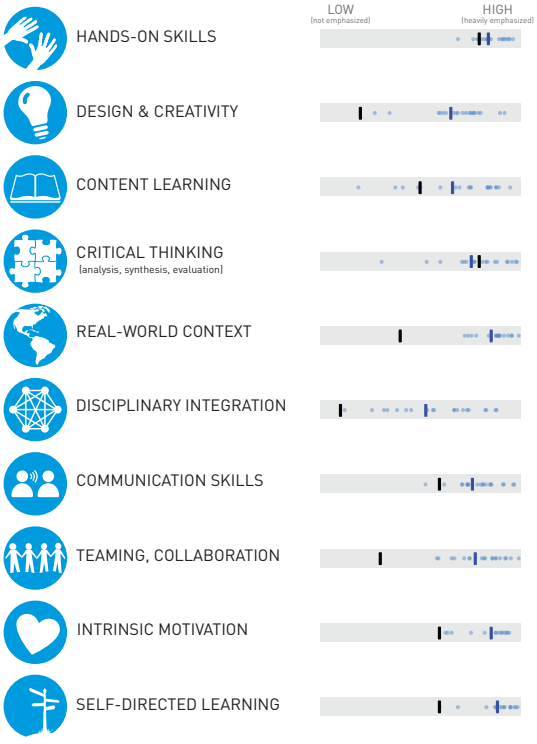

Fig. 3. Student (blue bars) and instructor (black bars) goal ratings for a five-week project in an introdcutory science course. The blue circles represent individual student responses. Note the close instructor-student agreement in some goal areas, and disagreement in other areas.

B. *Course Analysis*

The goals framework also may be used to analyze existing course projects, to gain insight into how a specific project may contribute to student learning, to evaluate the overall balance of goals in a project, or to compare projects across different courses, programs, or disciplines. Used as an analytical tool, the framework addresses the question of which goals a project emphasizes or de-emphasizes *in actuality*, as opposed to *in theory*. High goal ratings should be supported by evidence in the form of project assignments or activities, products or deliverables, and assessments (Fig. 4).

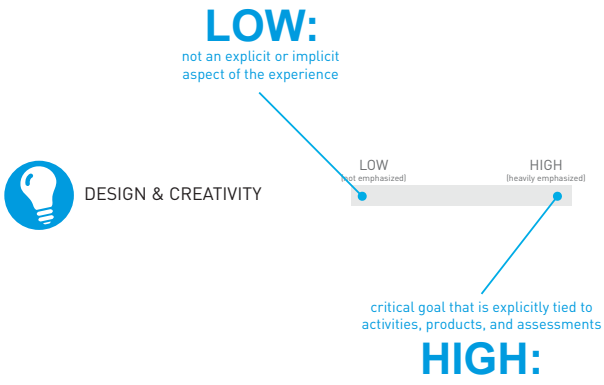

Fig. 4. Highly emphasized project goals should map directly to course activities, products, and assessments.

Fig. 5 illustrates instructors' analyses of the goals in three different undergraduate projects, including a first-year design project, an upper-level humanities self-study project, and an upper-level technical project. In the first-year design project, students work independently and within certain constraints to generate concepts for a mechanical toy; develop one of their concepts into a detailed design; create sketch models, 3D CAD models, and dynamic simulations; build and test a physical prototype using machine shop tools; diagnose and iterate on their design; and demonstrate a final design in a public setting. In the humanities self-study, students select and research a topic of personal interest which includes a thesis that they will support, develop a detailed learning plan, monitor and control their own learning process, produce a final written report, and reflect and self-evaluate their learning experience. In the upper-level technical project, students work as a team to test a hypothesis about material failure, using hands-on laboratory testing and sophisticated materials analytical techniques. They support their lab work with library research and scientific theory, and communicate their findings in both a written report and formal presentation.

As an analytical tool, we find that the project goals framework enables instructors to critically reflect on which of their intended goals map directly to project activities, products, and assessments, and which goals are less emphasized or even unsupported in their project. We also observe that the framework enables instructors to recognize when their project goals are not entirely clear to them, their colleagues, or their students, or when they are attempting to address too many learning outcomes in a single project. When applied across the curriculum, the goals framework enables faculty groups to

diagnose which goals are heavily developed or underdeveloped throughout a program, and identify opportunities for connections between different course projects, for example, by assigning certain goals to required first year course projects, and then reinforcing or deepening these goals in later semesters.

C. *Course Revision*

The project goals framework also supports revision or redesign of existing courses. Use of the framework in course modification typically involves analyzing and mapping the current goals of a course, identifying one or two goals to increase, and recognizing the "costs" or trade-offs associated with each goal increase (Fig. 6). This enables instructors to imagine ways to shift their course focus via a project, and identify opportunities to broaden the scope of their course goals. During course revision or redesign processes, we typically link the project goals framework to a goals-activities-products-assessment (GAPA) framework (Fig. 7).

GAPA is an adaptation of the objectives-instruction-assessments triangle from instructional design [23], with two important modifications. First, GAPA encourages PjBL designers to distinguish between project *activities* and project *products*, to enable instructors to predict how different assignments lead to different deliverables, or to backfill the learning steps necessary to create a particular artifact. Second, the GAPA framework places students at the center of the course design, as a reminder to instructors that they are creating experiences for a particular group of people. Well-designed course projects will ensure strong alignment of the GAPA components, and recognize the connection between the project experience and students' personal needs, values, and learning contexts.

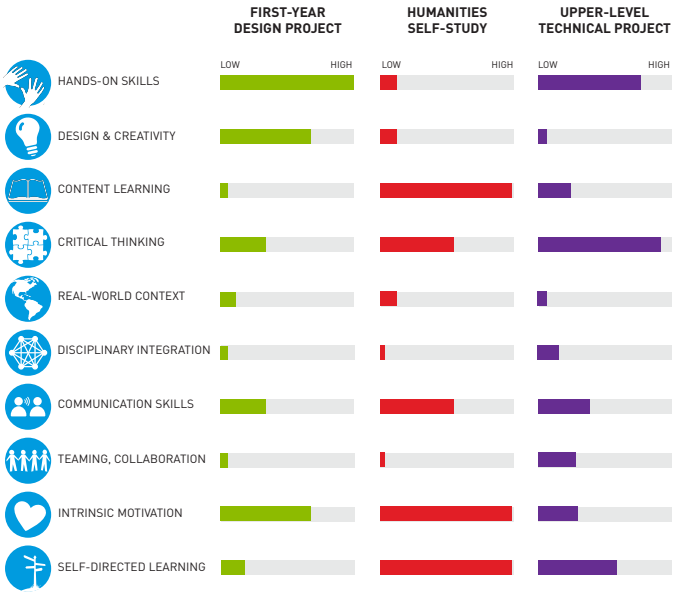

Fig. 5. Instructors' analyses of goals in three existing undergraduate projects, including an first-year individual hands-on project in design (green), an upper-level independent study project in history (red), and a lab-based analytical project in an upper-level technical elective course (purple).

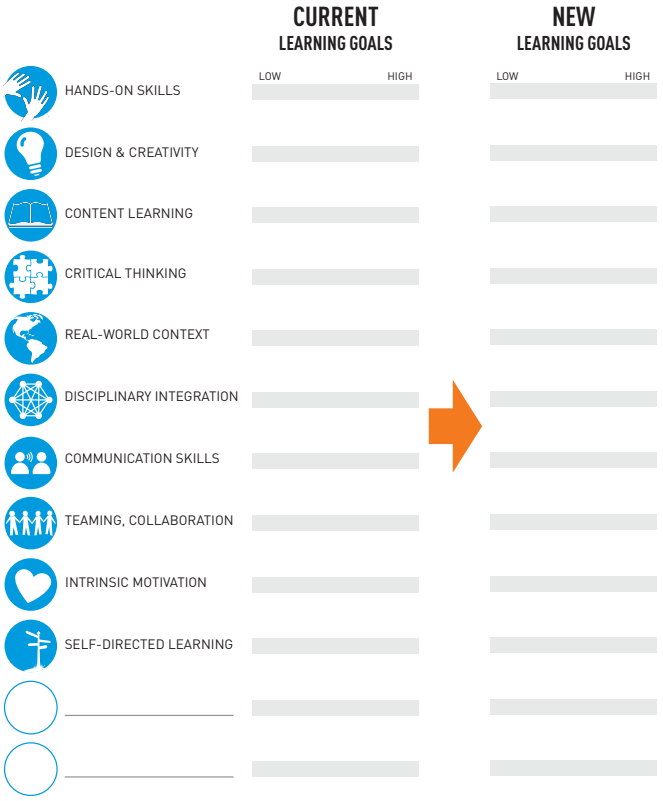

Fig. 6. A simple visual tool to help instructors apply the project goals framework to course revision. This approach enables instructors to compare current goals with proposed new goals, and to weigh trade-offs associated their proposed changes to the course goal structure.

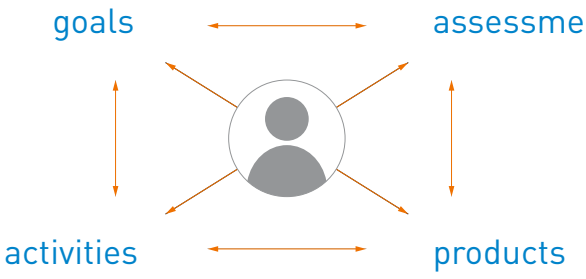

Fig. 7. The goals-activities-products-assessments (GAPA) framework for project design, illustrating how project goals should align with course activities, products, and assessments, and emphasizing that all course designs should center on students' needs and contexts.

D. *New Course Design*

The project goals framework enables individual faculty or instructional teams to sketch and discuss ideas for entirely new project-based experiences. For example, Fig. 8 illustrates how faculty applied the project goals framework to the design of an introductory-level environmental science course. The two-person team of STEM faculty worked collaboratively to outline the learning goals of a two-project sequence. Both projects emphasized critical thinking through analysis and interpretation of laboratory data, and real-world context

through fieldwork and connection to environmental impacts. Project 1 included a heavier emphasis on disciplinary content and the design of investigations, while Project 2 focused more on disciplinary integration and communication skills.

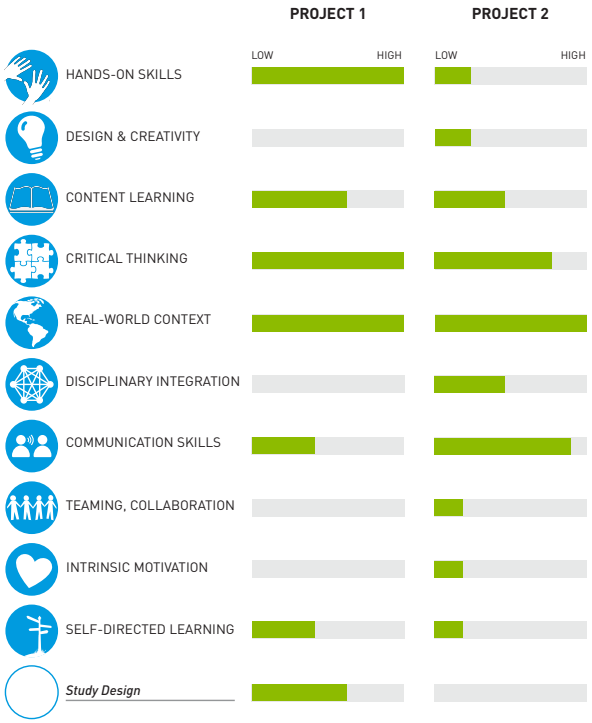

Fig. 8. Goals selection for a two-project sequence in a new introductory environmental science course, co-designed by two STEM faculty members.

In new course design, the framework is typically linked to the GAPA framework and a set of prompts such as:

- What are the primary learning goals of this project? How will you describe the project to students?
- What will students do throughout the project, e.g., design a new product, engage with the community, analyze a system, conduct experiments? How will these activities help students make progress toward the emphasized goals?
- How will you structure the project to emphasize your goals? For example, how long will the project last (days, weeks, months)? Is it an individual or team-based project? What choices will students have? What constraints will you impose?
- What will students produce during this project e.g., an analytical report, a software model, a physical product, public presentation or poster, design critique, exams, homework assignments, etc.?
- How will you handle assessment, including feedback and evaluation of learning processes or outcomes? Who (e.g., instructors, peers, experts) is involved in feedback, at what times, and with what purpose? How are students evaluated, e.g., demonstrations, panel review, performance metric, competency-based rubrics?
- What resources will students need, e.g., tools, equipment, information, people, budget, space, etc.?
- How will the learning environment(s) look and feel, e.g., classroom, studio, team project space, outdoor space, laboratory, etc.?

Clearly, identification of project goals is only one step of the course design process; but it is an immensely important step. Specifying project goals can help instructors gain clarity about the purpose of the project-based experience, communicate their intent to students and colleagues, generate and develop ideas that align with the goal structure, and critically evaluate the success of a course project.

V. Summary

We assert that intentional project design, particularly regarding the learning goals of a project experience, is necessary to maximize the benefits of project-based learning. At the same time, we recognize that practitioners view PjBL as a highly flexible pedagogical approach, and create project experiences with vastly different forms to help student progress toward many different learning goals. This paper presents a simple project-goals framework that encourages instructors to explore the PjBL opportunities within new or existing courses, by considering a wide range of learning goals that a project experience may help students achieve. In addition, the goals framework provides a tool to support faculty communication about project goals, and analysis of existing course designs.

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