Educational Outcomes of the Purdue University College of Agriculture

Targeted outcomes for Bachelor of Science graduates from Purdue College of Agriculture include:

Professional Preparation: Demonstrate proficiency in their chosen discipline that incorporates knowledge, skills, technology, and professional conduct.

Scientific Principles: Demonstrate use of the scientific method to identify problems, formulate and test hypotheses, conduct experiments and analyze data, and derive conclusions.

Critical Thinking: Demonstrate critical thinking by using data and reasoning to develop sound responses to complex problems.

Communication: Demonstrate the ability to write and speak with effectiveness while considering audience and purpose.

Teamwork: Demonstrate the ability to work effectively as part of a problem-solving team.

Cultural Understanding: Demonstrate knowledge of a range of cultures and an understanding of human values and points of view of other than their own.

Social Science Principles: Demonstrate ability to apply social, economic, political, and environmental principles to living in a global community.

Civic Responsibility: Demonstrate awareness of civic responsibility to community and society at large.

Lifelong Learning: Demonstrate skills necessary for lifelong learning.

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CHAPTER 3 EVIDENCE AND CATEGORIES OF ISE IMPACTS

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If you don't know where you're going, any road will get you there

Lewis Carroll

You have an idea that you think will make a great ISE project. As a potential PI, your most important consideration is how to develop and write a competitive proposal that will enable you to actualize this great idea. Now the challenge that you and your project team face is figuring out how to describe succinctly, yet concretely, the impacts intended for your project. In order to be funded, you will need to describe the intended impacts of the project for the proposed audience(s), demonstrate how your project activities will achieve these impacts, and describe a plan for how you will evaluate the intended impacts. The purpose of this chapter is to help you and your project team develop a set of appropriate, measurable and valid project impacts; and a plan for evaluation that will demonstrate whether, and if so how, you accomplished your project goals and objectives.

In the late 1980s, Mary Ellen Munley - a leader in museum education - wrote a paper in which she argued persuasively about asking the right question(s), suggesting that project developers and evaluators could benefit greatly from the insights of Lewis Carroll (Munley, 1986, 1987). Although tongue in cheek, Munley's point is well taken—evaluation, in and of itself, is merely a process and a set of tools to document the outcomes and accomplishments of any effort. An even more essential part of project development - from which any evaluation plan will flow - is the development of clear goals and objectives for what one plans to do, for whom, and why.

Before proceeding though, it is important to emphasize that evaluation is a process and tool for planning. It is not what happens 'behind the curtain' but is a deliberate system of monitoring and tracking that spawns from, and feeds back into, the planning process in a cyclical and iterative way. It is conducted to ensure that programs are on track and successful and is key to effective practice. In other words, evaluation is the flipside of good planning. This means before setting out and even beginning to design a project, let alone an evaluation plan, it is critical to be able to clearly describe what one is actually attempting to accomplish by using a *backward research design* approach (Wiggins and McTighe, 2001). Some of the questions a project team should be able to answer at the outset of initiating a project using a backward research design approach include:

(1) What audience impacts will this project facilitate?

(2) What approach/type of project will best enable us to accomplish these goals and why do we feel that this is the best approach to take?

(3) How will we know whether the activities of the project accomplished these intended goals and objectives and with what evidence will we support the assertion that they did?

(4) How will we ensure that unanticipated outcomes are also documented?

These are the essential questions of the field; some you and your team should be able to answer yourselves, and others you will want to involve an evaluator in helping you answer early on while developing and writing the proposal. Finding an evaluator from the outset whose philosophy and approach matches your ideas and the type of project you are thinking about undertaking, particularly to help you plan and design the summative evaluation, is critical to writing a successful proposal. Although you and your team will want to be involved in thinking about all phases of evaluation, it is important the summative evaluation be conducted by an independent and unbiased evaluator to ensure the integrity of the process. This is money well spent since in addition to research skills, good evaluators bring an understanding of the planning process as cyclical and iterative – a set of deliberate steps which outline and track progress toward a goal.

However, evaluation is not just for preparing good proposals. It is also an integral part of running good projects. During crucial stages of program development, evaluation documents or measures achievements or outcomes against intended goals and objectives (while also being open to unanticipated outcomes as well). All forms of evaluation play an important role in planning, enabling "reflective practice" and facilitating project team/institutional learning. Since evaluation is a process that contributes to decision-making at key points of project development and implementation, and evaluation can be used to ensure success throughout the process of project development, it is important to include a comprehensive plan for evaluation. At a minimum, that includes front-end formative and summative evaluation, and ideally also includes remedial efforts to tweak and improve projects as they are initially implemented. Utilizing all forms of evaluation helps to ensure the progress and success of your efforts.

WHAT IMPACTS DO YOUR PROJECT TEAM WANT TO FACILITATE?

As we suggested, the challenge that you face as a PI and project team is figuring out how to describe succinctly and concretely the impacts intended for the proposed project. This is challenging for many reasons. By their very nature, informal science education projects and experiences are varied and designed to serve different audiences. It is a field in which multiple outcomes are the norm, and where learning is often the result of combined, interwoven and overlapping experiences (informal, formal and everyday). Thus the focus needs to be about understanding how the experience of participating in/or engaging with your project has *contributed* to fostering, reinforcing and sustaining science interest and understanding. This is a tall order indeed.

As described in Chapter 1, with the new online project monitoring system, the ISE program is going to be able to better document and track the project outcomes of individual projects. In addition, the outcomes you document will be used by the program overall to assess outcomes across the various categories of projects that ISE funds (exhibitions, youth and community programs, media and cyber-enabled learning projects, projects for either the public or professional audiences or sometimes both). A critical component of this monitoring system is the set of impact categories provided in Chapter 1, and defined in Table 3-1, below. As emphasized, your intended project impacts should fall within *some*, but *not all* of these categories (each project should target a few intended outcomes that fall within at least one of these categories of impacts).

Table 3-1 Impact categories as they relate to public audiences:

Impact category	Generic definition
Awareness, knowledge or understanding	Measurable demonstration of assessment of, change in, or exercise of awareness, knowledge, understanding of a particular scientific topic, concept, phenomena, theory, or careers central to the project
Engagement or interest	Measurable demonstration of assessment of, change in, or exercise of engagement/interest in a particular scientific topic, concept, phenomena, theory, or careers central to the project
Attitude	Measurable demonstration of assessment of, change in, or exercise of attitude toward a particular scientific topic, concept, phenomena, theory, or careers central to the project or one's capabilities relative to these areas. Although similar to awareness/interest/engagement, attitudes refer to changes in relatively stable, more intractable constructs such as empathy for animals and their habitats, appreciation for the role of scientists in society or attitudes toward stem cell research
Behavior	Measurable demonstration of assessment of, change in, or exercise of behavior related to a STEM topic. These types of impacts are particularly relevant to projects that are environmental in nature or have some kind of a health science focus since action is a desired outcome.
Skills	Measurable demonstration of the development and/or reinforcement of skills, either entirely new ones or the reinforcement, even practice, of developing skills. These tend to be procedural aspects of knowing, as opposed to the more declarative aspects of knowledge impacts. Although they can sometimes manifest as engagement, typically observed skills include a level of depth and skill such as engaging in scientific inquiry skills (observing, classifying, exploring, questioning, predicting, or experimenting), as well as developing/practicing very specific skills related to the use of scientific instruments and devices (e.g. using microscopes or telescopes successfully).
Other	Project specific

What follows is a brief and general description of the framework of impacts. These impact categories are not arbitrary but theoretically grounded in the informal science education professional literature specifically, and educational research more generally. They represent valid and common impacts observed as a result of informal science education activities. These categories though are not as black and white as they appear. There are often relationships and intersections between different types of impacts you may want to emphasize in your project, for example, the relationship between attitudes and knowledge.

Table 3-2 provides a work sheet template that you and your team can use to think through the potential impacts of your project, the indicators you will use to assess this impact, and what your criteria for evidence will be. In the next chapter of this guide this work sheet will be used to develop impacts, indicators and evidence for a hypothetical project. In subsequent chapters, you will see how each of these categories can be used to specifically define your intended outcomes depending upon whether the proposed project is an exhibition, a youth and community program, or a media project; focused on a public or professional audience, or both.

1) Knowledge. This category of impact emphasizes what a participant, be s/he a youth in a community program, or a visitor to a museum, or a web site user, consciously knows. Impacts in this category include knowledge, awareness, or understanding that can be stated by participants in their own words, whether that is during, immediately after, or long after, the experience. The content of the impact depends upon the project topic and can include STEM-related concepts, principles, phenomena, or theories, the history or philosophy of science, careers, or science as a process. Evidence for this impact includes changes in participants' knowledge (directly assessed or self-reported), as well as observed cognitive activities such as reinforcing prior knowledge, making inferences, or building an experiential basis for future learning (though this is more difficult to assess). It also includes memory of an experience over time, especially aspects of the experience that relate to STEM concepts, processes, or activities. Participants' reflections and monitoring of their own learning also falls into this category.

2) Engagement. Impacts in this category capture the excitement and involvement of participants in a topic, area, or aspect of STEM. The category includes participation and engagement, prerequisites for other types of learning which are also linked to interest. It could be supported by evidence that a project deliverable has evoked short-term interest, or has strengthened prior longer-term interest, in a topic or area of STEM. This impact is often a focus of projects that aim to engage historically under-represented participants in STEM.

3) Attitude. Impacts in this category encompass changes in long-term perspectives toward a STEM-related topic, a group of people, species or ecosystem, activities, theories or careers. An ISE project may strive to influence attitudes where none existed before, or may change attitudes. Indicators for the "attitude" impact can be less reliable than indicators of knowledge or engagement, because they tend to rely on self-report by participants, who may not always be fully aware or entirely honest about their attitudes. For this reason it is desirable to assess for attitude in multiple contexts and over a range of time frames if possible.

Table 3-2. Work Sheet for Developing Intended Impacts, Indicators & Evidence

ISE Category of Impact	Potential indicators	Evidence that impact was attained
Awareness, knowledge or understanding of STEM concepts, processes or careers		
Engagement or interest in STEM concepts, processes, or careers		
Attitude towards STEM-related topics or capabilities		
Behavior resulting from experience		
Skills based on experience		
Other (describe)		

4) Behavior: Some ISE projects propose to change participants' long-term behavior after the experience, be it an exhibition, a youth program, or a giant screen film. This category of impact is particularly targeted in projects that are environmental in nature or have some connection to the health sciences since subsequent action is a desired outcome. Evidence of behavior change might include participants' self-reported intentions to change their behavior, and longitudinal follow-ups with them (or others) to determine whether such behavior change has occurred. Like attitude, evidence for behavior change can be influenced by people's bias to please (their tendency to say what they think the researcher wants to hear), so follow-up assessments of actual behavior change are particularly important. Clearly there is a potentially important relationship between the categories of attitude and behavior change. For projects where this relationship is a

central focus, PIs and evaluators may wish to refer to background theories such as: the Theory of Reasoned Action, Theory of Planned Behavior, Prochaska's Theory of Behavior Change, Elaboration Likelihood, and Social Marketing.

5) Skills: This impact category targets the procedural aspects of knowing. Indicators include evidence that participants have learned to do something STEM-related that they could not previously do, or that they used skills they already possessed to reinforce and enhance existing STEM-related capacities. Less experienced members of a visiting group often learn skills by watching, mimicking, and jointly participating with more experienced members. Typical STEM-related skills include scientific inquiry skills (such as observation, exploration, questioning, prediction, experimentation, argumentation, interpretation, and synthesis), as well as, specific skills related to using scientific technologies or representations. This category also includes skills related to learning in the particular informal environment, for example learning how to manipulate an interactive exhibition, navigate a web site, play a computer game or collaborate with a group of youth in an after-school program. In addition, impacts can include broader skills that are related to STEM themes or are linked to lifelong STEM learning. Evidence for this kind of impact includes self-reported reflections by people of the development of new skills, or the practice of developing skills, or direct observation by researchers/evaluators.

6. Other: This category is for impacts which cannot be fit into any of the above categories. An example might be a project which is designed to impact the creativity of its audience members. Creativity might be classified in one or in several of the five categories above, but depending on the definition a particular project uses, it might be necessary to give it is own category. There will undoubtedly be projects defining novel impacts which will simply not fit under any of the five categories given. So that's why the "Other" category exists. However, we encourage you to not to overuse the "other" category and put at least part of the impacts your project is intended to produce under knowledge, engagement, attitude, behavior, or skills, to support the NSF-wide reporting process. "Other" category impacts will mostly be *one-off* examples and will be difficult to aggregate to see multi-project trends or progress.

In the descriptions of impact categories above and throughout this book, we often refer to "changes" in describing the many different kinds of impacts a project may have. But as noted in the description of the "knowledge" category above, there are other forms of desirable impacts in addition to changes. Many projects are assessing baseline information of what people know or how they behave when using a tool such as the Internet, an exhibition, or a television program. Sometimes a project may be providing opportunities for reinforcing existing knowledge, for practicing skills, or for clarifying attitudes. Change in a quantitative measure is one of many valid, verifiable ways of demonstrating impact. For the sake of convenience, we will sometimes use *change* in describing outcomes, but our intention is to include all careful measures and evidence of impact.

Now that we have described this framework for impacts, let's look at a concrete example. Imagine that your team has decided to create a project for the public that will have the following impacts on girls: (1) create awareness for STEM careers; (2) strengthen girls' sense of competence in, and identity with, STEM; (3) enhance understanding of specific STEM processes and information in the social sciences; and (4) raise interest in STEM. Each of these outcomes can be categorized in some way using this framework. If you want to

TABLE 1
Frequency and percentage of academic outcomes with impact

	Positive impact (row %)		No impact		Negative impact		Total
Direct academic outcomes							
Science	14	(93)	1	(7)	0	(0)	15
Language arts	8	(72)	3	(27)	0	(0)	11
Math	8	(80)	1	(10)	1	(10)	10
Writing	2	(67)	1	(33)	0	(0)	3
Social studies	1	(100)	0	(0)	0	(0)	1
Subtotal	33	(83)	6	(15)	1	(2)	40
Indirect academic outcomes							
Social development	10	(77)	3	(23)	0	(0)	13
Nutrition knowledge	8	(73)	3	(27)	0	(0)	11
Self-concept	6	(60)	4	(40)	0	(0)	10
Attitude toward academics	9	(100)	0	(0)	0	(0)	9
School bonding	4	(67)	1	(17)	1	(17)	6
Curiosity and wonder	4	(100)	0	(0)	0	(0)	4
Life skills	4	(100)	0	(0)	0	(0)	4
Problem solving	4	(100)	0	(0)	0	(0)	4
Motivation	3	(100)	0	(0)	0	(0)	3
Attendance	0	(0)	2	(100)	0	(0)	2
Discipline	2	(100)	0	(0)	0	(0)	2
Study habits	1	(100)	0	(0)	0	(0)	1
Subtotal	55	(80)	13	(19)	1	(1)	69
Other outcomes							
Attitude toward gardening	14	(100)	0	(0)	0	(0)	14
Environmental empathy	10	(77)	2	(15)	1	(8)	13
Growing food	11	(92)	1	(8)	0	(0)	12
Nutrition attitudes	8	(80)	2	(20)	0	(0)	10
Healthy eating	5	(83)	1	(17)	0	(0)	6

(continued)

Developing intended learning outcomes, indicators & evidences:

Target Audiences	Impact categories	Identified learning outcomes	Possible Evidences

Write your learning outcome statements:
