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Improving Problem-based Learning in Creative Communities Through Effective Group Evaluation

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Improving Problem-based Learning in Creative Communities Through Effective Group Evaluation

Richard E. West, Greg Williams, and David Williams

Abstract

In this case study, we researched one cohort from the Center for Animation, a higher education teaching environment that has successfully fostered group creativity and learning outcomes through problem-based learning. Through live and videotaped observations of the interactions of this community over 18 months, in addition to focused interviews with nine key community leaders, we considered the evaluative culture and actions of this community, and how these evaluative practices improved their creative problem solving. We describe their evaluation practices in the context of principles derived from the Joint Committees' Evaluation Standards (Yarbrough, Shulha, Hopson, & Caruthers, 2011), which are well-respected standards used by professional evaluators. Specifically, we found that problem-based learning strategies were successful in part because the community members (1) established a context and culture of high expectations, collaboration, and evaluation; (2) united the students, teachers, and industry leaders as shared stakeholders in the success of the project; (3) identified early the key criteria for evaluating progress; and (4) asked questions to evaluate progress towards meeting the criteria, using many approaches to gathering information. We discuss the implications for applying these principles to other problem-based learning environments, particularly in higher education, as well as future research.

Keywords: evaluation, creativity, innovation, problem-based learning, communities of innovation, collaborative learning

Introduction

Problem-based learning (PBL) has been shown to be an effective teaching/learning strategy for many kinds of learning (Cheung, 2011), especially for 21st-century learners. PBL emphasizes student-focused learning (Barrows & Tamblyn, 1980) where students are primarily responsible to determine the problems, seek out the answers, evaluate the possible solutions, and revise their views based on various kinds of feedback. Problem-based learning can also teach effective group problem solving and collaborative innovation, skills that are increasingly important in a world where organizations are global, virtual, collaborative, and focused on creative output (West, 2009; Sawyer, 2008). One area of PBL that has received less attention in the research is how to teach problem-based learners to evaluate their progress and learn from their previous efforts. This is peculiar, since self-reflection and group evaluation are key components of effective group problem solving (Bielaczyc & Collins, 2006; Engeström, 1999; Hakkarainen, Palonen, Paavola, & Lehtinen, 2004; Sawyer, 2008) and community-based innovation (West & Hannafin, 2011).

In this article, we report findings from an in-depth case study of a highly acclaimed student community that used predominately PBL and associated evaluation strategies to help students produce award-winning animated films. After reviewing literature on the critical role of evaluation in both PBL and collaborative innovation frameworks, we present and explore several examples of students and faculty using evaluation to enhance PBL learning within an innovative community. We conclude with recommendations for future research and practice.

Literature Review

As early as the 1960s, PBL emerged in the field of medical education as an alternative method of instruction, focused more on knowledge application than acquisition. Barrows and Tamblyn (1980), while instigating this movement towards PBL, clearly outlined its method and definition:

The emphasis is on active acquisition of information and skills by the student, depending on his ability to identify his educational needs, his best manner of learning, his pace of learning, and his ability to evaluate his learning. The teacher is available for guidance as needed until the student gains full independence. (p. 9)

Over the next few decades, PBL scholars developed a focus in the method on five student objectives: (1) constructing an extensive and flexible knowledge base, (2) developing effective problem-solving skills, (3) developing self-directed, lifelong learning skills, (4) becoming effective collaborators, and (5) becoming intrinsically motivated to learn

(Hmelo-Silver, 2004). Savery (2006) extended these objectives by emphasizing that the problem simulations used in problem-based learning must be ill structured and allow for free inquiry; learning should be multidisciplinary and valued in the real world; and there should be frequent self and peer assessment.

Though beginning in medical education, educators in other subjects, ranging from art and design education to media literacy and music teaching, have experimented with PBL and other student-directed methods (Artino, 2008; Sayer et al., 2006; Jones, 2010). Hmelo-Silver (2004) said, "Educators are interested in PBL because of its emphasis on active, transferable learning and its potential for motivating students" (p. 236). Cheung (2011) reported PBL to be a successful approach in nursing, criminal justice, engineering, management, mass communication and marketing, while Artino (2008) noted that PBL methods have been employed in K–12 schools to help teach mathematics and other subjects to young children.

Problem-based learning approaches have been found to also improve the critical skill of creativity in students. Belski (2009), for example, studied the effectiveness of teaching thinking and creative problem solving through the Theory of Inventive Problem Solving approach and found that students perceived the course to be useful, to improve their problem solving skills, and to help them become more systematic and structured in their approach to solving problems. Cheung (2011) looked specifically at how problem-based learning affected creativity in advertising design students over a traditional lecture approach and similarly found that the group participating in PBL exhibited much higher creative flexibility.

As the use of PBL has expanded to these other fields, age groups, and cognitive domains, scholars have found that students and teachers benefit in many ways from the teaching model, though modified and adjusted methods are often needed for specific teaching environments (Grant 2011; Kumar & Kogut, 2006; Kwan, 2008). However, some scholars have remained skeptical, in particular because PBL is a method that is student-based with minimal guidance (Kirschner & Clark, 2006). Responding to this claim, Schmidt, Loyens, Sofie, van Gog, and Paas (2007) defended PBL, contending "that the elements of PBL allow for flexible adaptation of guidance, making this instructional approach potentially more compatible with the manner in which our cognitive structures are organized than the direct-guided instructional approach." (p. 91). Still, there is clearly a need for more research into the roles and strategies of instructor guidance in PBL.

The Role of Evaluation in PBL

We believe one potentially productive research topic in this area of instructor guidance would be to explore efforts by instructors to increase the responsiveness of PBL instruction to learners' needs through continual evaluation. In discussing evaluation,

we mean the continual process of comparing *what is* to *what should be* as defined by both teachers and students in formative and summative ways. Formal summative evaluation of learning is often called assessment; and the evaluation we are studying goes beyond assessment as we want to examine teachers evaluating students but also creating a safe academic community where teachers and students productively and formatively evaluate themselves, each other, their products, and the overall programs in which they are engaged.

Since its inception, PBL advocates have argued that informal/formative evaluation is always present (Barrows & Tamblyn, 1980). Evaluation activities such as decision-making and reflection are key attributes to the PBL process for both students and facilitators (Hmelo-Silver & Barrows, 2006). Indeed, one of the goals of PBL is the development of effective problem solving skills, including the metacognitive skills that involve evaluating whether a goal has been met (Hmelo-Silver, 2004).

Especially, the critical role of the facilitator in PBL involves promoting group evaluation skills. Hmelo-Silver (2004) explained that a PBL facilitator primarily uses questioning to promote self-reflection and evaluation among the students. However, she acknowledged that this technique has been primarily studied with small groups, and that there was uncertainty how to provide this level of facilitation in a group of 25 students or more, as was the case in the group observed for the research reported in the current paper. One possible solution to make facilitation more scalable could be to use peer facilitators in addition to a faculty one. Indeed, Steel, Medder, and Turner (2001) divided 127 second-year medical students into either a faculty-led group or a student-led group and found no difference in their learning. However, students did perceive that the peer-led groups were more efficient, and the researchers observed this could be because the students sometimes took shortcuts in the PBL process. Still, better training of peer facilitators might allow for larger PBL groups to still engage in the process effectively and allow for more opportunities for facilitator-led evaluation.

Despite these examples, research attention to the explicit role of evaluation in PBL seems minimal, with the focus mostly on formal and summative assessment of progress towards learning outcomes (Barrows & Tamblyn, 1980; Bridges & Hallinger, 1995; Hsu, 1999). For example, Belland, French, and Ertmer (2009) reviewed the kinds of assessments PBL scholars used in determining the impact PBL had on various student outcomes from increased self-direction to problem solving to content knowledge. These authors concluded that the research community should “pay full attention to measurement issues as they pursue their research agendas with the goal of producing the most accurate and defensible results possible” (79). However, the focus of this review was strictly on assessment or summative evaluation of the PBL pedagogy, not on formative evaluation conducted during PBL to promote greater learner and growth. There has been a call for

more research on peer assessment in PBL environments (Papincsak & Groves, 2007) but as yet this has not been fully explored.

Evaluation in Creative Problem Solving Groups

Other research disciplines, however, can add insight on the value and nature of peer and self-evaluation in problem solving, particularly in creative problem solving. For example, evaluation and critique (or reflection) have been identified as key elements of collaborative innovation, which may be considered a specific kind of PBL (Sawyer, 2008; West, 2009). For example, some scholars have said that when members of creative communities understand specific criteria they will be evaluated on, they tend to be more creative than when following the more traditional brainstorming model generated by Alex Osborn in the 1950s (Sawyer, 2008). Bielaczyc and Collins (2006) similarly noted, "it is important to engage in systematic reflection about ways to improve processes and products . . . One way is to set out criteria for evaluating a particular piece of work, where the goals are to determine how things might be done better in the future" (p. 43). Another strategy is to foster appropriate critique among students themselves, as well as reflection and self-monitoring. However, critique and reflection, if not done within an atmosphere of psychological safety, can destroy creativity and problem solving (Rogers, 1954). Apparently, evaluation among participants of creative, problem-based learning groups can either water the initial seeds of creative solutions or drown them. Barrows and Tamblyn (1980) added,

Evaluation should be an integral part of the learning process, where it can give the student accurate feedback about his progress and indicate specific learning needs. Since the ultimate goal of self-directed learning is to make it a part of the student's life, the evaluation tools should be designed so that the student may use them himself. (p. 112)

Principles for Improving Evaluation in Education

As Barrows and Tamblyn (1980) explained, evaluation in PBL should be a set of tools that students can apply themselves, and by explicitly teaching students to be evaluative in their practice we might be able to overcome the challenge of how instructors can facilitate large groups, as mentioned by Hmelo-Silver (2004). Several joint committees (e.g., Yarbrough, Shulha, Hopson, & Caruthers, 2011 and Gullickson, 2003) of scholars and practitioners from many educational fields have developed key standards for effective evaluation practices. These standards guide the practice of professional evaluators, but we feel they offer utility as well for educational environments. Because of this, in this study we chose to adapt these well known standards into a set of educational principles so that we could explore their fit for understanding evaluation in a successful PBL environment. We assumed, by

Table 1. Ten evaluation principles based on Joint Committee standards.

Evaluation Principles or Areas to Look for in an Evaluation of High Quality. Does the evaluation:	These Principles Should Guide PBL Evaluations by:	Associated Joint Committee Standards (Yarbrough et. al., 2011)
1. clarify or take into account the historical, cultural, and other context variations in which the evaluation is taking place?	clarifying “what should be” or the criteria against which the chosen evaluands will be evaluated	Contextual Viability Evaluations should recognize, monitor, and balance the cultural and political interests and needs of individuals and groups.
2. involve stakeholders (such as teachers, students, and outside interested persons) by including their values, criteria, and ideas?	according to the values, definitions, and questions of the stakeholders.	Attention to Stakeholders Evaluations should devote attention to the full range of individuals and groups invested in the program and affected by its evaluation.
3. clarify evaluands or things to be evaluated within the educational setting from the perspectives of all relevant stakeholders and in terms of the criteria they value most?		Explicit Program and Context Descriptions Evaluations should document programs and their contexts with appropriate detail and scope for the evaluation purposes.
4. identify criteria and standards the stakeholders value most to use in judging the evaluands chosen?		Explicit Values Evaluations should clarify and specify the individual and cultural values underpinning purposes, processes, and judgments.
5. prioritize stakeholders’ questions so attention is focused on what matters most to all the stakeholders?		Negotiated Purposes Evaluation purposes should be identified and continually negotiated based on the needs of stakeholders.
6. match collection & analysis methods to questions so the information needed to answer those questions is gathered and used in interpreting results and yielding judgments?		Valid Information Evaluation information should serve the intended purposes and support valid interpretations. Reliable Information Evaluation procedures should yield sufficiently dependable and consistent information for the intended uses.

doing this analysis, that if a successful PBL program was actively and appropriately using these principles, other PBL programs might find doing or improving evaluation according to the same principles a worthwhile endeavor.

Table 1 (continued).

7. collect data to answer questions that are credible, trustworthy, and dependable?	identifying “what is” in terms of evaluand performance.	Sound Designs and Analyses Evaluations should employ technically adequate designs and analyses that are appropriate for the evaluation purposes.
8. analyze data to yield evaluation judgments the stakeholders trust and are inclined to use?	comparing “what is” to “what should be” to evaluate the evaluands.	Explicit Evaluation Reasoning Evaluation reasoning leading from information and analyses to findings, interpretations, conclusions, and judgments should be clearly and completely documented.
9. share reports of results and recommendations with stakeholders in ways that facilitate making decisions?	sharing results with stakeholders, who may use them to make decisions	Communication and Reporting Evaluation communications should have adequate scope and guard against misconceptions, biases, distortions, and errors.
10. meta-evaluate throughout every evaluation to raise the quality of evaluation and associated results?	improving the evaluation processes while conducting them and thus improving the evaluands too.	Meta-evaluation. Evaluators should use these and other applicable standards to examine the accountability of the evaluation design, procedures employed, information collected, and outcomes.

We have derived these ten principles for guiding PBL evaluations from the Joint Committee Standards (Yarbrough et. al., 2011, see also Williams & Graham, 2010), which are summarized in Table 1.

As described in Table 1, the Joint Committees repeatedly addressed the need for stakeholders, such as students and instructors, to decide *what should be* (the vision or end goal for their efforts) by clarifying the evaluation context, deciding who the stakeholders are and what they want to evaluate or what the evaluands are, and then articulating criteria for judging those evaluands, questions to guide the investigation, and data gathering methods that fit those questions. As an example, within a PBL environment, instructors may reflect and discuss with all the stakeholders how to meet both the students’ internal and often unspoken evaluands (such as intrinsic motivations and career goals) as well as the explicit outcomes of the course they are teaching.

Before or while clarifying *what should be*, evaluation also involves using the questions and methods to generate data regarding *what is*, analyzing it and interpreting the data in terms of comparing or evaluating “what is” to “what should be.” Findings should

be shared with stakeholders, providing recommendations for action. Throughout all these activities, meta-evaluation, or evaluation of all the evaluation activities and results generated by the participants themselves, as well as interested outsiders, help raise the quality of the evaluations.

In this study, we used these evaluation principles derived from the Joint Committee Standards as analytic lenses for addressing the following research question: How did a collaborative problem-based learning community use evaluation practices to improve the creativity of their final solution?

Method

Research Design and Setting

The research design for this study was a case study approach (Merriam, 1998). The Center for Animation (CFA) is a highly unique educational experiment as a multidisciplinary program at a large university in the Western USA, operating under the direction of three colleges: engineering and technology, fine arts and communication, and physical and mathematical sciences. The CFA draws students from a wide range of backgrounds to participate in projects, including fine arts, computer science, film studies, and music. In contrast to peer programs at other institutions that require students to produce individual films, the CFA teaches animation skills in the context of a group animated short, begun by a cohort of students in their junior year and completed at the end of their senior year. This animation film project is designed to help students develop strong animation portfolios while simultaneously developing the leadership and teamwork attributes considered essential for industry work.

The project begins in December of the students' junior year, after they have completed a course in storytelling. Interested students submit their story ideas and prototype sketches to the faculty, who select several stories they feel would provide enough scope for all the students to create successful portfolio pieces. The authors of the stories then pitch their ideas to their cohort, and the students vote on the film to produce, along with whom they want as director and producer. They then choose their work teams based on their interests (e.g., lighting, graphics, and computer work).

Additional students, some not yet accepted into the CFA, who want to improve their application credentials, and others already in the CFA who are too new in the program (sophomores) or too old (seniors completing their own project, but working on the juniors' project temporarily) to normally be considered part of the project may be asked to join the design team at various points in the average 1.5 years it takes for a project to be completed. Often, these students join the project to improve their design portfolios. Students with specific expertise (such as music students to compose the soundtrack or film students to develop the storyboards) are sought out as needed.

Beginning in January, the different teams and individual designers present their work twice a week in formal evaluation meetings called “dailies,” because they represent what is done daily in professional studios, to the whole group for critique and feedback. The student leaders manage the project, run the dailies, evaluate the quality of their peers’ work, and assign tasks to various teams, all with support from the faculty, who serve as consultants or tutors sharing expertise when requested or needed. The faculty also coordinate opportunities to receive mentoring and evaluation feedback from professional animators from studios such as Pixar, Sony, and Dreamworks.

This approach to teaching animation has been immensely successful in terms of formal industry evaluations, as CFA films have won 12 first place awards from the Academy of Television Arts & Sciences Foundation (the “Student Emmys”) in the last decade while placing many students at the top professional animation studios in the industry. The CFA also is unique in how well it employs a PBL approach, although they do not do so explicitly but rather as a natural part of their implicit teaching strategy. The instructional design of the CFA emerged from the instructors’ experiences working in design fields, where work is collaborative and problem-centered. They applied these ideas to the design of the CFA, without being explicitly trained on PBL principles. Still, the following are examples of how principles of PBL according to Barrows and Tamblyn (1980), as well as Savery (2006) emerged in the CFA environment.

- *Acquisition of information and skills based on students’ abilities to identify educational needs and self-regulate learning.* Graduating CFA students are highly sought after for their animation knowledge, skills, and self-regulation. In the CFA, the students set their own goals for the film, establish their own work patterns, and hold each other accountable, even for course grades. It was also not uncommon for the student leaders to require a “push” for the designers on a Saturday or evening to push through major designs in order to meet their deadlines, and for the student leaders to work alongside their peers or show up to provide mentoring and guidance, even on tasks that were not directly assigned to them. In the end, the students’ main goal of submitting a video to the Student Emmy competition created their own deadline, as it was not required by the CFA program; and so they evaluated and regulated their own progress toward this goal.
- *Instructor guidance provided as needed.* The instructors attended design critique/evaluation meetings to listen to students report progress, but their critiques and instruction focused on giving students options and opinions, and allowing them to choose their own directions through self and peer evaluation. When challenges arose, the instructors allowed the student leaders to make decisions, and asked how they could facilitate support for overcoming the challenges. For example,

when a server crashed near the final deadline, losing many weeks of work, the instructors found additional financial resources for hiring key student designers so they could quit their other jobs and work additional hours on the project.

- *The problems must be ill-structured and allow for free inquiry.* There are no correct answers in the CFA, as the goal is to simply produce the most entertaining animated film possible. While the instructors reviewed all student pitches for film possibilities and ultimately selected six for consideration, they left the final choice up to the students, as well as the majority of design decisions along the way. Thus, the ultimate film was really a result of the students' vision, creativity, and ongoing evaluations for developing their project.
- *Learning should be integrated from a wide range of disciplines or subjects.* Students from many departments and cohorts assist on each film, allowing for a wide diversity of ideas, perspectives, and skill sets. In our observations, we noted students with computer science, graphic design, music, and film experience all assisting on the project. Even one of the instructors often worked side-by-side with the students in the lab as one of their mentors but also a peer designer. The CFA director also brokered opportunities with outside mentors from professional design studios to come in and spend a day at a time working with the students.
- *The activities carried out in problem-based learning must be those valued in the real world.* Using the Emmy competition as an end goal encourages students to focus on creating films valued by others. This allows the students to focus on not only their portfolios, but also creating an entertaining film for a real audience.
- *Self and peer assessment.* Students are typically asked to assign themselves grades based on their perceptions of their contributions to the film and their diligence in meeting the deadlines put forward by the student leaders. These self grades are reviewed by their student leaders, and if they agree with the grade, they submit it to the instructors who have final authority but often heed the opinions of the student leaders. At dailies, students formatively evaluate their own work in front of peers by discussing what they think are the strengths and weaknesses of their work, while peers provide additional feedback for improvement and congratulations.

Participants

In this study, we observed one cohort as they worked on their animated film for a year and a half. While there was a core of student leaders (13) that remained constant, 60 students eventually worked on the film, assisted mostly by four instructors. For our study we purposively sampled key faculty and student leaders in this community, including the faculty

director of the CFA; two key professors involved in the CFA; and the student producer, directors, and the animation and lighting team leads. We sampled these participants because of their roles within the CFA and this film specifically. In doing so, we recognize our sample for the interviews only included males, which in part reflects the high ratio of males in the program (46 of the 60 students involved were male, and 12 of the 13 student leaders). However, future research should additionally look at the role gender may play in these evaluative situations. Those participants highlighted in this paper included (all names have been changed):

- Brad, the student director, was also a co-author of the original story. Brad's personality was naturally gregarious and friendly, and he had a deep passion for the film's success. Because of this, and especially after Jordan left for an employment opportunity, Brad's enthusiasm propelled the project as he managed most aspects of the creative vision for the film. Brad and Jordan, below, were selected for interviews because of their roles as the co-authors of the story and as the main student leaders.
- Jordan, the student producer and co-author of the original story, also created and developed one of the animated characters from beginning to end. Jordan was more reserved and reflective than Brad, and complemented him well early on by helping him understand the benefit of listening to other's viewpoints on changing the original story. A skilled animator, he eventually left school early to work for a professional studio.
- Brian, one of the original creators of the CFA, was the main faculty member on the project. Brian's background was architecture, leading him even more to take a hands-off, consulting approach to the CFA. In interviews, Brian described his role as mostly moderating the relationships and personalities within the CFA and brokering financial and networking resources to assist the students, although he did observe most dailies and offered his feedback when he felt it was important. Brian, Kirk, and Ron were selected for interviews because they are three of the main faculty interacting with students on the project.
- Kirk, a co-creator of the CFA with Brian and a faculty member, oversaw the beginning stages of the story and other general production aspects of the student film. Kirk's background was as an animator for a major studio, and his participation was more hands-on in helping the students develop the story.
- Ron, a faculty member, spent time helping the students with artistic issues and creating his own art for Hollywood studios. Ron did not often attend dailies, but served as a mentor as needed and taught some of the animation courses.
- Eric, a younger student without any major leadership role, was responsible for developing the wood objects for a critical scene. We highlight Eric as one example of the interactions between the student leaders and peers with an individual

student's work. While others could have been chosen, Eric's experience, detailed in this report, was a good representation of the themes we found in the data.

- Professional mentors also visited the CFA to offer external evaluation feedback. During the project, guests from Pixar, Dreamworks, Sony, and other major design studios came to visit the CFA and interview students for employment. During their visit, they observed one of the dailies and offered feedback on the project, and often worked side-by-side with the students in the lab giving expertise on specific design skills and techniques. The data from these visits informed our observations of the CFA but were not formally analyzed for this particular paper.
- Other students, like Eric, contributed to various aspects of the project, but are not highlighted in this report.

Data Collection

Data consisted of videotaped recordings of student and faculty interactions in weekly project meetings held for over a year and a half. In addition, we conducted nine formal interviews with three faculty members and six students, as well as many informal interviews with students and instructors in their studio. As described above, we focused on the experiences of Brad and Jordan as student leaders of this group and Eric as a representative case of the kinds of findings we saw in the data. In total, we collected over 100 hours of recorded data, although only a small portion was selected for discussion in this paper to best represent the evaluation principles CFA personnel use throughout their teaching and learning processes.

Data Analysis

We utilized HyperResearch to help reduce and analyze the data in their original video form, allowing us to code not only the words but also nonverbal communication. We followed suggestions from Spradley (1979) to conduct domain, taxonomic, componential, and theme analyses. We first reduced the data by coding for domains related to moments of evaluation, reflection, or critique and organized these into taxonomies. We then re-analyzed these domains, looking for dimensions of contrast and themes, and reviewed the data for key moments and narratives from the transcripts that addressed the ten principles for educational evaluation. Throughout this process, we attempted to deductively look for examples of the evaluation principles in the data, as well as inductively understand emerging themes that could be important to understanding how participants use evaluation within this context and how others might benefit from that understanding.

Trustworthiness and Precautions

In order to establish greater trust in our results, we followed Lincoln and Guba's (1984) guidelines for establishing credibility, such as triangulating our data analyses by comparing

findings across many observations and interviews. In addition, we used member checking to establish the veracity of the narratives and quotes, and used peer debriefings to check our assumptions and findings with other scholars familiar with the setting.

Findings

We discuss our findings in the context of the 10 evaluation principles outlined earlier, emphasizing primarily the first five due to space constraints and because these principles establish the foundation for community-based evaluations by creating unified evaluative purposes, criteria, questions, and culture. These principles were at play continuously and simultaneously in the experiences of these students and faculty. To provide some structure around which to organize the discussion of their evaluations, we have organized the vignettes, quotes, and interpretations of those experiences into these sections: (1) the context/background elements, (2) how key stakeholders collaborated to define common visions, (3) the stakeholders' emerging criteria for judging those evaluands, (4) evaluative questioning, and (5) a summary of how stakeholders used these principles to continually push evaluation processes.

Context/Background Elements that Established Setting and Purpose (Principle 1)

This section highlights the importance of setting and purpose as key elements that made up this educational evaluation context (Principle 1 from Figure 1). The setting for the CFA mirrors that of industry by having students work in an interdisciplinary studio environment, with a lab and a viewing room, where they regularly critiqued one another's work. Ron explained the unique setting of the program, which was conducive to cross-disciplinary evaluation: "Not many schools re-create this kind of studio environment with their students, and a lot of it is due to the collaborative nature of [our] animation program and the fact that students have resources in the visual arts, theater and media arts, and in the college of engineering."

The physical setting of the program encouraged the students to follow the real-world industry model of participants, with different interests or criteria, evaluating one another's work continually. The student leaders worked with the other students on a daily basis in the lab and bi-weekly in the "dailies," or formal critique meetings. The collaborative setting of the program was heavily emphasized in the CFA. "It takes a lot of work," said Kirk, ". . . [and] it can be pretty challenging for the students to kind of figure out how to compromise." CFA members reported needing to remain open to the ideas or evaluative criteria of others. Brian explained:

It is that collaborative, interdisciplinary . . . big group project. . . . So I [want to] turn out a student that is a problem solver, that has mutual respect for a lot of people, [each] with a different background, different passion [and values] who

can learn how to compromise. The students love the collaborative nature. And I think the reason why they love it so much is because the faculty emphasize that this is exactly what they will be doing in the industry.

Understanding the purpose and culture of the program was important to the faculty members, and essential for incoming students to understand. Ron expounded further on the purpose that pervades the context of the CFA:

They know what the expectations are in industry, they know what kind of portfolio they have to have, and so their mindset is that they are going to do everything they can to become competitive, so that when they graduate, their senior film shows their best work.

Even before students were accepted into the CFA, they had to prove to the faculty that they understood and accepted the evaluative context of the program. A student who was planning on applying to the CFA said faculty encouraged interested students to begin helping with a film,

so you can get to know the students and faculty. They can look at your [application] portfolio and know not that you can just draw, but that you can work, and work in a team. There [are] probably 10 of us [pre-major students] working on this [film].

Thus, when students were formally admitted to the CFA, they already knew what was expected. The students knew that it was very competitive, that they would have to work hard, and that they would have to be fully dedicated. By working on the group project, students knew about critique meetings and the kinds of evaluation conducted in the CFA. The education environment was carefully crafted so students understood the criteria they would be expected to meet both in the CFA and afterwards in their employment, and that they had responsibility for self-evaluation, as well as collaborative learning and group evaluation to help make everyone else better.

Stakeholders Identifying and Evaluating Shared Evaluands (Principles 2 & 3)

In evaluation practice, acknowledging the needs of all stakeholders is critical. In the CFA case, there were four primary groups of stakeholders: students, student leaders, instructors, and visiting professionals. Below is an example of a typical visit of professional animators to the CFA that illustrates how these stakeholders collaborated to use evaluation principles to accomplish the unified goal of producing a high quality film.

Before a visitor arrived for one visit, Brian exhorted the students to ask questions of the guest: "Don't panic about all the suggestions [they] give you, we will talk about

it [later] and decide what we can work with and what we will have to discard. This is your story, not [theirs], *but* we are going to try and incorporate the good things from [their] suggestions.”

Brian explained they *must* listen to every single thing they are told, and not try and prove why they are right and the visitors are wrong. “If you are talking, you are not learning. You want to ask, ask, ask. Find out what is wrong with your film. Even if you don’t do what [they are] suggesting, you can at least look at your film to see if you can change something.”

When the industry visitors arrived and sat with the students in the viewing room, Brian introduced some of the student leaders to the professionals and then explained the day’s activities: “This is kind of our regular ‘dailies’ kind of thing, we are going to show where we are on the film, see what we have done in the past week, make sure things are ok. Any time you have a comment or question, don’t hesitate to ask because you are our target audience on the film. If things aren’t looking right, if they aren’t making sense to you, we want to know now, not later. You are a big help to this process.”

The students displayed their project on the screen, explaining different parts of the project to the professionals. One professional, Gina, paused the project to make a comment about a character in the film who was training for a boxing match.

Gina: Can you stop that for a second? Ok this is going to date me, but [for this training sequence] they *have* to run up steps. *Rocky!*

(Everyone laughs)

Gina: He’s got to run up steps! With a big triumphant cheer at the top.

Brad: (laughing): Yeah, that actually would be pretty great.

Student 1: Yeah he could be like, lugging a medicine ball. (Brad laughs)

Susan (another visiting professional): Oh yeah, did you hear that? You could have him run up and kind of not be able to make it and fall at the top—

Student 2: Trips . . . (more laughing). Yeah we were trying to get a quick transition, you know, no zooms or slow motion. But, you probably didn’t get that from watching this.

Gina: You’ll get there. That transition is a little rough but you will get there.

As the session ended Brian summarized the timetable the students were working on while the professionals praised the students and their work and the student leaders meta-evaluated their own evaluations of the emerging product and invited the professionals to evaluate them further.

Gina: It looks really, really good you guys. I am really impressed.

Susan: You guys have done *a lot* of work.

Brad: So our end goal—is to finish everything by this December. That way—we can . . .

Eric: Get jobs at (Gina's company)!

(Laughter)

Brad: Well and that way we just have that last semester so we can really focus and make sure our demo reels are what they should be, cause we have stuff we could show you now, but if you come back we want you to be able to see the best of what we got.

Gina: Right, of course. That is a great plan.

Brad: Anything else that you would suggest? Changes, fixes, things you don't like?

Susan: You know, nothing that comes to mind.

Brad: Well if you think of anything, *please* let us know.

Later Jordan meta-evaluated the influence of the visiting professionals' formative evaluations of their emerging film:

What they usually do, is they come in and watch it and say, 'ok, this is really good, but this could be better. This shot is too boring, or this shot is too slow, or I am not understanding what is going on here,' and stuff like that. So they just offer little bits of info like 'what if you could do this' and we take what they say and push it into our story, and it really helps a lot.

As mentioned earlier, four categories of stakeholders appeared in the data: students, student-leaders, instructors, and visiting professionals. Each stakeholder group displayed a unique ability to focus on the student film as the central evaluand, while implying evaluations of the students, their skills/portfolios, and the CFA process. The student groups held the largest share in the CFA, and the large group project was of great importance to them. The students knew the importance of the project, and what it meant for them in getting a job with a solid company. Thus, everything the students did in the CFA revolved around the evaluands of the film and their evolving portfolios associated with creation of the film. This helped them to be teachable and expand their own evaluation and group creativity skills as they considered the evaluative feedback given by the visiting professionals.

Brian considered this perspective to be different from other programs. He explained an experience he'd had:

The CEO of Dreamworks ripped on other professors at a conference for not having their students work together on a big project like [we do]. He said, "Animation is a team sport. You are training the next generation of prima donnas. If you don't teach people how to work as a team then we will not keep hiring from your programs."

The CFA students understood the importance of the group film, and were willing to supplant other evaluands, such as ego or their own personal film ideas that they could have developed separately, in order to help make the group film successful.

The teachers had less of a stake than the students in the senior film project and in the students getting good jobs, however they still maintained a strong interest in the success of both. The industry professionals evaluated the CFA very positively, and like the students and faculty, they considered the student film to be their own primary evaluand, with the students, their portfolios, and the CFA itself as important secondary evaluands. Brian explained the role the student film had in helping students learn to work together and be more employable, something employers noticed and valued.

Most studios, when they call me about students they are hiring, never ask about technical skills, knowledge, or creativity. They can see that in the portfolio. It is always work ethic, reliability, honesty, and can they get along with others. They know I know that, and they can't even ask other professors from other programs 'cause they don't know if they work in a team.

Gina and Susan clearly enjoyed observing and recruiting at the CFA. Other professionals also came as mentors. Speaking on campus, the President of Pixar, Ed Catmull gave his evaluation of the program, mentioning the CFA's attention to self-evaluation: "[They

have] an extraordinary program here. They pay a lot of attention to what is going on in the areas of the entertainment industry, listen carefully, [are] smart about what they do, and the students are really good that are coming out of here" (Penrod & Jeppesen, 2008).

Because all of these disparate stakeholders shared interests in the same evaluand of the student-directed film project, they had a united purpose, making evaluation efforts more effective.

Criteria (Principle 4)

The criteria by which the stakeholders evaluate are often varied in educational settings. However, the nature of the animation industry, and thus of the CFA, was to begin a project by agreeing on a design language, or set of principles or decisions made about the style guidelines and frameworks to unify the look of the film. For example, in the project we studied, the students were aiming for deep greens, celtic circles and roundness, and a depression era atmosphere. The next vignette begins with instruction about design language from Brian and is followed by the student producer's criteria for the film as he talked about some of the elements of the project's design language.

After sharing examples of design languages at places like Apple, BMW, and another student's film, Brian encouraged:

So you have got to decide, what is the design language of this film? And if you can verbalize it, then you have got something in context that everyone now can follow and everyone now has a direction. And now you can say 'well [that] doesn't quite work because . . . this is our design language.' It really, really helps. . . . You need to be able to say, 'it needs to be blue for these reasons.' And then a person that likes red says, 'I like red.' And you win every time . . . so if you can verbalize why something should be a certain way you can save so much arguing and so much hurt feelings."

Jordan later commented on several key criteria that influenced the making of this film: "Brad had the original idea of making a story about a boxer in the depression era and [to] make it a lot like *City Lights*, a Charlie Chaplin film. But he wanted it to be fun, slapstick, and use a lot of Guy Ritchie's stuff, who's got really modern camera work. . . . But yeah, it was just him and I meeting when we could, talking about it. Watching movies and inspirations for it."

A small exchange in one of the student meetings illustrated the importance of establishing a design language and the process of evaluation that students engaged in continually throughout the process of making this film. Ty, one of the students, had been working on a chandelier (see Figure 1), which was displayed on the screen to be critiqued:

Jordan: It looks really nice, but—just to use an example, it is not very pushed. Like, it looks perfect.

Brad: And that's the problem.

Jordan: And it doesn't fit with our style very much. It looks great, don't get me wrong Ty, but it is just not pushed, it's not the style that we need or what we are going for. It doesn't have the offset realism or the imbalanced rectangularity.

Brad: Yeah, because these chains are a bit too regular. I actually really like the look of the chain Jocelyn did and so push yours to look more like that. And again, these are too perfectly spherical, so just warp them a bit. Everyone has access in their group's folder, to the style guide that (the graphics lead) set up, and so for every model we need to look at that shade language.



Figure 1. Chandelier model.

Establishing a design language was a unique way for the students and teachers to agree on the film's aesthetic and technical criteria. Because the stakeholders shared a strong interest in the project, criteria for how to determine the value of the student film were proposed early and discussed throughout the process. Students constantly checked on one another, evaluated each other's work, and posted references on the walls, while the faculty and visiting professionals pointed out areas of concern and acted as guideposts to the original vision. This shared criteria enabled all the stakeholders to evaluate the student film quickly and efficiently, thus maximizing the impact of the PBL environment by uniting the stakeholders in a common vision of *what should be*.

Evaluation Questions (Principle 5)

The fifth evaluation principle emphasizes asking questions that answer how well the evaluand is meeting the criteria. In the CFA environment students frequently had to discover what questions would lead to the most accurate solutions, both in the building of the film and in organizing each other to create the project. With the film as the key evaluand, and the criteria for the project being the design language, many different evaluation ques-

tions were raised. The instructors had experience in knowing what questions would lead to sound evaluation in making a movie and used questioning to lead students to evaluate their progress and discover solutions without getting too far off course. One student said:

I think they just allow us the flexibility to experiment and lead for ourselves. They never really give us any straight answers on how to do something. They always just sit back and ask questions [such as] “Well if you were given this situation, how would you do this?” And then they give us the tools on how to do it and just say go for it.

By having such an ill-structured problem-solving setting, students learned to take more responsibility for their learning and generate and evaluate their own creative ideas.

In addition to the guidance of instructors, team leaders had significant roles in asking questions that would lead to successful evaluation and problem solving processes. As mentioned earlier, students met during *dailies* to critique each other’s work, both as a whole group and as leaders of smaller student teams. Brad explained:

Generally what would happen is that we would meet as a group very briefly, then Jordan, myself, and then the team leads like our art director, our lighting director, our texture lead, and our technical director, would stay in the room while everyone else left. And we [would] have a big screen on which to review artwork textures, lighting, all of those things. And we would just review them individually and go over [them] with each lead person, “Okay, this is what you are responsible for. These are your deadlines; are they being met? What can we do to help facilitate that?” or “This is where we are, why aren’t we further along? Why aren’t we here? What can we do to get there? What can we do to facilitate your needs and make sure that our deadlines can get met also?”

Finding the best questions for determining whether the evaluand was meeting the criteria was ultimately the students’ responsibility. The professors acted as meta-evaluative tutors or guides, using Socratic methods to help the students find the best evaluation questions, which in turn resulted in positive solutions and evaluation and creativity skills developed by the students.

Summary of CFA Evaluation Process

As indicated throughout the previous sections, the remaining five evaluation principles (picking methods to answer questions, data collection and analysis, making the evaluation by comparing what is to what should be, reporting and recommending action, and meta-evaluations of primary evaluations) often took place simultaneously with or in response to the principles already illustrated. The vignettes shared in this article make it clear that this

very successful collaborative PBL program used all the evaluation principles to create an environment where students were empowered to use and act upon informal evaluation to learn the necessary creativity, teamwork, and technical skills.

To summarize the process we observed and believe to be key to the success of this PBL program, first the faculty, previous student groups, and current student leaders helped set the evaluative context by creating high expectations for what it would take to get into the program and succeed. They invited freshmen and sophomores who wanted to become part of the program to begin evaluating themselves through apprenticeship-like participation on the team while the current students and faculty evaluated themselves and these “applicants.” They created a set of courses and instructional arrangements that simulate the filmmaking industry and established industry-level criteria and standards for products, processes, and participation. These included many opportunities such as regular meetings and visits from professionals to invite critique, feedback, review, reflection and other forms of evaluation.

Second, throughout all these processes the faculty and students joined in defining whom the key and secondary stakeholders were, ranging from themselves to potential employers. They spent great effort developing appropriate relationships among these participants, so all relevant stakeholders could voice their views openly and often.

Third, the CFA discussed their definitions of the evaluands they cared about and their associated criteria and developed a shared vision among all stakeholders.

Fourth, daily evaluations involved data gathering and analysis through listening, watching, asking, thinking, and discussing the many evaluands that combined to produce the film product and the students’ portfolios, as well as the future of this program. As these data were gathered and interpreted, the stakeholders reached evaluative conclusions by comparing what they were learning about the current status of the project to their ideals. Their evaluations usually yielded evaluative conclusions about quality that led to formative and summative recommendations to improve, retain, or eliminate many minor evaluands as building blocks for the final project and the students’ portfolios. Repeated and continuous evaluations that adjusted to the changing nature of the evaluands, in what Patton (2011) calls a Developmental Evaluation process, constituted this creative and PBL environment.

Finally, stakeholders continually engaged in meta-evaluations, or evaluations of the evaluations. Collaboration among faculty, student leaders, other students, and professional consultants consisted mainly of these self and invited critiques of how well each stakeholder was evaluating their shared evaluands against their shared criteria. Combining all 10 elements into these continuous evaluations and meta-evaluations was key to this PBL and creativity teaching and learning program.

Conclusions

This study suggests that a main reason for the success of the Center for Animation is the effective evaluation practices fostered in this environment. We have attempted to describe these practices in the context of principles derived from the Joint Committees' Evaluation Standards (Yarbrough et al., 2011). Because this was a case study of one cohort, of one program at one university, future research should replicate this work in other successful and creative PBL environments. However, based on the research presented here, we propose that creative problem solving communities can better reach their full potential by adopting the following successful evaluation practices seen in the CFA.

First, establish a context and culture of high expectations, collaboration, and evaluation. In particular, the setting should be authentic (approximating industry settings) and collaborative. Herrington and Herrington (2008) wrote that in designing authentic higher education experiences, cognitive authenticity is more important than physical authenticity. Thus, in the setting for this study, the physical setting was a computer lab not unlike many others, but cognitively, the students were experiencing something very unique in that they were producing a film with all of the various components of professional animation films, except their film was shorter. In addition, they formed the same teams, with the same daily evaluation practices that industry utilizes. This authenticity led to higher expectations for the quality of work, and these expectations can improve learning by helping students feel challenged and motivated to excel, and by increasing their willingness to earnestly seek feedback on their work in order to meet expectations, particularly if they see their professors working to help them succeed. In other domains, we would expect similar benefits from striving to create environments and tasks where students engage in work that approximates those done in their model industry. Studio-based instruction (Brandt et al., 2013) is one compelling way to accomplish this in many design or problem-centered fields.

Second, unite the students, teachers, and industry leaders as shared stakeholders in the success of the project. Setting aside personal agendas and uniting in a shared vision of what the target goals are can assist members of the community in collaboratively evaluating their progress towards that final goal. In the CFA, all the stakeholders focused on helping the students develop a successful, Emmy-winning film, knowing that if they achieved this goal, they would also achieve their individual goals as well. This is similar to how the Stanford d.School involves industry leaders as teaching collaborators (see "Radical Collaboration" on <http://dschool.stanford.edu/our-point-of-view/>). Establishing these collaborations is not easy, but we are exploring doing this in other areas on campus by finding ways to involve industry in sharing their knowledge, while in return providing products and students of value to them.

Third, identify key criteria, agreed upon by everyone in the group, for evaluating progress. CFA instructors emphasized developing a style guide of predetermined deci-

sions. Similarly, Gibbons and Brewer (2005) have argued that it is critical for designers to understand and make clear their design languages. With the CFA, this made evaluation easier, especially for novices such as the students, and it served as a form of scaffolded instruction. We recommend spending the first group sessions focused specifically on clarifying the goals of the group, timeline, and criteria for success. While industry leaders and instructors may offer suggestions, ultimately these decisions on criteria must come from the students, as they did with the CFA. Agreeing on these evaluation criteria early can be time consuming, but in the case of the CFA, it paid strong benefits later.

Finally, ask questions to evaluate progress towards meeting the criteria, using many approaches to gathering information and leading to recommendations for action. Key to the success of the CFA were the weekly meetings where students questioned each other's progress, as well as the design decisions of their student directors and producers, in an atmosphere of safe critique and feedback. Previous research has found that critique and evaluative questioning, in an atmosphere of psychological safety (Rogers, 1954) can not only improve the learning of the one being critiqued, but also the one giving the critique (West & Hannafin, 2011). Developing this culture of safety and questioning is difficult, but can be accomplished with informal socializing (in the CFA, they often had pizza or other social events), and an environment where failure is not destructive to the individual, but rather a challenge that the group must overcome. In particular, skillful questioning by the instructors helped the students to better judge for themselves their progress, helping them to develop autonomy that improved their film as well as their self-improvement skills.

Perhaps the most important lesson learned was the importance of instructors emphasizing the value of continual evaluation. As the director of the CFA explained, "I expect them to know how to self-evaluate and to exercise that knowledge." This culture of evaluation was passed from instructors to student leaders, who in turn were responsible for creating this culture among the student groups. In doing so, the CFA not only produced quality animators, but also quality facilitators of creative groups—definitely a marketable 21st-century skill.

Future Research

While the findings from this study provide many valuable insights, future research could improve upon this study in several ways. First, specific exploration of how the last five principles for effective educational evaluation (Williams & Graham, 2010) derived from the Joint Committee Standards (Yarbrough et. al., 2011) are experienced in effective creative problem-solving groups would be useful. Second, it is important to replicate this study in additional contexts, particularly ones with greater gender and ethnic diversity to see whether the evaluative climate and practices can be maintained without intimidating and silencing some voices. Third, this study looked at general principles, and additional research could look more specifically at instructor, and then also student, practices to

implement these principles effectively in varied contexts. Fourth, there is currently a great divide between the theory of constructivist and studio-based learning that facilitates creative problem solving, and the ability to actually implement these theories in practice in current educational systems. Additional research and theory is needed to help transition willing teachers and institutions to models of learning that can support the kinds of creative problem solving described in this paper.

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