Students' Perceptions, Faculty Intentions, and Classroom Implementations in First-Year Project-Based Learning Courses

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Project-Based Learning (PjBL) has been shown to be an effective method to enhance student learning, particularly in science and engineering (S&E) fields. However, the implementation of a PjBL environment plays the deciding role in the students' interest and learning outcomes. This paper presents a comparative study of two PjBL courses, Physics Laboratory and Engineering Design, which have similar intended goals and features but different implementation related to self-direction and student autonomy. Classroom observations and interviews with both students and faculty are analyzed using Grounded Theory. Stefanou et al.'s framework of autonomy support within the PjBL paradigm is identified as a data source and is then used to analyze both courses. We further discuss the implications of the course goal implementations on student interest and affect, and argue for a more comprehensive PjBL model in introductory college-level S&E courses.

Keywords: Project-based learning, first year, engineering education, physics, mathematics, grounded theory, instructor support, course scaffolding, student autonomy, Stefanou

Inspired by low retention rates in science, technology, engineering, and mathematics (STEM) fields, there has been much recent curricular innovation aiming to increase OR targeting student engagement within their first year courses (Committee on Prospering in the Global Economy of the 21st Century, 2007). Project Based Learning (PjBL) is one such innovation that has been shown to increase student participation, interest, and performance within the classroom (Ströbel and van Barneveld, 2009; Thomas, 2000). For the purpose of this paper, we use the combined frameworks of Blumenfeld *et al.* (1991), Heitmann (1996), Morgan (1996), and Perrenet *et al.* (2000) to define PjBL: PjBL places emphasis on the application of knowledge and skills through one or more overarching projects, which span multiple class periods, often address real-world problems and are likely to have an interdisciplinary component and a group work orientation. To encourage student engagement in and ownership of the learning process, faculty act as guides, supporting acquisition of content knowledge and providing project scaffolding, while students exercise autonomy by carrying out independent open-ended projects. Students participating in projects create one or more significant tangible deliverables, often derived from the scaffolding provided by the faculty, intended to reflect the knowledge and skills gained through the project work (Blumenfeld *et al.*, 1991; Heitmann, 1996; Morgan, 1996; Perrenet *et al.*, 2000).

PjBL has been used in many STEM classrooms, and is shown to increase student engagement within the course; however, the success of a PjBL classroom is not guaranteed and instead depends on how PjBL is implemented within the course (Blumenfeld *et al.*, 1991; Heitmann, 1996; Morgan, 1996; Perrenet *et al.*, 2000; Ströbel and van Barneveld, 2009; Thomas, 2000; Zastavker, *et al.*, 2007). A greater understanding

of how PjBL affects students will improve the overall success of PjBL classrooms. Additionally, it is necessary to investigate how faculty implement PjBL within the classroom to confirm that course implementations align with PjBL course goals.

In this paper, we are investigating three specific aspects of PjBL: course scaffolding, instructor support, and student autonomy. In order to ground this study in a theoretical framework, we use Stefanou's framework of autonomy support (Stefanou *et al.*, 2004). Stefanou proposes that student autonomy support can be described at three different levels: organizational, which allows students decision making roles in classroom management issues, procedural, which allows students the opportunity to use different media to present ideas, and cognitive, which allows students to evaluate work from a self-referent standard. Using Stefanou's framework, this paper examines how students' perceptions of PjBL course differ from faculty intentions and classroom implementations in their physics and engineering courses. We investigate two different introductory physics and engineering courses and discuss the implications of course implementation on student interest and affect.

Methodology

The study site investigated is a small, technical, undergraduate institute, and is not Olin College. The institution employs project based learning strategies throughout its curriculum, with a large focus on hands-on work, a strong technical core, and collaborative and interdisciplinary learning.

We used data from a larger, mixed-methods, multi-site study. While only qualitative data was used for this analysis, quantitative survey data, results, and analysis can be found in the appendix. The study is based on classroom observations and student and faculty interviews. The twelve students, six male and six female, that were interviewed were chosen via purposive sampling: all students were enrolled in the same introductory math, physics, and engineering courses, and were matched for performance levels, selecting four students in each of the high, middle, and low performance groups, as described by their teaching faculty (Patton, 1990; Trost, 1986). Three faculty were also interviewed: two Engineering faculty and one Physics faculty. All interviews were conducted by an open-ended, in-depth interview protocol; each interview lasted approximately one hour. Classroom observations were conducted for four *Engineering Design* sessions and one *Physics Lab* session. External observers recorded general observations and specific observations grouped into nine categories: context of the course, application of knowledge, application of disciplinary knowledge, integration, hands-on, self-direction, tasks, gender issues, and classroom environment.

Grounded theory was used to analyze the qualitative data (Corbin & Strauss, 2008). Interviews were coded using a codebook created to identify aspects of PjBL and the connection between faculty and students. Thematic memos were written, particularly for classroom observations, and the data was then organized into matrices based on themes that appeared in the codes and memos. Three main emergent themes were identified: course scaffolding, instructor support, and student autonomy. We performed a literature search, and used the results as a data set in accordance with Maxell's method, to apply our findings to a broader context (Maxwell, 2005). We identified Stefanou as a data source and applied their framework of autonomy support to both *Engineering Design* and *Physics Lab*.

Analytical validity was performed through several different methods. Intercoder reliability with Emily Towers was established, resulting in an intercoder reliability rate of 86% for the student interviews, as well as investigator triangulation. Pattern matching was performed for each interview. Peer review was used, receiving feedback from both the larger research group associated with this project and the peer group in AHS Capstone.

The two courses under investigation, *Physics Lab* and *Engineering Design*, are taken concurrently during the second semester of the first year for all engineering majors.

- *Physics Lab*: In this course, students perform table-top experiments to demonstrate the physical concept behind topics introduced in a co-requisite Physics Lecture course. The basic principles of mechanics, i.e., linear and rotational dynamics, oscillations, and waves are covered. Students work in groups of two on labs that generally span one or two class periods. Each lab requires open-ended experimental design, data collection, and analysis to be performed both within and outside the classroom. This course attempts to achieve its goals of open-ended experimental design by providing students with an initial problem statement and minimal guidance to facilitate student flexibility and independence. Assessment is based on written laboratory reports, which the students refer to as "tech reports".
- *Engineering Design*: In this course, students are introduced to the basics of the design process through three multi-week projects, which become progressively longer in duration. Students complete each project in teams of two to six students. In the final project, each team is responsible for designing a product, which often has social relevance, to satisfy an external client's specifications. Lectures and reading on design theory and methods, project management techniques, and engineering ethics supplement the project work and provide background for the tasks. As a part of the assessment, students meet weekly with the multiple faculty co-teaching the course. They are assessed based on the design process, intermediate deliverables produced throughout the project, and on the final deliverable. In this course, students tackle semi-structured, open-ended problems with close instructor guidance throughout the course.

Results and Analysis

Despite the similarities within the two courses, students perceive *Physics Lab* and *Engineering Design* quite differently. The general student opinion of *Physics Lab* is that it hated, as shown by the student quote: "*I absolutely hate Physics Lab.*" (Loretta). Student will express frustration towards Physics Lab, so much frustration that they not only dislike the class, but say that they do not like the subject of Physics anymore and have changed their mind about majoring in Physics. However, *Engineering Design* is seen quite favorably. It is a well-liked course, as illustrated by the student quote: "*It's been my favorite class.*" (Isabelle). The students responded quite positively towards Engineering Design, which in turn increases their interest towards the course and the greater subject material. However, both courses are quite similar when looking at intended student learning objectives and implementation (Table 1).

	Physics Laboratory	Engineering Design

Content	Tabletop experiments illustrative of basic principles of mechanics: linear/rotational dynamics, waves and oscillations	Design theory and methods, project management techniques and engineering ethics
Professional Skills	Methods and practice of physical measurement and scientific hypothesis testing	Methods and practice of engineering design process
Application of Knowledge and Skills	Application of theoretical knowledge and mathematical concepts for solving mechanics problems	Application of techniques for solving design problems and knowledge from mathematics and physics
Duration	~ 2 weeks	2 – 6 weeks
Context	Problems posed by nature from mechanics and kinematics	Problems posed by not-for-profit clients
Open-ended aspects	Experimental process and analysis	Design process and deliverable
Hands-on Environment	laboratory experiments	Design projects
End Product	Written and oral reports	Working prototypes, written and oral reports
Group Work	2 students	2 – 6 students
Instructor Support	Instructor-student meetings on "as needed" basis	Regular instructor-student meetings for guidance
Process Transparency	scientific /experimental process followed in all work but not presented in class	design process followed in all work and presented in class
Student Autonomy	Students choose the experimental procedure and analytical tools necessary for a deliverable	Students choose design process and a deliverable

Table 1: *Physics Laboratory* and *Engineering Design* Course Descriptions Analyzed within PjBL Paradigm

The slight different in course implementation requires further exploration. In this study, we investigated three different aspects of PjBL: course scaffolding, instructor support, and student autonomy.

Course Scaffolding

Course scaffolding is an interactive process that both faculty and students actively engage in to promote learning (van de Pol, 2010). Student perceptions of course scaffolding for *Physics Lab* and *Engineering Design* are quite different. In *Physics Lab*, students perceive that the course goals have large emphasis on process that the students need to follow, and this is what the course scaffolding provides. However, in general, students feel quite lost within the course and have difficulty moving beyond the lab specific process they are using to perform experimentation and see what the greater picture is: *"[W]hen it comes to analyzing a particular lab, sometimes it's not really explained what it is exactly that professor wants me to do."* (Thomas). Here, Thomas understands what the purpose of the course is and what the intended course goals are, which is more than many of his peers are able to do, but is unable to apply these new concepts within the course, which is a common occurrence amongst the students, demonstrating a lack of a strong, clear course scaffold. In *Engineering Design*, students perceive that the course scaffold places a large focus on process, which the faculty emphasize so that the students can

better understand: "*[The professors] pointed out the design process of engineering could be structured… Then you… come up with several design alternatives, you pick between them, and you do prototyping and you do testing.*" (Betty). As shown in this quote, the students are able to clearly see what the scaffold is that they were supposed to be working in for their Design projects, by the fact that the professors clearly pointed out the design process. This then develops an intrinsic value to student experiences because of student engagement in the course scaffolding.

Looking now at faculty intentions towards the course, we find another different between the two courses. In *Physics Lab,* Dr. Farns describes the course scaffold intentions as "*[the course is] purely applied, in the sense that the things that [the students]'ve learned in Physics [Lecture] are applicable to the laboratories of Physics Lab.*" Here, his course scaffold intentions emphasize the content of the course and how students can apply content from other Physics courses, such as the concurrent Physics Lecture course, to their lab class. By focusing on the content of the course, the professor is not engaged in the process within the course, which is necessary for a proper course scaffolding. In *Engineering Design*, there is a much greater focus on process and interaction with the students: "*So while we do talk to [the students in class]…, we don't try not to talk at them. Mostly we have either discussions about the design process or they are actually working on a project.*" (Dr. Lars). As shown by this quote, the professors place an emphasis not only on the content of the course, but also the process that the students need to follow, and work in a very individual, interactive fashion with the students. This way, students are able to learn the content but also receive a good course scaffold through faculty interaction.

Finally, examination of the classroom implementation with regards to course scaffolding reveals a similar trend. In *Physics Lab*, we observed that sometimes faculty will pose open-ended problems and often students will solve open-ended problems. This exemplifies how students are more engaged in the process than the faculty are, even though there needs to be equivalent levels in order for it to be a good course scaffold, and confirmed that there is some interaction as part of the course scaffold, but not as much as is truly necessary. In *Engineering Design*, we observed that often both students and instructors will consider multiple pathways to reach one or more solutions to a problem. Here, students and faculty engage in the process to prompt learning to the same degree, which is necessary for a good course scaffolding.

Overall, in *Physics Lab*, there is some emphasis on process within course scaffolding, but mostly on content, which removes the interactive aspect necessary for a good course scaffold, while in *Engineering Design*, all three data sets show that the professors place an emphasis on content and process within their curriculum, and that they will engage in this process with the students to prompt learning, as following the classic definition of course scaffolding.

Instructor Support

Instructor support is when an instructor facilitates independent learning and demonstrates processes rather than directly impart knowledge, with a large emphasis as instructor as guide or mentor here rather than instructor as knowledge source. Students had different perceptions on the levels of instructor support within the two classes. In *Physics Lab*, students perceive a lack of good instructor

support, and often feel like they don't know what is going on all the time within the course: *"[The instructor] should explain things more and at the beginning of the course because I was really confused and I wasn't the only one. Nobody knew what was going on."* (Isabelle) The students feel a lack of instructor guidance in their lab course right from the beginning, which results in them feeling confused about what the purpose of the course was, and often frustrating students. This demonstrates a lack of contingency – where instructors will alter the levels of support based on student ability – on the behalf of the faculty. Additionally, students will not understand why the professors don't directly impart knowledge on how to "fix" their lab whenever there is experimental error: *"[The instructor] can't... do the report for us...he couldn't, say, help us [understand] why our data was wrong."* (Carolina). The students do not see how the instructor istrying to guide them through the process, and are instead frustrated by this perceived lack of support. In *Engineering Design*, students are very conscious of the high levels of instructor support and how this level changes as the semester progresses: *"[The course] has three different projects each with a decreasing amount of instruction and professor interaction."* (Marco). Students are able to see what kind of role the professors play as the semester progresses, and they are satisfied with this amount, demonstrating strong contingency within the course.

Looking at faculty intentions surrounding instructor support also showed a difference between the two courses. In *Physics Lab*, the professor believes that fostering a close personal connection with the students is necessary: *"I get to go around and talk with [the students]… [T]hat actually helps the teaching dynamic quite a bit because I'm not professor so and so who isn't an actual person."* (Dr. Farns). Here, Dr. Farns describes what he perceives as a personal connection with the students he develops during his interactions in Lab. Instead of serving as a guide for the students, he feels that connecting with them on a personal level results in a better teaching dynamic and greater understanding by the students. While he is clearly trying to avoid the "directly imparting knowledge" aspect of teaching, he takes a different route than the traditional mentor approach, which unfortunately seems not to be as successful with the students. In *Engineering Design*, the professors intend to have high levels of guidance at the beginning and then slowly fade away: *"In the first half of the semester there's a lot of dependence on us. Now [in the second half], it almost feels like we're intruding."* (Dr. Nole). The professors in Engineering Design begin the semester with high levels of instructor guidance, but with each successive project, there was less direct instructor support and a shift to instructor serving as guides. This is exactly the levels of contingency observed by the students.

Finally, looking at classroom implementation of instructor support, we again see differences between the two courses. In *Physics Lab*, we observed that rarely do instructors manage time and set agendas and goals. This demonstrates that faculty are not directly imparting knowledge and corresponds to what both the students see and the faculty intend. We also observed that never do instructors give students a choice in a task or problem, which shows that instructors are not facilitating student learning. In *Engineering Design*, we observed that never do instructors provide lessons goals, which demonstrates that, rather than directly imparting knowledge, instructors attempted to facilitate the learning. We also observed that sometimes do instructors give students a choice in a task or problem. Here, instructors are making sure that they are serving to facilitate learning to the appropriate level for the students at one time, which demonstrates contingency within the course.

In *Physics Lab*, students desired more from the faculty that they intend for the course, for the personal connection that is fostered by the faculty is not enough to support and facilitate student learning, while in *Engineering Design*, students clearly see the gradually fading levels of support the instructors intend and then implement within the course, which they find facilitates their learning quite well.

Student Autonomy

Student autonomy is what the students' choices are within a course, such the timeline for a project, the final deliverables, and their teammates. In *Physics Lab*, students find themselves flailing in the amount/kind of autonomy that they have: *"Physics Lab is really open-ended… you figure out what you want to do, then you figure out how you're going to interpret the data... and I don't like the open-endedness... It's really frustrating."* (Carolina). Carolina admits to liking the open-endedness aspect of Engineering Design, so the frustration she exhibits here is derived from the specific Physics Lab course implementation of autonomy and open-endedness and how she perceives the implementation, rather than from a general dislike of this open-ended approach. In general, students find themselves overwhelmed with the levels of autonomy, partially because they feel isolated within the course and can't feel that they can turn to their professors for guidance or their fellow peers for moral support and guidance, which frustrates them. In *Engineering Design*, students love the amount of autonomy that they receive towards their projects: *"The best thing [about the course] is… [t]hat we're given a problem, then basically free reign to do whatever we want with it."* (Patty). Patty reflects here on the high amount of autonomy the students have with regards to their *Engineering Design* projects and how much she enjoys this, which is a commonly expressed opinion amongst the students. *Engineering Design* allows students to foster a sense of ownership over the project, because of the increasing amount of autonomy that the students get within the course.

Looking at faculty intentions towards student autonomy, there is a large difference between the two courses. In *Physics Lab*, student autonomy is not discussed at all. This lack of discussion may imply that there is very little reflection surrounding student autonomy by the Physics Lab faculty, which limits what the students can perceive within the course. In *Engineering Design*, faculty intend students to gain more autonomy over time: *"[The students have]… developed some independence really quickly doing [the projects]."* (Dr. Nole). The engineering design faculty describe high levels of student autonomy, and say that these levels are intentional by the time the students reach their final course project, which is also what students perceive.

Finally, looking at classroom implementation, there was once again a difference between the courses. In *Physics Lab*, we observed often that students set and reach their own intermediate, explicitly stated goals within a lesson and that students will identify and locate materials and information in a student-initiated process. As demonstrated by this, since there are high levels of student autonomy observed in Physics Lab, the student dislike and disconnect towards it is most likely stemming from the lack of faculty reflection and the subsection emphasis within the course. In *Engineering Design*, we observed that often students set and reach their own intermediate, explicitly stated goals within a lesson and sometimes students take opportunities to make choices on a task or problem. This identified high levels of student autonomy and the subsequent student ownership that the faculty intend with the course.

In *Physics Lab*, students flounder in the high levels of autonomy within the course, which may be due to the fact that there is no faculty reflection surrounded student autonomy, while in *Engineering* Design, students experience high, faculty intended levels of autonomy surrounding their coursework, which allows them to experience high levels of ownership of their projects.

Discussion

In order to better compare these two courses, we applied Stefanou's framework of autonomy support to each course (Figure 1).
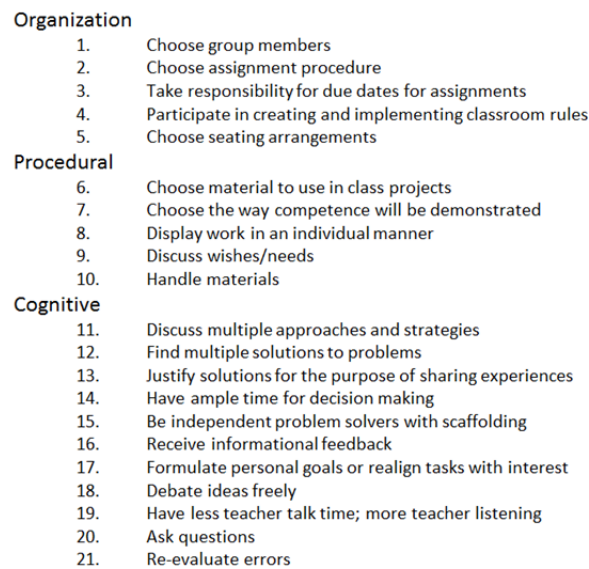
Organization
1. Choose group members
2. Choose assignment procedure
3. Take responsibility for due dates for assignments
4. Participate in creating and implementing classroom rules
5. Choose seating arrangements

Procedural
6. Choose material to use in class projects
7. Choose the way competence will be demonstrated
8. Display work in an individual manner
9. Discuss wishes/needs
10. Handle materials

Cognitive
11. Discuss multiple approaches and strategies
12. Find multiple solutions to problems
13. Justify solutions for the purpose of sharing experiences
14. Have ample time for decision making
15. Be independent problem solvers with scaffolding
16. Receive informational feedback
17. Formulate personal goals or realign tasks with interest
18. Debate ideas freely
19. Have less teacher talk time; more teacher listening
20. Ask questions
21. Re-evaluate errors

Figure 1: Stefanou's Framework of Autonomy Support

Aspects of each of the autonomy support frameworks were identified as present or not present within each course, as seen through student interviews, faculty interviews, and classroom observations. In *Physics Lab*, there was a large difference between faculty intentions, student perceptions, and classroom observations for each of the autonomy support frameworks (Figure 2).

Figure 2: Levels of Autonomy Support in *Physics Lab*

For the organizational autonomy support framework, faculty intend a mid-level that is observed within the classroom, but the students instead perceive the levels of autonomy support at low level. For the procedural autonomy support framework, faculty intend a high level of procedural autonomy support, which students perceive; however, this is not observed within the classroom. For the cognitive autonomy support framework, faculty intend complete amount of cognitive autonomy support; however, students perceive and it is observed only about half of the framework supported.

In *Engineering Design*, there was a much large overlap between faculty intentions, student perceptions, and classroom observations for each of the autonomy support frameworks (Figure 3).
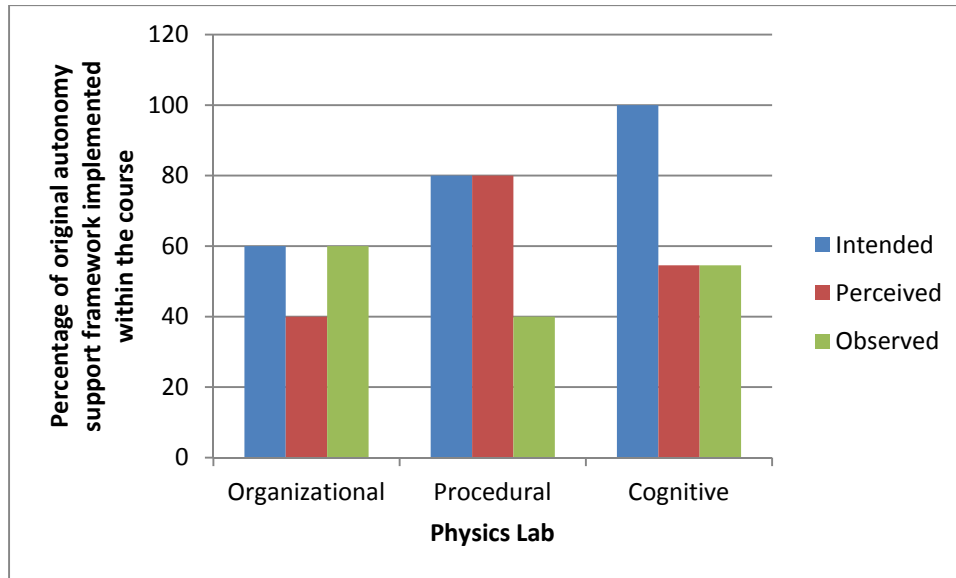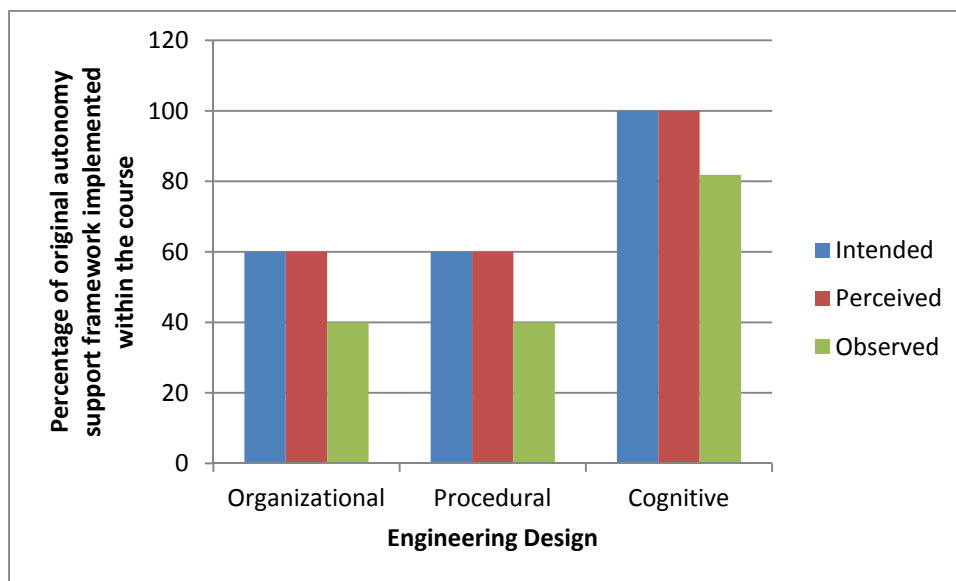

Figure 3: Levels of Autonomy Support in *Engineering Design*

Faculty intend and students perceive mid-level of both organizational and procedural autonomy support within the class. Only a low level is observed, but this is a result of incomplete data rather than purposeful exclusion from the classroom implementation. For cognitive autonomy support, faculty intend and students perceive complete amounts of autonomy support within the class. A high level is observed based on classroom observations, but this comes incomplete data rather than purposeful exclusion from the classroom implementation

Based on our findings, we determined that students can perceive intended course outcomes, particularly those with an emphasis on a process-focused course scaffolding in which both the students and faculty engage, high initial instructor support levels, and high levels of autonomy for course projects. Additionally, faculty intentions for a course often overlap with specific classroom implementations. However, whenever there is a misconnect between this overlap, students will very quickly perceive this and find it frustrating. Within Stefanou's framework, we determined that the most difficult aspect to implement, yet the most important for student learning within a PjBL environment is cognitive autonomy support, which is in line with Stefanou's own finds. Cognitive autonomy may not be developed unless it is supported by a strong organizational and procedural scaffolding. Whenever there is an overlap in student perceptions, faculty intentions, and classroom implementation, this results in positive student attitude towards the course, which in turn increases students' participation, interest, and performance. Instructors need to be very explicit when communicating course intentions with the students, for high levels of explicit intentions, the students are able to see the professor's intentions and incorporate them into their own learning and without high levels of explicit intentions, students' perceptions of the course, and often the corresponding material, suffer.

Acknowledgements

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Appendix

The following section describes our quantitative research findings. The majority of the text was written by Susan White at the American Institute of Physics.

Methods

37 students were surveyed at the end of their first academic year at Tygon College, after completing Tygon Math, Tygon Physics Lecture and Lab, and Tygon Engineering Design.

> 7 students who were interviewed completed the survey.

> 42 total student participants

Students were surveyed on their pre-college STEM experiences, their interests and professional goals, their academic life, their introductory math, physics, and engineering courses, and the academic and social atmosphere.

We defined constructs to measure students' enjoyment in their physics lab and engineering design course using the following questions:

- Overall, I liked the course.
- Interest
- Bored (which was recoded)

We defined constructs to measure students' opinions about instructor support in their physics lab and engineering design course using the following questions:

- I felt engaged by the teaching methods.
- I felt supported by the teaching staff.
- positive attitude and genuine care for students was displayed by the faculty (included for the engineering design course only)

Cronbach's alpha for these constructs are given in the results section.

We then used regression analysis (ordinary least squares) to examine the effect of various factors upon student enjoyment.

Results

Cronbach's alpha for the student enjoyment construct in the physics lab is 0.734; for students' perception of instructor support in physics lab, it is 0.732. Since both measures are greater than 0.7, there is evidence to suggest that the individual questions are measuring different facets of the same construct and consider the constructs to be acceptable. We then ran a regression with student enjoyment in the physics lab as the dependent variable and sex and instructor support as independent variables. Sex was not significant. We omitted sex from the final model and find that students' perceptions of instructor support has a positive and significant impact (p=0.000) on students' enjoyment of the lab as measure by our constructs. Cronbach's alpha for the student enjoyment construct in engineering design is 0.859. We examined the impact of students managing their project timeline and

goals, initiating engineering problems of their own design, the extent to which they worked independently within the course, and their sex upon student enjoyment in the course using regression analysis. The only variable that is significant is sex. Sex is coded with female = 1 and male = 0, so the positive coefficient for sex indicates that women averaged higher on the student enjoyment construct in the engineering design course than men. Cronbach's alpha for students' perception of instructor support construct for the engineering design course is 0.837, so we believe this construct is valid. We then examined the impact of instructor support in engineering design upon students' enjoyment in the physics lab. We included sex in the initial model, and it was not significant. The one-tailed p-value for instructor support in engineering design is 0.0295. This suggests that instructor support in engineering design has a positive impact upon students' enjoyment of physics lab.

SPSS Output

P28 Enjoyment construct:

Reliability

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	Total	94	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.734	3

Item Statistics

	Mean	Std. Deviation	N
p28Overall	2.4872	1.21117	39
P28Intrst	2.5385	1.16633	39
P28BoredR	2.8462	1.22557	39

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
p28Overall	5.3846	4.138	.584	.616
P28Intrst	5.3333	4.281	.589	.613
P28BoredR	5.0256	4.394	.504	.713

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
7.8718	8.483	2.91258	3

IF (fromRecode=0) P28EnjoynoUnch = p28Overall + P28Intrst + P28BoredR.

EXECUTE.

P28 Instructor Support Construct

Reliability

Notes

Output Created		10-Apr-2012 14:28:10
Comments		
Input	Data	F:\susan\PjBL\reduced data set.sav
	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	94
	Matrix Input	

Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on all cases with valid data for all variables in the procedure.
Syntax		RELIABILITY /VARIABLES=P28Engaged P28Support /SCALE('ALL VARIABLES') ALL /MODEL=ALPHA /STATISTICS=DESCRIPTIVE SCALE /SUMMARY=TOTAL.
Resources	Processor Time	00 00:00:00.015
	Elapsed Time	00 00:00:00.015

[DataSet1] F:\susan\PjBL\reduced data set.sav

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	39	41.5
	Excluded[a]	55	58.5
	Total	94	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.732	2

Item Statistics

	Mean	Std. Deviation	N
P28Engaged	2.5897	1.14059	39
P28Support	3.4103	1.14059	39

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
P28Engaged	3.4103	1.301	.578	.
P28Support	2.5897	1.301	.578	.

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
6.0000	4.105	2.02614	2

IF (fromRecode=0) p28InstSupp = P28Engaged + P28Support.

EXECUTE.

Regression Analysis with P28 Enjoyment as DV (IVs were sex and P28 Instructor support).

First, the full model (with both variables): (Note that sex is not significant.)

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.443	1.137		2.149	.039
	GndrBinary	-.152	.706	-.027	-.215	.831
	p28InstSupp	.943	.172	.685	5.473	.000

a. Dependent Variable: P28EnjoynoUnch

And the model with P 28 Instructor support only

Regression

Notes

Output Created		10-Apr-2012 14:31:18
Comments		
Input	Data	F:\susan\PjBL\reduced data set.sav
	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	94
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on cases with no missing values for any variable used.

[DataSet1] F:\susan\PjBL\reduced data set.sav

Variables Entered/Removed[b]

Model	Variables Entered	Variables Removed	Method
1	p28InstSupp[a]	.	Enter

a. All requested variables entered.

b. Dependent Variable: P28EnjoynoUnch

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.660[a]	.436	.420	2.21755

a. Predictors: (Constant), p28InstSupp

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	140.410	1	140.410	28.553	.000[a]
	Residual	181.949	37	4.918		
	Total	322.359	38			

a. Predictors: (Constant), p28InstSupp

b. Dependent Variable: P28EnjoynoUnch

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	2.179	1.123		1.941	.060
	p28InstSupp	.949	.178	.660	5.343	.000

a. Dependent Variable: P28EnjoynoUnch

Engineering Design Enjoyment Construct

Reliability

Notes

Output Created		13-Mar-2012 10:56:53
Comments		
Input	Data	F:\susan\PjBL\reduced data set.sav
	Active Dataset	DataSet1
	Filter	fromRecode=0 (FILTER)
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	42
	Matrix Input	
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on all cases with valid data for all variables in the procedure.
Syntax		RELIABILITY
		/VARIABLES=ELike EIntrst EBoredR
		/SCALE('ALL VARIABLES') ALL
		/MODEL=ALPHA
		/STATISTICS=DESCRIPTIVE SCALE
		/SUMMARY=TOTAL.
Resources	Processor Time	00 00:00:00.016
	Elapsed Time	00 00:00:00.031

[DataSet1] F:\susan\PjBL\reduced data set.sav

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	38	90.5

	Excluded[a]	4	9.5
	Total	42	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.859	3

Item Statistics

	Mean	Std. Deviation	N
ELike	4.1842	1.03598	38
EIntrst	3.9211	1.07506	38
EBoredR	4.0789	.85049	38

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
ELike	8.0000	3.081	.758	.780
EIntrst	8.2632	2.740	.847	.688
EBoredR	8.1053	4.043	.627	.897

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
12.1842	6.911	2.62890	3

IF (fromRecode=0) EEnjoyTyg=ELike+EIntrst+EBoredR.
EXECUTE.

Note: Even though Cronbach's alpha would have been higher (0.897 vs 0.859) if we had omitted EBoredR, the 0.859 is quite good, so we included all three. Also note that EBoredR is recoded since the original question was opposite the other two (bored versus liking and being interested)

Examining the possibility of using own goals, own problems, and independent as a construct

Reliability

Notes		
Output Created		11-Apr-2012 11:10:03
Comments		
Input	Data	F:\susan\PjBL\reduced data set.sav

	Active Dataset	DataSet1
	Filter	fromRecode=0 (FILTER)
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	42
	Matrix Input	
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on all cases with valid data for all variables in the procedure.
Syntax		RELIABILITY
		/VARIABLES=EOwnGoal EOwnProb EIndep
		/SCALE('ALL VARIABLES') ALL
		/MODEL=ALPHA
		/STATISTICS=DESCRIPTIVE SCALE
		/SUMMARY=TOTAL.
Resources	Processor Time	00 00:00:00.000
	Elapsed Time	00 00:00:00.015

[DataSet1] F:\susan\PjBL\reduced data set.sav

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	36	85.7
	Excluded[a]	6	14.3
	Total	42	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.348	3

Item Statistics

	Mean	Std. Deviation	N
EOwnGoal	4.81	.467	36
EOwnProb	3.31	1.600	36
EIndep	3.22	.929	36

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
EOwnGoal	6.53	4.256	.139	.391
EOwnProb	8.03	1.056	.342	-.048[a]
EIndep	8.11	3.073	.248	.191

a. The value is negative due to a negative average covariance among items. This violates reliability model assumptions. You may want to check item codings.

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
11.33	4.743	2.178	3

The negative correlation is really small (-0.048); however, even just two measures together did not make a good construct.

Regression Analysis for Engineering Enjoyment and Own Goals, Own Problems, Independent

(This is results of the initial full regression. Note that none of the variables is significant except GndrBinary. I ran a series of regressions omitting the independent variable with the largest p-value each time. In the end, only GndrBinary was significant.)

Coefficients[a]

		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	17.415	4.013		4.339	.000
	EOwnGoal	-1.290	.829	-.269	-1.556	.130
	EOwnProb	.320	.234	.222	1.368	.181
	EIndep	-.310	.391	-.126	-.793	.434
	GndrBinary	2.455	.756	.549	3.249	.003

a. Dependent Variable: EEnjoyTyg

Omitting EIndep:

Coefficients[a]

		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	12.599	3.184		3.957	.000
	EOwnGoal	-.440	.706	-.106	-.623	.537

EOwnProb	.237	.221	.164	1.073	.291
GndrBinary	2.298	.752	.511	3.056	.004

a. Dependent Variable: EEnjoyTyg

Omitting EOwnGoal:

Coefficients[a]

		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	10.685	.834		12.812	.000
	EOwnProb	.213	.215	.147	.988	.330
	GndrBinary	2.094	.671	.466	3.122	.004

a. Dependent Variable: EEnjoyTyg

The final model:

Regression

Notes

Output Created		13-Mar-2012 11:00:12
Comments		
Input	Data	F:\susan\PjBL\reduced data set.sav
	Active Dataset	DataSet1
	Filter	fromRecode=0 (FILTER)
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	42
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on cases with no missing values for any variable used.

Syntax		REGRESSION
		/MISSING LISTWISE
		/STATISTICS COEFF OUTS R ANOVA
		/CRITERIA=PIN(.05) POUT(.10)
		/NOORIGIN
		/DEPENDENT EEnjoyTyg
		/METHOD=ENTER GndrBinary.
Resources	Processor Time	00 00:00:00.000
	Elapsed Time	00 00:00:00.000
	Memory Required	5396 bytes
	Additional Memory Required for Residual Plots	0 bytes

[DataSet1] F:\susan\PjBL\reduced data set.sav

Variables Entered/Removed[b]

Model	Variables Entered	Variables Removed	Method
1	GndrBinary[a]	.	Enter

a. All requested variables entered.

b. Dependent Variable: EEnjoyTyg

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.474[a]	.225	.203	2.03485

a. Predictors: (Constant), GndrBinary

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	41.998	1	41.998	10.143	.003[a]
	Residual	144.921	35	4.141		
	Total	186.919	36			

a. Predictors: (Constant), GndrBinary

b. Dependent Variable: EEnjoyTyg

Coefficients[a]

Model		Unstandardized Coefficients	Standardized Coefficients	t	Sig.

	B	Std. Error	Beta		
1 (Constant)	11.368	.467		24.353	.000
GndrBinary	2.132	.669	.474	3.185	.003

a. Dependent Variable: EEnjoyTyg

Note: the R-square value indicates the 22.5% of the variation in the construct score is explained by the sex of the respondent. The regression coefficients indicate that the average score for males is 11.368 and for females it is 13.5 (11.368 + 2.132)

Engineering Design Student Enjoyment Construct

Reliability

Notes

Output Created		11-Apr-2012 11:48:18
Comments		
Input	Data	F:\susan\PjBL\reduced data set.sav
	Active Dataset	DataSet1
	Filter	fromRecode=0 (FILTER)
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	42
	Matrix Input	
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on all cases with valid data for all variables in the procedure.

Syntax		RELIABILITY
		  /VARIABLES=EEngage ESupport EPosAtt
		  /SCALE('ALL VARIABLES') ALL
		  /MODEL=ALPHA
		  /STATISTICS=DESCRIPTIVE SCALE
		  /SUMMARY=TOTAL.

Resources	Processor Time	00 00:00:00.000
	Elapsed Time	00 00:00:00.000

[DataSet1] F:\susan\PjBL\reduced data set.sav

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	38	90.5
	Excluded[a]	4	9.5
	Total	42	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.837	3

Item Statistics

	Mean	Std. Deviation	N
EEngage	3.53	1.246	38
ESupport	3.87	.963	38
EPosAtt	4.29	.956	38

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
EEngage	8.16	3.164	.669	.835
ESupport	7.82	3.830	.775	.712
EPosAtt	7.39	4.083	.695	.785

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
11.68	7.681	2.772	3

IF (fromRecode=0) EInstSuppTygon=EEngage+ESupport+EPosAtt.
EXECUTE.

Regression P28Enjoyment with Sex and EInstSupport as IV

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.973	2.262		2.198	.035

EInstSuppTygon	.279	.196	.251	1.422	.164
GndrBinary	-.462	.995	-.082	-.465	.645

a. Dependent Variable: P28EnjoynoUnch

Regression

Notes		
Output Created		11-Apr-2012 11:56:20
Comments		
Input	Data	F:\susan\PjBL\reduced data set.sav
	Active Dataset	DataSet1
	Filter	fromRecode=0 (FILTER)
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	42
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on cases with no missing values for any variable used.
Syntax		REGRESSION
		/MISSING LISTWISE
		/STATISTICS COEFF OUTS R ANOVA
		/CRITERIA=PIN(.05) POUT(.10)
		/NOORIGIN
		/DEPENDENT P28EnjoynoUnch
		/METHOD=ENTER EInstSuppTygon.
Resources	Processor Time	00 00:00:00.016
	Elapsed Time	00 00:00:00.016
	Memory Required	5500 bytes
	Additional Memory Required for Residual Plots	0 bytes

[DataSet1] F:\susan\PjBL\reduced data set.sav

Variables Entered/Removed[b]			
Model	Variables Entered	Variables Removed	Method
1	EInstSuppTygon	.	Enter

Variables Entered/Removed[b]

Model	Variables Entered	Variables Removed	Method
1	EInstSuppTygon	.	Enter

a. All requested variables entered.

b. Dependent Variable: P28EnjoynoUnch

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.309[a]	.096	.070	2.82989

a. Predictors: (Constant), EInstSuppTygon

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	30.466	1	30.466	3.804	.059[a]
	Residual	288.297	36	8.008		
	Total	318.763	37			

a. Predictors: (Constant), EInstSuppTygon

b. Dependent Variable: P28EnjoynoUnch

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	4.096	2.014		2.033	.049
	EInstSuppTygon	.327	.168	.309	1.950	.059

a. Dependent Variable: P28EnjoynoUnch

Note that this p-value 0.059) is for a two-tailed test. If we think, *a priori*, that the instructor support in engineering design should have a positive impact on student's enjoyment of physics lab, then we should use a one-tailed test. In that case, the p-value is 0.0295