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ARTICLE

Mediating Students' Fixation with Grades in an Inquiry-Based Undergraduate Biology Course

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Abstract

The paper analyzes focus group data to explore student perceptions of an inquiry-based undergraduate biology course. Though the course was designed to mimic the scientific process by incorporating uncertainty, peer review, and self-reflection, students came to class focused on getting As and with a developed schema for didactic instruction and passive learning. They perceived the autonomy and self-directedness of the learning experience as a threat to their grades, and responded with strategies that protected their grades and ego, but were deleterious to learning. Students could identify merits of the inquiry-based approach; however, they made clear: they prioritized grades, and were unwilling to trust an unfamiliar pedagogy if they perceived it jeopardized their grades. In the framework of self-regulated learning, the discussion considers how to scaffold students to foreground learning over achievement.

1 Introduction

The shift in the past 50 years in science education has been towards inquiry-based (IB) activities, which present science as a theory-building enterprise in which students develop conceptual understanding through engaged and constructivist learning (Duncan and Rivet 2013). Student-driven inquiry, characterized by novel questions, uncertainty, and collaboration are intended to help students more fully appreciate the nature of science and scientific inquiry (Buchanan et al. 2016; Bybee 2015; Spell et al. 2014) and develop science literacy (Bybee 2015).

In 2015, the biology department at Borealis University (BU)[1] redesigned its introductory biology for science major course. Using a backwards design framework (Wiggins and

[1]The institution name and course number are pseudonyms.

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McTighe 2005), the faculty identified course outcomes: (1) development of skills (e.g., writing, communication, and physical skills such as pipetting, microscopy), and (2) acquisition and application of core concepts to novel situations (e.g., explaining the results of an experiment in the context of evolution). The course was designed to target higher-order thinking skills through a collaborative and intentionally non-competitive design. Emphasizing active learning (Freeman et al. 2014; Wieman 2014), the curriculum required students to work cooperatively in groups to design and execute experiments that are authentically novel, gather and analyze data, and present their findings orally and in writing. Evaluative criteria included rubrics for transferred skills, and summative assessments for acquisition and application. Scientific concepts of uncertainty, peer review, and self-reflection were explicit parts of the design.

Observing improved final grades and course retention rates in the 4 years following implementation of the new IB curriculum,[2] we secured funding to responsively redesign other science courses. We interviewed students in the IB sections about their experience with the intention of informing the new curriculum design and addressing a gap in the literature around qualitative investigations of student perspectives of IB learning (Buchanan et al. 2016; Pulfrey et al. 2011). However, we found that students focused on their grades (rather than learning), and their fixation on achievement was deleterious to their experience. Though students experienced an IB and constructivist curriculum, it was in the context of an achievement-oriented undergraduate experience and their learning was ultimately represented in a traditional grading system—with a final letter grade on their academic transcript.

In general, assessment of students in science is a challenge—the goals of science courses and labs are multiple, and thus accurately assessing student performance requires a variety of tools and modes (Hofstein 2004). Concomitantly, the literature reveals polarization on how extrinsic rewards impact intrinsic motivation to learn (Deci et al. 1999, 2001; Lin et al. 2003). Thus, this paper explores how students reconciled and responded to an innovative way of teaching, but a typical way of grading.

2 Inquiry-Based Learning and Self-Regulated Learning

Though IB learning employs a range of pedagogical approaches including group work, guided reflection, and instructor probing, its fundamental tenet is centralizing students' investigative work (Aditomo et al. 2013), rooting learning in students' own questions as they explore the natural, constructed, and social worlds (Kirubaraj and Santha 2018). By planning and designing experiments, collecting and using data, and connecting data as evidence for conclusions (Capps and Crawford 2013), students expand their understandings and make deeper associations. Ultimately, these learning experiences provide context for students to "think critically and reflectively about the creation and production of knowledge" (Justice et al. 2007, p. 203).

IB activities are inherently constructivist in nature, and require students to engage and take responsibility for their own learning process. Zimmerman (1989) advanced this responsibility as characteristic of the self-regulated learner (SRL), stressing students' autonomy and control

[2] The proportion of students passing the course with a C or better increased from 71% (± 0.08 SD) in the former curriculum to 85% (± 0.06 SD) in the IB design. The 85% pass rate signifies the proportion of students who satisfied the introductory biology prerequisite and were eligible to take the next courses in the sequence; this number was 46% when the curriculum was delivered as a sequence of two courses in two separate semesters.

of their learning experience as they take on challenging tasks and develop their understandings through self-monitoring. Learning environments that support SRL incorporate instruction that builds on students' intrinsic interest in both of the subject matter and the challenges required to increase mastery, boosting initiative and autonomy to engage productively with peers in exploration and problem-solving (Hmelo and Lin 2000; Ryan and Deci 2000). Caine et al. (2009) noted implementation should attend to students' emotional states as well (see also Tomas et al. 2016), creating an optimal learning environment of relaxed alertness characterized by an appropriate level of challenge in a safe environment that accommodates risks and mistakes (Mega et al. 2014). In other words, for students to engage optimally in the IB curricular activities, they must have a SRL mindset.

Efforts to incorporate IB in biology instruction heightened following the *Vision & Change* publication[3] (Brewer and Smith 2011) which stressed the importance of integrating research for *all* students—majors and non-majors—and at all levels of instruction. The ubiquity of recent scholarship exploring the application and effectiveness of IB pedagogies attests the discipline's commitment to this approach. Research at the secondary and postsecondary levels has documented that IB or active teaching and learning approaches promote positive student outcomes including persistence and engagement (Buchanan et al. 2016), especially for lower-achieving students (Kogan and Laursen 2014); support confidence and perceptions of competence (Kogan and Laursen 2014); promote positive attitudes about science (Beck and Blumer 2012, 2016; Brownell et al. 2013; Harrison et al. 2011; Kloser et al. 2013); and require students to apply higher-order thinking skills (Hofstein et al. 2004) including sophisticated questioning and peer conversation (Hofstein et al. 2005; Hofstein et al. 2004; Karelina and Etkina 2007).

While IB approaches have gained popularity in higher education, especially as an important learning strategy of science and technology disciplines (Aditomo et al. 2013), there has been little qualitative research unraveling student experiences with this teaching and learning approach in the introductory-level science curricula (Brew 2010). While quantitative analyses in this realm seem to be generally positive (Howard and Miskowski 2005; Kloser et al. 2013; Levy and Petrulis 2012; Thompson and Soyibo 2002), Brownell et al. (2013) noted many studies using self-reported survey data are challenged by volunteer bias, and effects have not been replicated in randomized treatments. Qualitative studies of IB pedagogies in other content areas suggest that students respond and evaluate their IB experience differently by discipline (Dahlgren and Dahlgren 2002), and that individual students have different levels of interest in IB strategies. Scholarship noting that students need time and support to overcome initial uncertainty and disorientation with this new pedagogical approach (Evensen et al. 2001 [medicine]; Kivela and Kivela 2005 [hospitality]; Levy and Petrulis 2012 [liberal arts]) suggests that the relationship between positive student outcomes and their learning experience may be more nuanced.

The reciprocal relationship between motivation and SRL has been widely recognized in the literature; the intrinsic or extrinsic orientation of motivation links to students' underlying attitudes and goals (Ryan and Deci 2000) and the strategies they endorse (Wolters 1998) when engaging with a learning task (Liao et al. 2012; Pintrich 1999, 2004; Rosário et al. 2013;

[3] Led by the National Science Foundation and in partnership with the Howard Hughes Medical Institute, the National Institutes of Health, and the American Association for the Advancement of Science, *Vision and Change in Undergraduate Biology Education: A Call to Action* was the final report of a national initiative to transform undergraduate biology education. In addition to identifying core concepts and competencies for biology, the report emphasized the need for best practice pedagogies, particularly IB learning experiences.

Vollmeyer and Rheinberg 2006; Wolters 2003). Because the undergraduate student learning experience is at best a blend of extrinsic and intrinsic motivators (Pulfrey et al. 2013) and often heavily influenced by extrinsic pressures to earn good grades (Guay et al. 2008; Pope 2008; Ratelle et al. 2007), our analysis seeks to unravel the role of extrinsic motivation in an IB learning environment that was designed to be intriguing and thought-provoking for SRL. Exploring this relationship presents a unique opportunity for educators to engage extrinsic motivators to augment, rather than undermine, IB pedagogies.

3 Setting and Context

BU is a mid-sized (14,955 undergraduate students in 2018) open-enrollment institution offering graduate and undergraduate programs.[4] Forty-one percent of BU students identify as non-White. Attendance patterns and academic preparation at BU are typical to open-enrollment institutions: 54% of students attend part-time and 35% receive Pell grants, and 63% require developmental education in at least one area.

Nationwide, *General Biology I* has been identified as the sixth-highest "obstacle course," that is, a course that predicts college dropout among community college students (Zeidenberg and Jenkins 2012). *Introductory Biology for Majors* (BIOL 101) is BU's introductory biology course for science majors. Rather than a two-semester sequence, 101 is a 6-credit experiential learning course, completed in a single semester. The class is structured in three modules, each with a different lecture instructor who uses his or her own disciplinary expertise to teach module activities. Curricular material is drawn from *Vision and Change* priorities for concepts and skills; module 1 covers evolution and ecological relationships, module 2 concepts are information storage and use (genetics/DNA), and module 3 focuses on energy flow within cells and bodies (physiology). In addition to biology content knowledge, the class is structured to scaffold students in developing their understanding of scientific methods by increasing the complexity of tasks related to quantitative skills, presentation skills, and scientific writing in each of the modules. Figure 1 illustrates how each module is intended to build on the next.

Though BIOL 101 was developed using best practice guidelines, IB instruction is nuanced and can be an adjustment for faculty as well as students, and even after multiple iterations, there are opportunities to improve its implementation. The course was developed collaboratively by faculty at BU who had training and disciplinary engagement in IB pedagogies. Most of the faculty responsible for teaching the course attended training on IB pedagogies through the institution's faculty development center, as well as specialized training in active learning pedagogies for undergraduate science during a 2-day expert workshop. Additionally, to support faculty in the delivery of IB instruction, a faculty course coordinator with expertise in pedagogical applications in science supports alignment across sections. BIOL 101 has nine contact hours per week, three in a whole-class section of 75–125 students, and six in smaller lab sections of up to 20 students. Whole-class time includes short lectures interspersed with formative feedback assessments that allow the professor to check understanding and adjust the content accordingly. In the lab, students are divided into small groups, and class time is given for completing assignments applying material from the lecture, and "unstructured" time for students to work collaboratively on small

[4] Open-enrollment institutions have non-competitive admission processes, and accept all students who hold a high school diploma, GED, or certificate of attendance. In the USA, 26% of 4-year public institutions and 99% of 2-year public institutions have this designation (National Center for Education Statistics 2020).

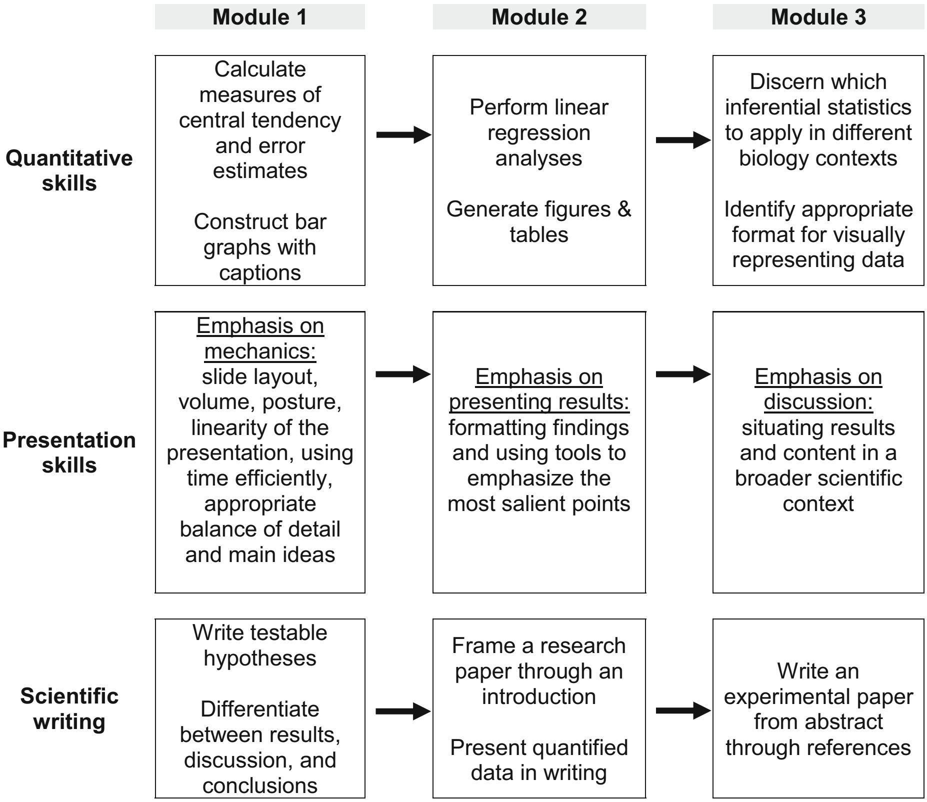

Fig. 1 Scaffolding of skills over the course. Each class module is designed to build on skills introduced in the previous one, with expectations for student work increasing commensurately

research projects. For each module, students design and execute a project from question and hypothesis through design, setup, execution, data collection and analysis, and interpreting results. The project is the basis for the oral presentation and write-up due at the end of each module. While the course does not have an assigned textbook, readings are provided as links or downloadable content via BlackBoard. Students who request a textbook for reference are advised to purchase an inexpensive (used) basic biology textbook.

The structure of an IB course—and the expectations that accompany it—is communicated to students via the course syllabus, information and announcements in the online course management platform (BlackBoard), and through instructors. The syllabus introduces the concept of IB learning, and communicates that the assignments are course structure are "designed to provide [students] the practical skills to be a scientist." The syllabus has a section dedicated to "group work" with additional hyperlinks and resources emphasizing individual responsibility and collaboration as part of the scientific method. In the first week of class, students take a syllabus "quiz" to demonstrate that they have read the document and understand course expectations and policies. The instructor verbally explains the IB framework as part of the course orientation, and the course coordinator visits individual lecture sections periodically to reinforce the course intentions, to apprise students of upcoming activities, and to support the instructors.

The "Grades" section of the syllabus outlines point values, assignment types, and the late policy. Grades in BIOL 101 are calculated from points assigned in two categories: *completion* *points* and *graded activities*. *Completion points* make up 20% of students' final grade, and are credit/no credit activities including pre-course/pre-module assessments, completion of scaffolding activities that lead to larger assignments, and participating in formative assessment activities during the lecture. *Graded activities* comprise 80% of students' final grade and include points for correct answers for formative assessment questions posed during lecture, concept quizzes, and lab write-ups and presentations. All lab write-ups and presentations are graded using a rubric, which is shared with students ahead of time. Faculty use the rubric as the feedback mechanism, providing comments in the rubric itself (rather than on students' submitted documents) that include both praise and opportunities for improvement. To help students understand how each module builds on the next, the same rubrics are used across modules, but the emphasis for each iteration is bolded to draw students' attention to that skill, and point values are adjusted accordingly.

4 Methods

Topics for our investigation were informed by the broader research agenda that included a review of institutional data, classroom observations (Foster 2006), and document analysis (Bowen 2009) of syllabi and course materials. We also solicited input from biology faculty, who requested the investigation explore factors related to student completion (e.g., personal commitment, course difficulty, and goal clarity [Tinto 1993]), interaction with instructors (Christe 2015; Ronco and Cahill 2006) and peers (Astin 1993; Christe 2015), and student satisfaction. The project was reviewed and approved as expedited human subjects' research by the BU Institutional Review Board. In the fall 2018 semester, we matched introductory biology course rosters to institutional data, and used stratified random sampling for email invitations as a strategy to achieve maximum variation (Patton 1990) on dimensions of gender, race/ethnicity, major, and prior academic performance. We used a $20 gift card incentive to encourage participation in self-contained focus group interviews, which are used to elicit attitudes and opinions, as well as self-reported behavior (Morgan 1997). Sixty-eight students received email invitations, 38 responded to the recruitment, and 16 ultimately participated. Of the 38 who responded, 8 were not interested, 6 cited work or schedule conflicts, and 5 accepted the invitation but did not show up for the interviews or canceled last minute due to schedule conflicts.[5] Table 1 notes that academic and demographic characteristics in the course and in the participant sample were quite congruent.

We interviewed students in three focus group sessions, which took place at the end of the semester—just before final exams—and were organized in five sections (1) expectations, (2) course format and delivery, (3) assessment and assignments, (4) evaluation of the course, and (5) takeaways. Each discussion section was prompted by a single, open-ended question, and the interview guide listed prompts and probes to encourage further elucidation or to redirect the conversation as needed. Two of the authors served as the discussion facilitator and assistant; neither were affiliated with the biology department, and biology faculty across sections did not know which of their students participated in interviews. The separation was intended to ensure that students would feel comfortable sharing their impressions without worrying of repercussions on course grades or relationships with their faculty advisors. We used Puchta and

[5] Additionally, 3 students whose names were not in our random sample volunteered to participate in our study; however, because these students were not randomly selected, they were not included in the focus groups.

Table 1 Academic and demographic characteristics of population and sample

Characteristic	Course ($N = 90$)	Sample ($n = 16$)
Gender		
Male	46%	38%
Female	51%	63%
Other/no data	3%	0%
Race		
American Indian/Alaska Native	4%	0%
Asian/Pacific Islander	8%	6%
Black	4%	6%
White	63%	75%
Two or more races	14%	6%
Other or unspecified	6%	6%
Age		
18–24	81%	75%
25–29	12%	25%
30 or older	7%	0%
Cumulative College GPA		
3.5–4	22%	13%
3.0–3.49	27%	31%
2.5–2.99	20%	25%
2.0–2.49	11%	19%
Below 2.0	1%	0%
No GPA (first time freshman)	19%	13%
Final grade*		
A	12%	13%
B	41%	50%
C	30%	31%
D	7%	6%
F	4%	0%
W	6%	0%

Students were invited to participate using stratified random sampling, and the sample of participants largely reflected the demographic and academic characteristics of students in the course

*Obtained from institutional records and matched to class lists after interview data were collected

Potter's (2004) techniques for turn-taking to ensure all voices were heard, and probed both areas of consensus and disagreement.

The focus groups lasted 92, 65, and 75 min, and were transcribed in their entirety. Preliminary impressions of the focus group interviews noted the prominence of grades and evaluation, and this theme was thus identified as the focus for this analysis. In preliminary coding, we identified 361 significant statements (Riemen 1986) that addressed grades or evaluation. The significant statements were assigned meaning units (Kvale and Brinkmann 2009) which were then analyzed using axial coding (Wicks 2010) in the constant comparative method (Glaser and Strauss 1967), to systematically root the analysis in data while allowing categories of data to be re-grouped and to reveal new meaning following open coding. In this process, initial codes were collapsed into categories describing students' learning experiences. Though the lead author did most of the initial coding, to ensure reliability, she used memos to document the development of codes (Lewis-Beck et al. 2004), and the second author reviewed the codes and coding protocol following assignment of significant statements and meaning units. The final collapsing of codes was conducted with regular, open dialogue between the three authors. Figure 2 depicts the process for axial coding.

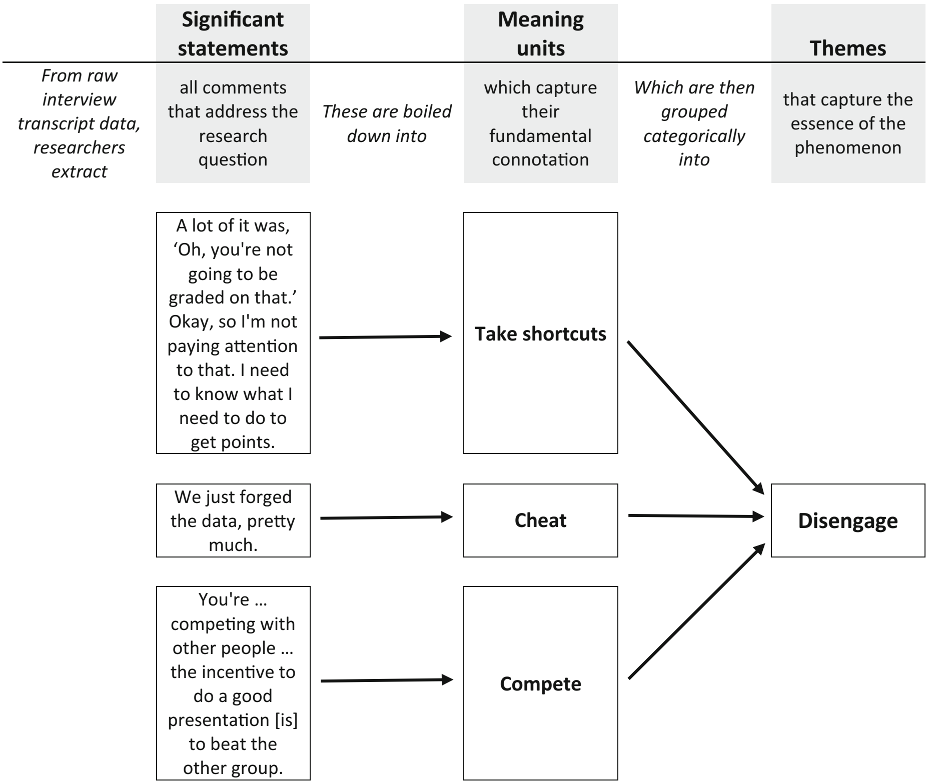

Fig. 2 The axial coding process. Though the axial coding process we used for analysis is more iterative than this diagram suggests, the themes emerge from and are anchored in the raw interview transcript data. We provide an example of some of the significant statements and meaning units that comprised the theme of disengagement

5 Students' Learning Experience

Though it was not the intended focus of the research, students' concern with grades dominated all topics of discussion, and emerged as the driver of how they perceived their learning experience. Grades constituted students' primary goals and motivation for the class. They came to the class with a well-developed schema for science classes, but not for IB pedagogies, and when their expectations were not aligned with the autonomy and self-directed nature of the IB learning experience, students were uncomfortable. They perceived course activities, instructors, and peers as threats to their grade, and fixation with grades impeded engagement as students foregrounded their scores over their learning.

Though students were nearing completion of the course, they were unaware of the disciplinary, institutional, and curricular contexts that prompted the discussion. As students, they had signed up for a required class without knowledge that it had recently been redesigned or that, since the inception of best practice pedagogies, students in the course were achieving higher pass rates. When probed to reflect, students could see the merits of the pedagogy, but indicated that, given the choice, they would be disinclined to take more courses that used IB approaches unless they had assurances of good grades.

5.1 Goal: Get an A

As science majors, all students took introductory biology as a degree requirement. They identified it as "the class you need to take in order to do all the upper division," and universally identified getting an A as their primary goal. As one student said, "This is a six credit course. I can't get a B." Another student explained,

> I'm in the military, so the military is paying for me, the Guard. And … if I got a C, I could lose that TA money. … Or I don't get awards for my job for military, because they do look at GPAs.

The students' goal of getting an A had tangible implications including securing grade-contingent merit scholarships, maintaining financial aid eligibility, and being competitive in graduate program applications. Before they even got to class, students knew they had a lot riding on their final grades, and they were acutely focused on these extrinsic pressures. As one student said, "some people don't care about getting Cs, and that's fine for people that don't wanna get into med school."

5.2 Expectation: Passive Learning

Because all of the students had taken science in high school, they entered class expecting it to be, "like every other science class," and, as an introductory (100-level) course, they expected it to be "easy." When probed, students described an expectation of didactic instruction; they anticipated a "traditional" science class with structured lectures aligned to assigned readings, and were surprised to find otherwise. One student noted that while the concepts were similar to other science courses, this one used a "completely different" approach. Another agreed that they were, "expecting a lot more detail and a lot broader information out of an introduction class" which was different from other classes that required them to, "try to understand something and just be done with it" when they took the test. Consistently, students used the word "specific" to describe the directions they expected: step-by-step instructions and examples or templates of what they were supposed to reproduce or memorize. One student lamented, "They post the slides but they don't post any information that you specifically have to study." Another student said, "They're not giving us specific examples of what they want [in] our papers. It's like, 'Here's the main points that we need to see, but we're not going to actually put it all together [for you].'" Though the students' comments reflected ability to do the work, they resisted it, favoring a more instructor-directed approach.

Because students were accustomed to didactic teaching, they expected to receive points for participation or effort, rather than demonstrated knowledge. In describing the daily quizzes that doubled as attendance records, a student said, "All of my other classes … you get your normal participation grade as long as you answer the questions and you get *extra* if they're right." Another student said her grade should reflect the amount of time she was putting in:

> Based on how I feel I'm working this class I should be one of those students that gets an A in this class. I believe that I should and I'm going to be very frustrated if I don't, especially being 6 credits. I want that A for my GPA, all of us do, but people who are working harder than the others should be getting better grades.

In a similar vein, two other students compared their experiences in writing their end-of-module experiment. One said, "I spent hours on this paper and I think I ended up with about 10 to 12 pages." His classmate, who said he invested less time and produced a shorter paper of about three pages said, "I scored almost the exact same as him and that's ridiculous!" These comments reveal attention to quantity of inputs over quality of learning. With this transactional mindset, students expected that if they showed up for class and put in the time on structured assignments, they deserved an A for their efforts.

5.3 Experience: Misaligned with Expectations

Though students came to class with well-developed schema for science classes, they quickly came to understand they would need to work independently:

> You get to the concept quiz and you go, 'I don't know any of this. Did they teach me this?' … And, that's when you start realizing, 'Oh, I'm supposed to be teaching myself besides what I'm learning in lecture.' And I think that's what's kind of intensive [sic] about it is, I have to go home and study on my own time with my own material, completely separate from the class.

This expectation of independent learning was framed as a complaint, and students were frustrated when instructors did not answer questions directly. When students were referred to rubrics to understand assignment expectations, they "got kinda irritated;" when instructors encouraged students to use Internet resources to explore their content questions, they responded "I didn't pay $1200 for you to [expletive] tell me to Google something." Another expressed frustration when she was encouraged to consult outside resources to figure something out. She said to the instructor,

> 'I'm paying you to teach me how to do this.' And [the instructor] didn't like that answer, but yeah. I mean, that's the case, right? I'm not coming to school to teach myself. I'm coming here for you to tell me how to do stuff.

Another student said, "I was expecting an introduction, something that explained what we were doing more so than just kind of feeding us to the wolves," framing the independent learning activities as vicious and uncaring. And though a student said, "I know *Crash Course* exists, I know *Khan Academy* is out there," he was frustrated that, "I'm not given the tools to succeed by the teacher, I have to do it myself." Though students realized that the course expected them to take personal responsibility for their learning, they perceived it to be "unfair" and found themselves "super frustrated" as they moved through the curriculum.

5.4 Perception: Threat to Grade

When students' experience and expectation misaligned, their resulting frustration and concern centered on their grades. A student said, "I didn't feel there was any real explanation on what we should do, how we should organize it or anything. We were just kinda let out to go on our own. And I didn't necessarily like that." Uncomfortable with the autonomy and lack of structure in self-directed learning activities, the students were unsure about how to perform for their professors so they could be rewarded with an A. They routinely asked, "What do I need to do to get an A?" and tried to please the professor by doing exactly those things. When a professor pushed a student to think through the procedure but declined to provide explicit directions, the student responded, "Okay, well, how are we going to get an A, then?" The concerns were not so much with the challenge or workload of the exercise itself, but rather how the self-directed activities would be graded. Intent on conforming to grading expectations, students were myopically focused on the task at hand and concerned with "little things…that take points off your project," rather than the quality of the learning experience.

Resultantly, the students came to regard the instructor as an authority figure who "set you up for failure in the grading," by neglecting to provide explicit directions. Statements that grades were "given" (rather than *earned*) underscored students' perception of diminished autonomy. A student explained, "The way that this course is structured it intentionally makes you not trust your superiors and feel like you can go to them for help because … they're only just going to dock you." Instructors who did not give explicit directions or answer questions directly were perceived as obstructionist. One student framed her professor's response to her repeated requests for directions as adversarial, saying, "[The instructor] said, 'You're not gonna have a step by step. You need to figure it out.' And I said, 'Well, I'm sorry, but I'm not paying tuition to figure it out myself.'"

These feelings were exacerbated when students received feedback. When the instructor explained that the constructive feedback on the first assignment was intended to help students improve on subsequent assignments, the student was concerned not with improving her skills, but rather how the score on her first paper would hurt her final grade: "I said, 'Excuse me, I'm planning to get an A in this class.' … There's no, [not doing] well the first time.'" If feedback was accompanied by a lower grade, it was the score—not the feedback—that interested students, and thus the feedback was regarded not as helpful, but rather as a threat.

Group work was an explicit part of the course design, but students framed their group work as a compensatory strategy for instructor laziness. Statements like, "it's not uncommon to see people asking for help from other students in order to learn stuff that they *should have been taught in lecture or lab*," [emphasis added] notably focused on instructor shortcomings over the value of the collaboration. However, though peers could be resources for learning, they were perceived to be a greater threat in graded group work. Other students were a risk of "flaking," producing sub-par work, or "pawning it off to everybody else in [the] group." As one student explained, "I'm in a group right now where my partner just will not listen to me and my grade is being severely affected," noting frustration over her lack of control. Other students were frustrated at, "if somebody in your group doesn't contribute you still get docked for them not contributing to the group," and the result was frequently that, "your group partner completely tanked your grade." Rather than enjoy the autonomy of self-directed learning activities or value collaboration, the threat of an unfavorable grade conjured feelings of animosity towards instructors and peers—the very people intended as resources in the IB course design.

5.5 Response: Protect Grade and Ego

Students responded to the perceived threat with actions that protected their grades, in a transactional mindset that linked all activities to their associated point value. One student said,

> I have no incentive to remember anything. I just have an incentive to get as good of a grade as I can on whatever is currently in front of me and if I forget about it [afterwards], it doesn't matter.

Another student corroborated, saying, "A lot of it was, 'Oh, you're not going to be graded on that.' Okay, well so I'm not paying attention to that. I need to know what I need to do to get points." Other students tried to manipulate assignments to ensure a good grade; a student described a common strategy: "I do the whole 'too long to be wrong' doctrine, where I'm just gonna kill you with word count and we're gonna see how well you feel at the end of this paper," uncritically producing quantity while intentionally shirking quality. In a few instances, students cheated to ensure a better grade, such as having a graduate student write sections of their papers or making up lab data.[6]

As students sought to game the system to their favor, they sometimes did it to the detriment of their classmates, for example, giving other students low scores in peer evaluations to make their own presentations score comparatively higher. Though these strategies may have produced higher scores or points on the assignment at hand, the grade-focused self-protective actions undermined not only the IB course design, but their own learning experience.

5.6 Reflection: IB Has Merit, but Grades Come First

Though students were frustrated with their learning experience, when probed to reflect they could identify the merits of the IB approach. They recognized that the course used a different approach, one intended to make them think critically and be accountable for their own learning. A student said, "They designed the course to make you struggle. That's what they want. They're not gonna help you, because they want you to push yourself and learn." Another student added,

> I got a bit more than I wanted, but … I was tired of the sort of coddling that a lot of the intro courses have, and it's been really refreshing, in a way, to have Bio 101 just throw things at you and make you work with it.

However, they could not offer a credit to the course without voicing concern for grading, with comments such as,

> It taught me a lot in an unconventional way and a way that was never taught in high school, middle school, and elementary school, even in college. … I think that in a lot of ways, I … almost learned more than I would've if I had taken a normal class. But very frustrating when everything is centered around your grades, it's kind of harsh.

The students made clear: they prioritize grades, and are unwilling to trust an unfamiliar pedagogy—however effective it may be for learning—if they perceive it jeopardizes their grades. A student explained her perceived rationale for the pedagogy,

> [The professor] told us in the get-go of getting into the class that she's not gonna be here to kind of be by our side the whole time to tell us what to do. She's like, 'I'm gonna guide you in a direction and push you off a little bit, but I cannot tell you…what you should be doing.' She knows what we should be doing, but she's not going to [tell us what to do], because that's not the goal. The goal is for us to be problem solvers, be progressive, and be able to solve our problem.

To which two other students simultaneously interjected, "And then you get a bad grade."

Students also perceived that grades were used as carrots to encourage them to work harder. A student said, "I get that they want to challenge students and I get that we need to work for our grade." Another student conceded, "I can get they don't want you to have such a high

[6] All data referencing mechanisms of academic dishonesty are deliberately left out of this manuscript to reduce risk to participants.

grade where you stop trying because they want you to keep working toward it," and therein revealed that once they were sitting on a good grade, students would expend less effort on learning.

To be fair, students did not mind working hard for the grades they wanted, but felt they should be recognized for their effort. As one student said, "It's very in depth, but it's something you could handle if you knew you were getting the grade you deserved for it." They also suggested that if the pedagogy required them to "figure it out on [their] own," their grade needed to be held harmless. As they put it, when "you're just learning fundamentals, you shouldn't be reprimanded for mistakes," and "to take the points off on learning assignments is kind of unfair."

Ultimately, at the time of the focus group interviews, grades affected students' overall impressions of the course. While some students foregrounded the learning and said that the course was "good overall" except for the grading, others evaluated their entire learning experience through the lens of the grade they received:

> Honestly, if I didn't have to take it and knowing how I feel taking it, I wouldn't take it. … It's just not an experience I enjoy. I'm very-grade oriented. All through high school, I had As, and coming in, I was like, 'I'm gonna get As.'

Regardless of their final grades (and, incidentally 2 of the participants earned As, 8 earned Bs, 5 earned a C, and 1 earned a D), their evaluations of the course were focused less on what they learned, but the letter that would be on their permanent university transcript. Grades were both the litmus test students used to evaluate their learning experience and the barrier prohibiting them from engaged learning.

6 Discussion

As in previous research, our participants' disengagement functioned as a self-preservation strategy to protect ego in a climate of grade uncertainty (see Crocker et al. 2003; Major et al. 1998; Regner and Loose 2006; Stephan et al. 2011), and their resistance was deleterious to the potential of the course design. While students in our study were distressed by grades, we imagine the experience also disappointed faculty, who had worked diligently to design meaningful projects that challenged students to critically apply concepts (see also Goulden and Griffin 1997; Pope 2008; Romanowski 2004; who also found that faculty are marginalized and frustrated by grading systems).

The incompatibility of grades and SRL is familiar and well documented (see Guay et al. 2008; Liu et al. 2014; Pope 2008; Pulfrey et al. 2011; Romanowski 2004). In this case, students experienced the carefully constructed IB course in the context of the achievement-driven university grade point structure, and this study advances the discussion around implementation challenges with IB. Our findings underscore how the institutional structure and culture of the achievement-oriented grading system challenge the motivation, autonomy, and relaxed alertness required for SRL.

6.1 Motivation

A key aspect of the SRL is intrinsic motivation for learning (Mega et al. 2014), both around initial attitudes about the task as well as persistence in completing it. Grades, on the other hand,

and the benefits that they afford (e.g., scholarships, promotions at work) are extrinsic motivators that draw students' attention away from creativity (Guay et al. 2008) and from continued lifelong learning when the performance-contingent reward goes away (Deci et al. 1999; Ryan and Weinstein 2009).

While there is a general consensus that extrinsic motivation is not good for SRL, students' regard for grades is not just about merit and achievement. Though our students focused on the financial and academic benefits of good grades, the literature also documents that grades have tremendous social capital. In our data, this was tacitly evident in the status that would result from promotions at work or graduate school admissions. To this end, many students regard grades as an indicator of competency and intelligence, which ties into self-esteem. To peers in the classroom and in the broader society, grades and degrees are indicators of competence, initiative, quality of task performance, and ability (Cameron et al. 2001; Cameron and Pierce 2005; Eisenberger et al. 1999).

Though in the SRL framework, one could consider grades to be extrinsic motivators for students; their tangible personal social capital (Pulfrey et al. 2011; Romanowski 2004) reveals than an unfavorable grade threatens self-esteem and reputation. Though our students said they were quite willing to work for grades, their defensive and self-protective strategies align with Pulfrey et al.'s (2011) findings and interpretations of students' reaction through prospect theory (Kahneman et al. 1991): when students perceive the stakes (their grade) as very high, aversion to loss (a bad grade) is far more compelling than attraction to gain (a good learning experience) and students respond with protective strategies. In other words, rather than motivating students to work harder, grades introduce stress that results in performance-avoidance. Though grades certainly were motivators for our students, they did not represent motivation to learn.

6.2 Learner Autonomy

Just as grades can diminish intrinsic motivation, they can also threaten feelings of control (Ryan and Deci 2000). SRL is characterized by learner autonomy and control over the learning environment, and IB activities, by design, are student-directed. Ironically, in our data, students felt they had power and control over their *grades* in a more traditional classroom that provided prescriptive, specific directions for learning and assignments. Though instructors at our institution gave students much autonomy in designing and carrying out their experiments, they still ultimately evaluated student performance and assigned grades, and with this apposition, the intended learning autonomy was not perceptible to students. As other scholars have documented in other learning environments, this put the instructor in a position of power, and also fueled competition between students (Pulfrey et al. 2011; Romanowski 2004).

Ratelle et al. (2007) noted that high school students tend to be less used to autonomy, and it is important to note that our data were collected in a freshman-level course. We expect that students were not only experiencing autonomy of the IB pedagogy but also transitioning into the college environment that is more autonomous in general. We conjecture that the "double dose" of autonomy may have been too unfamiliar for students to adapt to in a 16-week semester. Rather than independence, students interpreted a lack of direction as powerlessness which engendered performance-avoidance and dependence (Pulfrey et al. 2011), and undermined their learning experience. Unfortunately, students' fixation with evaluation and their academic transcript flipped the focus—their feelings of control over their grades in a more didactic classroom environment were rooted in an absence of autonomy in learning.

6.3 Relaxed Alertness

Students' fixation on grades also challenged another tenet of learning environment that supports SRL: a curious but relaxed emotional state. The extrinsic motivation attached to students' grades—including meeting financial obligations, promotions at work, and graduate school admissions—introduced a lot of pressure into the learning experience. Scholars have documented that high anxiety undermines performance and results in poorer learning (Caine et al. 2009; Guay et al. 2008; Liu et al. 2014), and grades, coupled with the unfamiliarity of the new pedagogy, introduced threat. We observed this in both students' response to the learning activities themselves and in response to the feedback that accompanied their grades. Guay et al. (2008) noted that perceived competence predicts the amount of challenge individuals are willing to take on; when our students received constructive criticism intended to promote deeper critical thinking, it threatened their feelings of competence and threatened their grades, which in turn encouraged them to challenge themselves less.

7 Recommendations for Teaching and Learning

A learning environment that promotes SRL attends to motivation, emotion, and appropriate levels of challenge. Better understanding how students perceive and respond to learning activities can inform not just the course design, but also provide a framework for addressing the shortcomings of the implementation detailed in our study. We recommend that faculty who experience or anticipate student resistance around IB learning activities acknowledge the influence of grades, scaffold students to increased levels of autonomy and SRL behaviors, and employ transparent design. We also recommend that institutions acknowledge the challenges around implementing best practice pedagogies, and support faculty with resources and tempered interpretations of course evaluations.[7]

7.1 Acknowledge Grades

Despite our many combined years of working as faculty, we were surprised at the intensity of students' fixation on grades, but it is counterproductive to dismiss this dynamic. While faculty are relatively indifferent to grades, students have emotional responses to them (Adams 2005; Goulden and Griffin 1997; Tippin et al. 2012), and ignoring or dismissing their feelings creates an adversarial starting ground for learning. This incongruence of faculty and students' regard for grades is thus a likely place for miscommunication and tension, and it is helpful for faculty to remember that students have been conditioned to work for grades in a competitive and meritocratic system (Guay et al. 2008; Pope 2008; Ratelle et al. 2007), especially in the era of high-stakes testing and accountability (Nichols and Berliner 2008). Responsively, instructors have an opportunity to reflect on how they explicitly and tacitly communicate the importance of grades to students, and to discuss the obsession with grades directly. As a starting place, we recommend that faculty emphasize the relevance and applications of content while acknowledging that learning and grades are not mutually exclusive (Romanowski 2004).

[7] Though alternatives to grades are worth exploring, they are beyond the scope of this paper. Instead, we consider how to address grades as faculty in our current institutional and cultural structure.

7.2 Scaffold

Our data also reveal that many students have not previously been exposed to high-impact practices (see also Kuh 2008), even though they have strong prior academic performance. Thus bringing students to a place where they can become SRLs requires faculty to deliver autonomy supportive instruction (Buchanan et al. 2016) that recognizes that students will come to class differently ready for autonomous learning (Liu et al. 2014) or novel course design (Exter et al. 2019). Scaffolding is a familiar concept in the constructivist literature, and Vygotsky's zone of proximal development emphasizes providing *optimal* levels of support and autonomy (Koestner and Losier 2002) that accounts for students' readiness, pushing them incrementally towards more self-directed activities. This has been operationalized in the staged self-directed learning model (Grow 1991), in which teachers equip students to become self-directed by matching the learner's stage of self-direction and preparing them to advance to higher stages. In the introductory biology curriculum, this may include breaking assignments into smaller chunks, therein providing more immediate and constructive feedback, guiding students in reflection around critique, and tapering these supports over the semester, incrementally shifting responsibility to students as they progress towards meeting both the cognitive demands and the social context for IB learning (Reiser et al. 2001). Our recommendation differs from other researchers who recommended blending lecture and IB activities in response to finding that students prefer lectures (see Minhas et al. 2012; Walker et al. 2008). While we acknowledge the value and place of lectures (see Burgan 2006), it is important to distinguish between tacitly reinforcing academic bad habits by acquiescing to student preference and scaffolding with intentionality.

7.3 Organized and Transparent Design

Scaffolding students to higher-order thinking and more SRL will require course organization and a transparent design that fosters communication and establishes a clear foundation of trust with students. Learners' engagement is influenced not only by their own interests, but also by aspects of the learning environment (Boekaerts and Cascallar 2006; Schmidt et al. 2018). Our students were uncomfortable without specific, step-by-step directions, and some of this discomfort could perhaps be mitigated through increased *course structure* with explicit expectations that are autonomy-supporting (Liu et al. 2014) rather than *directions* that are controlling (see Koestner and Losier 2002). How much students trust their instructors significantly predicts their commitment to active learning (Cavanagh et al. 2018); a transparent design framework may help to alleviate some grade obsession not only by clarifying assignments, but by addressing students' basic needs of competence, autonomy, and relatedness (Liu et al. 2014; Vansteenkiste et al. 2004; Young 2005), and by helping them to see the connections between course objectives and class activities that promote development of skills or knowledge (Winkelmes 2013).

7.4 Support Faculty

We are aware that our recommendations put much responsibility on faculty. With documented implementation challenges (see Akuma and Callaghan 2019), evidence that IB is more work than traditional lecture settings, and when students' instructor evaluations are higher for traditional sections (Walker et al. 2008), it seems easier to "throw in the towel" and just lecture, especially when student evaluations are considered in promotion and tenure recommendations and labor-intensive course planning distracts faculty from research and publishing. If institutions and departments are committed to best practices and to student learning, faculty will need resources to implement IB curricula and constructivist teaching practices (Capps and Crawford 2013; Hofstein et al. 2011; Hofstein and Lunetta 2004). This training and support will be especially critical for institutions that rely heavily on graduate assistants or adjuncts to deliver their introductory-level or lower-division content, as these instructors are themselves more likely to feel comfortable with the predictability and control of didactic instruction (Browne and Blackburn 1999; Compitello 2008). Institutions and promotion and tenure committees will also need to weigh and understand students' discomfort reaction to IB design and recognize that the most pedagogically sound practices, even when implemented well, may not translate to positive course evaluations (see also DeFeo et al. 2017), at least in the short term.

8 Limitations and Opportunities for Future Research

Though our data were collected and analyzed with integrity, our study contains some limitations. First and most significantly, our data reflect student responses to an IB course design at a single institution. Our data from this single case at the introductory level of study do not reflect the broad array of course delivery approaches, grading systems, or students, and thus may not be wholly generalizable to other settings. Even though the IB course was in its seventh iteration, faculty and teaching assistants were still adjusting to the new pedagogical approach. However, the growing pains evident in our data may offer insight for other programs; institutions will experience some pratfalls and challenges in the early implementation (Fullan et al. 2005), and we hope that studies like ours will be resources for other programs.

The timing of our data collection is also a limitation. We interviewed students in late November, just 3 weeks before final exams. This was a busy and stressful point in the semester and students' focus on final grades (which had not yet been earned or recorded) was likely heightened. We suspect that students might evaluate the course and their learning differently in retrospect, as previous studies note that confidence and course perception change after classes conclude (see Pulfrey et al. 2013; Walker et al. 2008). Though the timing of our study gives valuable perspective for interpreting end-of-course evaluations and for considering how emotional responses to grades can hinder learning, our data do not reflect long-term impressions and key takeaways, which may change and are certainly more important curricular outcomes.

We also note that our analysis included only science majors, whose extrinsic goals and intended applications of both grades and course content are likely different from non-majors. Because motivation differs across subjects (Guay et al. 2008) and learning objectives differ across course levels and concentrations, additional studies around how non-majors experience IB are warranted.

Lastly, we note that our initial focus in data collection was not on grades; rather, as we asked students to reflect on their learning experience, grades emerged organically as a theme and thus we framed our analysis accordingly and responsively. If we had set out to explore grades at the start, we would have used different topics and follow-up questions to further tease out students' reactions and responses. Our findings invite more focused studies of grading systems in IB courses.

9 Conclusions

While the theoretical and pedagogical merits of IB are clear, akin to the general non-reporting of negative results in research, there is not much discussion of student objection to it or how instructors should respond to student resistance. Scholars have provided experimental and quantitative evidence around the intersection of extrinsic motivation and pressure to perform in graded situations and the loss of autonomy that accompanies graded tasks (see Pulfrey et al. 2011), and we offer a qualitative complement to these findings, considering students' sense-making processes that underlie these observed behaviors. We hope our analysis will offer insight to helping students navigate the unfamiliar territory of foregrounding joy in learning over security in reward.

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Data Availability Per Institutional Review Board guidance, identifiable student data are not available for third party review. Contact the lead author Dayna DeFeo at djdefeo@alaska.edu for additional information.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Ethics Approval This project was reviewed and approved as human subjects research by the authors' Institutional Review Board.

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