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A Mixed-Methods Evaluation of Ungrading Homework in a Fluid Mechanics Course

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Abstract

To shift student focus from performance to mastery and improve metacognitive skills, assigned and graded homework was replaced with assigned homework that was not collected or graded. Instead, the course homework grade was derived from the completion of a weekly survey that asked students to reflect on their homework effort and study habits. This study took place in a required, third-year fluid mechanics course for mechanical and civil engineering students at a small liberal arts university.

The impact of the intervention was assessed quantitatively via a concept inventory and in-course exams. To assess conceptual knowledge, students completed the fluid mechanics section of the Thermal and Transport Concept Inventory (TTCI) as both a pre- and a post-test. The data showed that both groups ($N_{traditional} = 17$, $N_{ungraded} = 19$) began with equivalent conceptual knowledge. However, the ungraded group achieved significantly higher Post-test TTCI scores compared to the traditional group ($p = .021$, $d = 0.805$).

Considering the exam scores of students taught with the respective methods over the study's duration, the ungraded group ($N_{ungraded} = 38$) scored significantly higher on the first midterm exam ($p = .016$) than the traditionally graded group ($N_{traditional} = 58$), suggesting an acceleration of initial content mastery. Scores on subsequent midterm exams and the final were not significantly different between the groups.

In addition to the quantitative results, selected comments from the in-class surveys and the instructor's anonymous mid-semester evaluation are discussed. Feedback reflected a two-way experience, noting the value of flexibility but also the struggle for motivation in the absence of grades. These findings suggest that an ungrading approach that includes a metacognitive survey is a viable pedagogical tool in core engineering courses, fostering self-regulated learning without compromising student performance on traditional technical assessments.

Introduction and Background

George Fox University is a small, Christian, liberal arts university located in Newberg, OR. The engineering program at George Fox offers a B.S. in Engineering with concentrations in biomedical, civil, computer, electrical, and mechanical engineering. ENGM 330 Fluid Mechanics is a required course for students completing the mechanical and civil engineering concentrations. Students typically take the course during their third year in the program.

The instructor has taught Fluid Mechanics for over 15 years using a traditional pedagogy where homework was assigned, collected, and graded by a TA. However, motivated by a desire to shift student focus from performance (earning points) to mastery and to improve metacognitive skills, the instructor implemented an ungrading approach in Fall 2025. This shift is akin to previous pedagogical changes the instructor implemented to increase student autonomy in the program's

Heat Transfer course [1], where problem-based learning is used to drive student engagement and independent learning.

Course Structure and Intervention

Fluid Mechanics is a 3-credit hour course taught on Mondays, Wednesdays, and Fridays in 50-minute blocks. The course assessment structure included homework, projects, three midterm exams, and a final exam.

Reflecting the instructor's pedagogical view of using homework as practice, prior to Fall 2025, homework was worth 10% of the course grade throughout the study. The homework problems were assigned after each class session. A TA then graded each problem using a 0-3 point scale: 0 for none submitted, 1 for major errors or incomplete, 2 for minor errors, and 3 for a correct solution. Homework solutions were provided after the submission deadline and were available for the remainder of the semester. If a student's semester average for homework was equal to or greater than 70%, their homework average was rounded up to 100%. (If the average was less than 70%, the earned percentage would be applied to homework's 10% of the course grade.)

In Fall 2025, the same homework problems were suggested rather than required; students did not submit homework. Students had access to all homework solutions throughout the semester. While students were still expected to complete homework problems, the homework grade was derived solely from completing a weekly survey about the work from the previous week. The survey was designed to foster metacognition by asking students to reflect on their effort and study habits. The survey included questions focusing on time spent on homework, homework completion rate, and metacognitive reflections, such as identifying learning objectives and primary reasons for exam errors.

For exam weeks, instead of the homework survey, students completed a post-exam survey following the in-class review of their graded exam. Students were asked to identify how they prepared for the exam, why they missed points on each exam problem, and what they would do to prepare for the next exam.

To receive credit for completing a survey, students initially had from noon on Thursday of the week they were reviewing until 11:59 pm Sunday to complete it. About three weeks into the semester, after the instructor received several extension requests, the Sunday deadline was made a "flexible" deadline, and 11:59 pm the night before the next exam was the "inflexible" deadline. (In Canvas, the university's learning management system (LMS), this corresponds with the Assign Access fields "Due Date" and "Until," respectively.) While this deadline extension delayed students' reflection on a given week's learning objective until the "last-minute," they were still reflecting before the exam.

Assessment Instruments

To assess the impact of the ungrading intervention, this study utilized quantitative data from a concept inventory and exam scores, as well as quantitative and qualitative data from weekly

surveys. To assess conceptual understanding, the instructor used the fluid mechanics section of the Thermal and Transport Concept Inventory (TTCI) as pre/post test. The fluid mechanics section of the TTCI is a collection of 26 multiple-choice questions that were rigorously developed using assessment theory [2], [3]. (Examples of the TTCI questions are presented in a near-finalized version in the Appendix of [2].) Students completed the inventory via the AIChE Concept Warehouse [4].

The course included three midterm exams and a comprehensive final exam. The midterm exam questions remained largely consistent throughout the study period, enabling a direct comparison of student performance between the Fall 2025 cohort and previous years. New questions were developed for the 2025 Final Exam, but the topics and scope of each question were maintained.

The weekly survey that students completed instead of required homework included questions designed for them to reflect on metacognition (e.g., their effort and study habits). In addition, they completed voluntary mid-semester and end-of-semester course evaluation surveys, which included open-answer questions such as "What do you like and/or dislike about the approach to homework (problems not graded, required homework or exam survey completion) in this class?" They also responded to questions about what helped them understand the content and what they would like to see changed.

Quantitative Results & Discussion

TTCI Analysis

The TTCI analysis included any student who voluntarily answered at least 14 of the 26 questions on both the Pre-Test and the Post-test in any section of Fluid Mechanics taught by the instructor in Fall 2022 and Fall 2024 (Traditional) and in Fall 2025 (Ungrading). (No data was collected in Fall 2023 due to the instructor's sabbatical.) Table 1 summarizes the demographic data for these students. Student performance, based on the number of correct responses, was normalized to a 0-1.0 scale by dividing by the total number of questions.

Table 1: Demographic data for students completing both TTCI Pre- and Post-tests.

Demographic Information	Condition	Category	*N*	%
Gender	Traditional	Female	5	29.4%
		Male	12	70.6%
	Ungrading	Female	4	21.1%
		Male	15	78.9%
Ethnicity	Traditional	Non-white	3	17.7%
		White	14	82.3%
	Ungrading	Non-white	8	42.1%
		White	11	57.9%

Table 2: Comparisons were performed using simple main effects analysis. The Ungraded group showed significantly higher conceptual gains at the Post-test ($p < .05$).

Timepoint	Condition	Mean	SD	Statistical Comparison
Pre-Test	Traditional	0.442	(0.130)	$F(1, 34) = 0.221, p = .641$
	Ungraded	0.455	(0.140)	
Post-Test	Traditional	0.621	(0.128)	$F(1, 34) = 5.809, p = .021$
	Ungraded	**0.742**	(0.162)	Effect Size: $d = 0.805$

A Repeated Measures ANOVA was conducted with one within-subjects factor (Time: Pre-test vs. Post-test) and one between-subjects factor (Condition: Traditional vs. Ungraded). The Traditional group consisted of students from the 2022 and 2024 cohorts ($N = 17$), while the Ungraded group consisted of the Fall 2025 cohort ($N = 19$). As expected, there was a significant main effect of Time (F(1, 34) = 67.308, p < .001), indicating that students in both groups significantly improved their conceptual understanding of fluid mechanics over the course of the semester.

Analysis of the simple main effects (Table 2) revealed that at the start of the semester, the two cohorts were statistically equivalent, with no significant difference in Pre-test scores (F(1, 34) = 0.221, p < .641). However, the Ungraded group showed a statistically significant improvement on the Post-test compared to the Traditional group by the semester's end (F(1, 34) = 5.809, p = .021). This difference represents a large effect size (Cohen's d = 0.805), indicating that the ungrading approach was associated with higher conceptual gains compared to the traditional grading structure.

Exam Performance

The exam performance analysis included students who completed any section of Fluid Mechanics taught by the instructor in Fall 2022 and Fall 2024 (Traditional) and in Fall 2025 (Ungrading). To mitigate the effects of potential academic dishonesty and students who chose to disengage from the Final Exam, data from students whose Final Exam score was more than 30% below the average of their midterm exams were excluded from the analysis. (Note that the N for these data is higher than the TTCI analysis because completing the TTCI was voluntary, and the exams were required.) Table 3 summarizes the demographic data for these students. All exam scores reported were normalized to a 0-1.0 scale.

Follow-up univariate analyses (Table 4) revealed that the benefits of the ungrading approach were most pronounced toward the beginning of the semester. On Exam 1, the Ungraded cohort scored significantly higher (M = .90, SD = .10) than the Traditional cohort (M = .82, SD = .15). On Exam 2, the Ungraded group maintained an advantage (M = .87 vs. M = .81), with the difference approaching statistical significance (p = .054).

Table 3: Demographic data for students who completed exams.

Demographic Information	Condition	Gender	*N*	%
Gender	Traditional	Female	16	27.6%
		Male	42	72.4%
	Ungrading	Female	8	21.1%
		Male	30	78.9%
Ethnicity	Traditional	Non-white	13	22.4%
		White	45	77.6%
	Ungrading	Non-white	8	21.1%
		White	30	78.9%

Table 4: Comparison of Exam Scores by Grading Condition

	Traditional (*N* = 58)		Ungraded (*N* = 38)		Statistical Comparison	
Assessment	*Mean*	*SD*	*Mean*	*SD*	*F*(1, 131)	*p*
Exam 1	0.82	0.15	**0.90**	0.10	6.01	**.016**
Exam 2	0.81	0.14	0.87	0.12	3.79	.054
Exam 3	0.82	0.16	0.84	0.15	0.01	.935
Final Exam	0.84	0.11	0.82	0.15	1.61	.207

Note: Bold values indicate statistical significance ($p < .05$). Max score = 1.0

Performance converged in the latter half of the course. By the Final Exam, the two groups showed no statistically significant difference in performance ($p = .207$), with the Ungraded group ($M = .82$) performing comparably to the Traditional group ($M = .84$). This convergence suggests that while this ungrading approach may accelerate early conceptual mastery, it supports long-term retention rates equivalent to traditional grading structures.

Weekly Survey Responses

The weekly homework surveys provided quantitative insight into students' self-reported homework completion rate (Figure 1) and their confidence regarding the exam (Figure 2).

Figure 1 illustrates the trends in self-reported homework completion and overall survey participation ($M = 40.3$ students/week). Midterm exams were given in Weeks 4, 7, and 12. Notably, the data reveal a sharp shift in compliance behaviors: the number of students reporting they completed > 50% of the homework problems dropped from 43 in Week 1 to 31 in Week 3. While this decline can be viewed as a lack of engagement, the stabilization of completion rates from Week 8 onward suggests students were exercising the autonomy provided by the course structure to manage their own workload. The number of students completing "None" of the

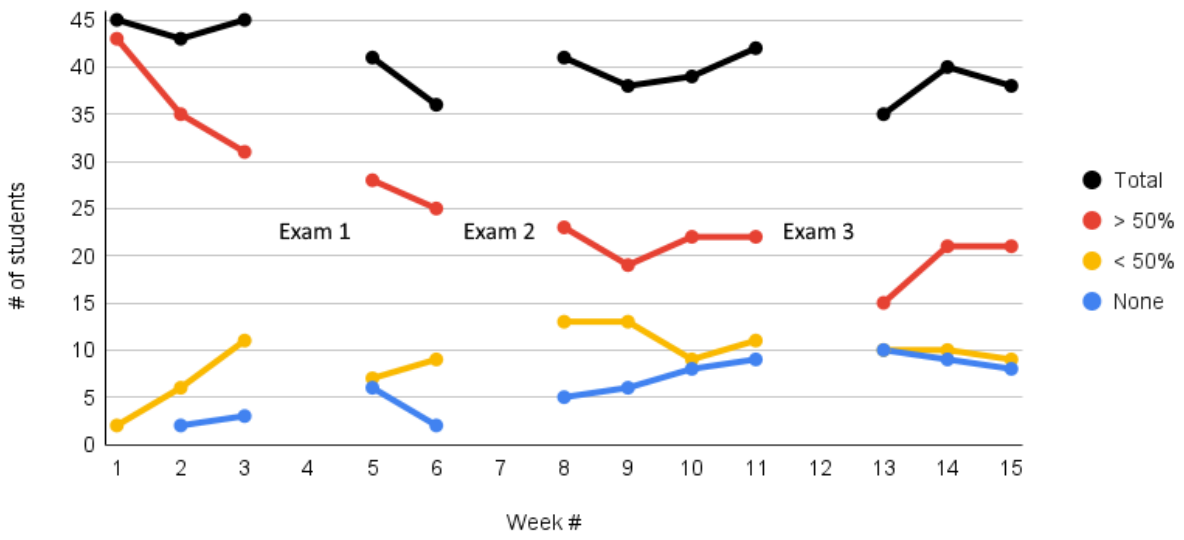


Figure 1: Weekly self-reported homework completion rates. Data represents the quantity of the cohort reporting their completion level for the week's ungraded homework.

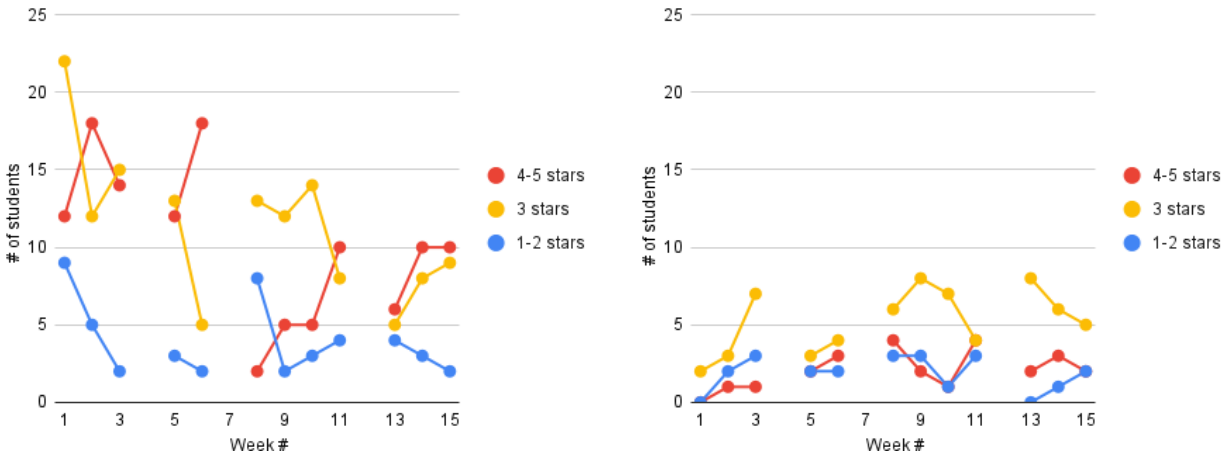
homework increased slightly after mid-semester — from 5 in Week 8 to 9 by Week 11. (Note that during Week 11, students were either completing or starting projects for three courses.) This "strategic skipping" did not correspond to a significant drop in exam performance, further supporting the validity of self-regulated learning.

Figure 2 takes each homework completion curve from Figure 1 — (a) > 50%, (b) < 50%, (c) None — and shows each group's self-reported confidence regarding the upcoming exam (1 star = low confidence, 5 stars = high). The majority of students completing > 50% of the homework consistently reported confidence scores of 3 stars or greater. Those completing < 50% of the homework most often reported 3 stars, while the students completing None of the homework (with a total *N* that never increased beyond 10) reported a variety of confidence levels throughout the semester.

Discussion

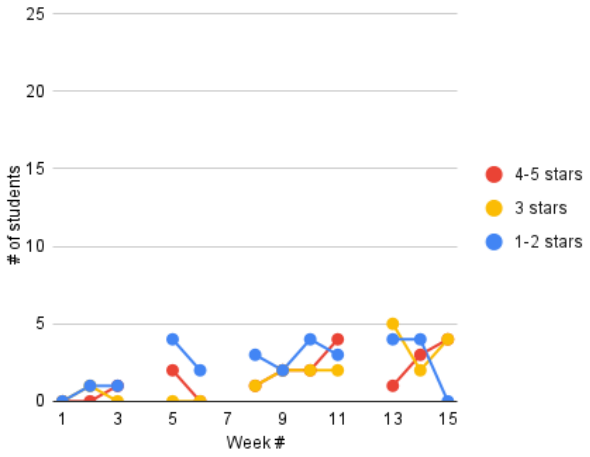
The combined results from the Thermal and Transport Concept Inventory (TTCI) and course examinations present a cohesive picture of student learning under the ungrading framework. The statistically significant improvement in TTCI Post-test scores suggests that removing the transactional pressure of homework grades may have encouraged deeper engagement with fundamental concepts.

This conceptual advantage appears to have translated into immediate performance benefits. The Ungraded cohort significantly outperformed previous cohorts on the first examination, indicating that the ungrading framework allowed students to acclimate to the rigorous course material more effectively than traditional incentives. While exam performance between the groups converged by the third midterm exam, this convergence indicates that the ungrading approach successfully



(a)

(b)



(c)

Figure 2: Weekly self-reported confidence (1 star = low, 5 stars = high) regarding the upcoming exam for students who completed (a) > 50%, (b) < 50%, and (c) None of the homework.

maintained the high academic standards of the course.

Critically, the fact that the Ungraded group achieved equivalent Final Exam scores while simultaneously demonstrating superior conceptual gains on the TTCI implies a discrepancy in what these instruments measure. While standard exams often reward procedural problem-solving, the TTCI targets misconceptions. The ungrading pedagogy, with its emphasis on metacognition through weekly surveys, may have fortified students' conceptual frameworks, preventing the formation of common misconceptions that often persist even in high-performing engineering students.

Comparing quantitative responses on the weekly surveys to the concept inventory and exam assessments, the decline in reported homework completion and the maintenance of high academic performance support giving students autonomy for their learning. As illustrated in the survey data, the sharp drop in "perfect" homework completion after Week 1 did not precipitate a corresponding decline in summative assessment scores. Instead, this trend likely reflects a transition from performative compliance — completing assignments solely for points — to strategic self-regulation, where students allocated their time based on their perceived need for practice. This metacognitive adjustment is further evidenced by the confidence data, which showed that the majority of students successfully identified high-stakes periods, reporting peak self-efficacy immediately preceding exams. Thus, the ungrading framework appeared to empower students to treat homework as a formative resource, fostering the professional skill of independent workload management while maintaining rigorous academic standards.

Qualitative Results & Discussion

Substantive qualitative feedback from students concerning the ungraded homework was typical of what others have highlighted [5]. Some students valued the flexibility of not having a due date and the self-pacing it provided. Yet, other students struggled with the motivation to complete homework that was not required.

Two student responses on the mid-semester survey captured this two-way experience:

- "I like the freedom to not have to do the hw if I'm busy, but I don't learn as much when I don't do the hw. The hw seems more like a recommended resource to help aid your learning for a particular topic. Not having it required helps me have more time in my days for other things and it also helps build some discipline in me to do the hw when I can so that I learn more."
- "I do really like this approach. But at the same time I struggle to keep a high priority on homework when I am not required to turn it in."

While captured on a survey at one point in the semester, these themes were present throughout the semester. During check-in conversations with students, the instructor would hear similar value and challenge statements of flexibility and motivation, respectively, toward ungrading.

In an effort to provide some extrinsic motivation without reinstituting grades, the instructor offered all students the option of an accountability check-in starting in Week 9. For the students who volunteered, the instructor went to them individually at the start of each class and asked how their homework was "going." Student response to this query varied from a basic "Nope" or a look of shame to a thumbs up or "Not right now, but I'm planning to do it this weekend." If students responded with just a "No," the instructor would often follow up with, "Do you have a plan?" If students expressed shame along with their response, the instructor often replied, "I'm just checking in." The objective was to provide accountability, not to shame.

On the mid-semester open response survey question about the ungraded homework, a student responded, “Like that it is flexible, but definitely appreciate the new accountability program for homework.”

Limitations

While this study’s results, especially the statistically significant increase in concept inventory performance, were promising, the *N* was very low. To strengthen the current study and enable analysis of the interventions’ impact on gender and ethnicity, data from more Traditional cohorts prior to Fall 2022 and Ungraded cohorts after Fall 2025 are needed. Yet, this may also introduce uncontrollable time-varying factors beyond the grading method. In addition, since most students voluntarily complete the Pre-test each year, the instructor will focus on approaches to motivate more students to complete the Post-test.

The data from the required weekly survey responses provided ample resolution of student engagement. However, survey fatigue may have contributed to certain response patterns as well as a decline in overall survey participation (45 in Week 1; 38 in Week 15).

Due to the voluntary accountability check-in that the instructor started in Week 9, selection bias may exist in the qualitative results. Students who opted in may have already been more motivated or receptive to feedback than the general cohort.

Conclusion and Implications

This study demonstrates that removing traditional grading from homework in a third-year Fluid Mechanics course did not compromise student performance on a concept inventory or exams. The significantly higher score on Exam 1 by the Ungrading cohort suggests that the ungrading structure may accelerate initial grasp of new, difficult material. In addition, this ungrading approach does not sacrifice problem-solving abilities, as evidenced by overall exam performance. If future cohorts continue to show the TTCI gains demonstrated in this study, the method also appears to foster a deeper conceptual understanding.

The instructor believes that the observed conceptual gains are likely driven by the metacognitive emphasis within the homework and exam survey structure, rather than simply the removal of cognitive penalties through ungraded assignments. Having students reflect on their learning helps to develop valuable professional skills, such as time management and self-regulated learning. Exam performance converged following the adjustment of the weekly survey deadline to a flexible/inflexible format, suggesting a potential (though not necessarily correlational) link. Returning to a fixed weekly deadline could compel students into more regular reflection on their learning, which may, in turn, facilitate the consistent refinement of their understanding.

Another implementation recommendation focuses on leveraging students’ established use of the university’s LMS, Canvas. To maintain students’ routine of using the Canvas as a dashboard, all traditional homework assignments and their due dates will be published. However, the instructor will set the “Display Grade as” field to “Not graded.” This approach allows students to view due

dates as helpful reference points, supporting their normal workflow. In addition, the Canvas "Until" date field can be set to the day before the subsequent exam. This provides structured guidance for students without compromising the fundamental principles of the ungrading philosophy.

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