COMPARISON OF STUDENT LEARNING ATTITUDES, KNOWLEDGE, AND OUTCOMES TOWARDS HONEY BEES IN ONLINE OR IN-PERSON INSTRUCTIONAL ENVIRONMENTS

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Author Note

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Abstract

Honey bee pollination of specialty crops is essential to agriculture and yet there are almost no university instructional programs to train the next generation of beekeepers. One reason for this lack of university investment in apiculture instruction is that there may not be enough students located at universities interested in the pursuit of beekeeping education. Teaching beekeeping as an online course can increase the number of students; however, two important questions emerge from the varying methods of teaching beekeeping: (a) Are online and in-person courses similar at teaching beekeeping principles, and (b) do the varying learning design methods change student perceptions in favor of honey bees and beekeeping? We investigated these questions with the use of an optional and anonymous online survey for students in both the 100% online Beekeeping course and the blended Practical Beekeeping course at the University of Florida during the summer semesters of 2021 and 2022. The survey was not a part of students' grade. The survey included a set of ten questions, evaluated on a Likert-type scale using a static group comparison design and a set of eight multiple choice questions to test potential differences in knowledge gained. Our findings suggest the relevance and value of both in-person and online beekeeping educational courses for improving knowledge and changing attitudes toward honey bees and the recruitment of future contributors to the beekeeping industry.

Keywords: beekeeping, online learning, constant comparative method, intent, learning outcomes

Interest in beekeeping has grown tremendously in recent years, primarily in the number of hobbyist or backyard beekeepers; however, the beekeeping industry has suffered significantly. Honey production, for example, has decreased by 28% over the past decade, and the number of colonies producing honey decreased by 9% (USDA NASS, 2014; USDA NASS, 2024). Nevertheless, managed honey bee colonies are critical to our modern agricultural systems. Honey bees contributed an estimated $17 billion to agricultural production in 2009 (Calderone, 2012), and more recently the sale of honey and honey bee products were valued at $350 million in 2023 (USDA NASS, 2024). In 2020, Florida beekeepers produced an estimated 15 million pounds of honey, 102,000 pounds of comb honey, 300,000 pounds of beeswax, and were involved in other aspects of beekeeping such as selling bees, queens, complete and nucleus hives, making the state the 4th largest honey producing state in the U.S. (USDA-NASS, 2022). Despite the growing beekeeping community and continued contribution to world economic systems, there has been relatively little effort put toward formal beekeeping or honey bee education at the university level.

A potential criticism of formalized beekeeping education at the university is that there are few students interested

in pursuing beekeeping as a career (Ferguson, 2007). This promotes the offering of these beekeeping courses in an online format that have a greater potential of attracting students outside of the educator's physical location. However, online courses may not be an effective method of instruction compared to in-person and hands-on courses for a topic as kinetic as beekeeping. For example, students in a microbiology laboratory that attended in-person were more likely to report a tactile learning style, compared to students that attended online (Brockman et al., 2020). Similarly, in an introductory field course, students reported lower community building in an online version of the course, but an increased self-sufficiency in research and observational skills (Race et al., 2021). In terms of performance, students taking human anatomy showed no significant differences between learning in-person vs. online (McKivigan et al., 2021), and students learning biostatistics in-person and online showed no significant difference in differential performance (Hoffman & Elmi, 2020). Overall, outcomes of in-person compared to online courses likely are influenced more by course design and subject material than the course format itself. However, the course format has not been formally explored for beekeeping education.

Online beekeeping education may also suffer from not having as large of an impact on student behavior and perceptions, again likely due to the lack of hands-on experience with honey bees. However, online education can affect students positively. In a recent study regarding the meat industry, researchers utilized the post-then-pre design to gauge students' attitudes and knowledge towards the meat industry pre-class and post-class (Carr et al., 2020). Students who completed both online surveys showed an improved attitude toward the meat industry. Again, no one has yet observed how various course instruction formats affect student perception related to the beekeeping industry.

Purpose and Hypotheses

The purpose of this study was to determine if differences exist between student attitudes, knowledge, and outcomes regarding honey bees between an in-person and online beekeeping course. We hypothesized that students in the online course would respond to bees more positively and gain more knowledge than in-person classes due to the group's lack of experience with hands on beekeeping experiences. Additionally, we hypothesized that students with prior beekeeping experience, prior beekeeping courses taken, and at a later stage in their academic studies would respond more positively than the rest of the students.

Methods

Study Design and Population

We used a static group comparison design between two beekeeping courses at University of Florida to fulfill our study's purpose. A static group comparison design allowed us to study two different beekeeping courses (Beekeeping I, online and Practical Beekeeping, blended) with only one course's students receiving stimuli or treatment (Ary et al., 2006). For this study, the stimuli consisted of in-person experiences such as colony management, honey extraction, and proper beekeeping tool use. Beekeeping I, an undergraduate beekeeping course that is taught 100% online, was the study group that did not receive the stimuli as there were few in-person or hands-on beekeeping activities as part of the course. This course requires students to observe another person working bees at least once during the semester. The Practical Beekeeping course, which is also an undergraduate beekeeping program, employs a hybrid teaching model that combines online and in-person elements (i.e. the stimuli). Both courses cover similar topics, such as basic honey bee biology, beekeeping equipment usage, pests and diseases, and honey extraction. Students in both courses answered the same questions in their assessments. A total of 72 students participated in the study from one of the beekeeping courses over a two-year period, with 38 participating in the online course and 34 participating in the in-person course. Of the total 72 students that responded to the survey, 85% (n = 61) had no experience in beekeeping prior to participating in their beekeeping course.

Instrumentation

The static group comparison design was accompanied by a test at the end of the semester (Ary et al., 2006) that allowed us to compare the results from the online and blended beekeeping courses. A survey was created in Qualtrics to evaluate students' attitudes, comfortability, and knowledge regarding beekeeping practices. The first section of the survey evaluated students' beekeeping attitudes using a retrospective pretest and a traditional posttest using a five-point Likert scale. Other studies, such as Sowcik et al. (2018), Abrams et al. (2015), and Rockwell and Kohn (1989), have utilized this design to measure the outcomes of a treatment or stimuli. The Likert-type scale ranged from 1 = *strongly disagree* to 5 = *strongly agree*. The scale had a moderately high reliability (Cronbach, 1971) of Cronbach's $\alpha = 0.682$ in the pretest and $\alpha = 0.743$ in the posttest.

Next, students were asked to answer a set of eight knowledge-based questions pertaining to course material that would have been covered in both courses to measure changes in knowledge gain (Table S1 for results). Each question consisted of four answer choices and the students had to mark which answer they felt was correct. The total scores of this test were used as a covariate in later analyses. Demographic data were collected regarding whether students had previously taken beekeeping courses, whether students had prior beekeeping knowledge, year in school, and sex.

The third section of the survey consisted of four open-ended questions to gauge respondents' experiences in their beekeeping courses. Students were asked the following questions: "How has this course changed your perceptions towards honey bees?", "Has this course changed the way that you will interact with honey bees in the future?", "How will you apply knowledge/skills learned in this class to your personal lives?", and "How will you apply knowledge/skills learned in this class to your professional lives?". The

entire instrument was reviewed by a panel of experts to establish face and content validity prior to data collection. The researchers received approval from the University of Florida Institutional Review Board prior to collecting data.

Data Collection

Students from both courses in 2021 and 2022 received the online survey via email during the final week of class. A reminder email was sent one week after class ended to complete the survey. Completion of the survey was requested but not mandatory for course credit from students. The questions posed to students (N = 72) can be viewed in Table 1. Response rates for each survey in each course were shown in Table 2.

Data Analysis

We used a paired t-test to test differences between pre- and post-course assessment responses. Following the initial test, a correlation matrix was made between post-course questions to ensure significantly different responses between questions. To test differences between post-course responses and various response variables (current course, prior courses, score on post-course test, and demographic variables) we used a linear model (Gaussian distribution) for each question with the model structure: [Question ~ prior course (y/n) + test score (total number correct) + current course (online/blended) + beekeeping experience (y/n) + year in school (freshman/sophomore/junior/senior/graduate student)].

Table 1

Paired means and statistical significance of beekeeping attitudes. Bold p-values indicate significance at the 0.05 alpha level.

	Beekeeping Attitudes	Before		After				
		M	*SD*	*M*	*SD*	*t*	*p*	*d*
1	Managing honey bee colonies is essential to modern agriculture	4.28	.78	4.78	.44	5.17	**<.001**	0.83
2	Honey bees harm the ecosystem by outcompeting native pollinators	2.31	1.04	2.28	1.01	0.22	0.41	1.01
3	Current beekeeping practices are ethical and consistent with animal welfare principles	3.84	.78	4.19	.77	2.87	**0.01**	1.06
4	The use of in-hive pesticides to control honey bee pests and diseases are necessary	3.39	.92	3.77	.90	2.63	**0.01**	1.24
5	I feel nervous when I see a honey bee near me	2.75	1.39	1.83	1.14	4.58	**<.001**	1.74
6	I am going to wear a full beekeeping suit if I open a honey bee hive	3.64	1.32	2.68	1.57	4.38	**<.001**	1.89
7	Occasionally being stung is just a part of beekeeping	4.26	.79	4.62	.59	3.42	**<.001**	0.92
8	I am genuinely interested in learning more about honey bees and beekeeping	4.28	.89	4.73	.55	3.85	**<.001**	0.99
9	I desire to keep my own honey bee colonies at some point	3.59	1.19	4.26	.95	4.16	**<.001**	1.37
10	I am considering beekeeping as a future profession	2.35	.95	2.59	1.17	1.84	**0.03**	1.13

Note. Respondents were asked to rate their agreeance regarding their beekeeping perceptions and attitudes before and after participating in the beekeeping courses on a Likert-type scale: *1 = Strongly disagree, 2 = Disagree, 3 = Neither agree nor disagree, 4 = Agree, and 5 = Strongly agree.*

Table 2

Respondents in each class and year. The percentage of students that responded were listed as the response rate.

Year	Course	Responded	Total	After	Response rate
2021	Practical Beekeeping	21	30	4.78	70%
2021	Beekeeping I	20	67	2.28	29.85%
2021	Total	41	97	4.19	42.27%
2022	Practical Beekeeping	13	23	3.77	56.52%
2022	Beekeeping I	18	87	1.83	20.69%
2022	Total	31	110	2.68	28.18%
Both	Total	72	207	4.62	34.78%

The constant comparative method was used to reduce the data from the five open-ended questions into identifiable, recurring themes (Lincoln & Guba, 1985). Trustworthiness was addressed through triangulation and peer debriefing (Eisner, 1991). The full team of researchers collaborated on the final interpretation of the data in a form of triangulation. An audit trail (Carcary et al. 2020) was maintained throughout the data analysis process, first individually, and then collectively. The researchers open-coded the qualitative responses individually first and then came together to compare the open-codes. The final open codes were agreed upon by all researchers. Finally, the researchers together created the axial codes, and direct quotes from the respondents were used to create a description of the findings.

Results

Attitudinal Changes Amongst In-Person and Online Beekeeping Courses

The paired t-test revealed that answers were significantly different before and after participating in beekeeping courses for all questions except question 2 (Table 1). Questions 5 ("I feel nervous when I see a honey bee near me") and 6 ("I am going to wear a full beekeeping suit if I open a honey bee hive") decreased significantly in agreement from the post reflective survey, and all other questions significantly increased (Table 1).

Between courses, two questions had significantly different responses in the post-course questionnaire. Question 3 ("Current beekeeping practices are ethical and consistent with animal welfare principles.") had significantly higher agreement in the blended course than the online course (Table 3; Figure 1). Question 6 ("I am going to wear a full beekeeping suit if I open a honey bee hive.") had significantly higher agreement in the online course than the blended course (Table 3; Figure 2). Additionally, students of a higher class in school (Senior/Graduate students) were significantly more likely to agree to question 6 (Table 3). Students who had taken prior courses in beekeeping were less likely to agree to question 5 ("I feel nervous when I see a honey bee near me") than students with no prior courses taken (Table 3). Finally, responses to questions 4 and 5 correlated with average test scores. For question 4 ("The use of in-hive pesticides to control honey bee pests and diseases are necessary"), test scores and the likelihood to agree were negatively correlated, while the two were positively correlated for question 5 ("I feel nervous when I see a honey bee near me") (Table 3).

The change in Question 2 ("Honey bees harm the ecosystem by outcompeting native pollinators") was significantly different between the two courses (Figure 3; $F_{1,63} = 5.92$, p-value = 0.018). The blended course decreased agreement with the question by the end of the course (-0.4 ± 0.21 SE), whereas the online course slightly increased in agreement (0.22 ± 0.25 SE). Additionally, students with higher test scores were more likely to increase their agreement with Question 2 (Figure 4; $F_{1,63} = 4.15$, p-value = 0.046). No other question showed significant differences in the change between the pre- and post-assessment.

Figure 1

Average agreement in post-course assessment to question 3: "Current beekeeping practices are ethical and consistent with animal welfare principles." Practical beekeeping is the blended course and Beekeeping I is the online course. Dots are means and bars are S.E.

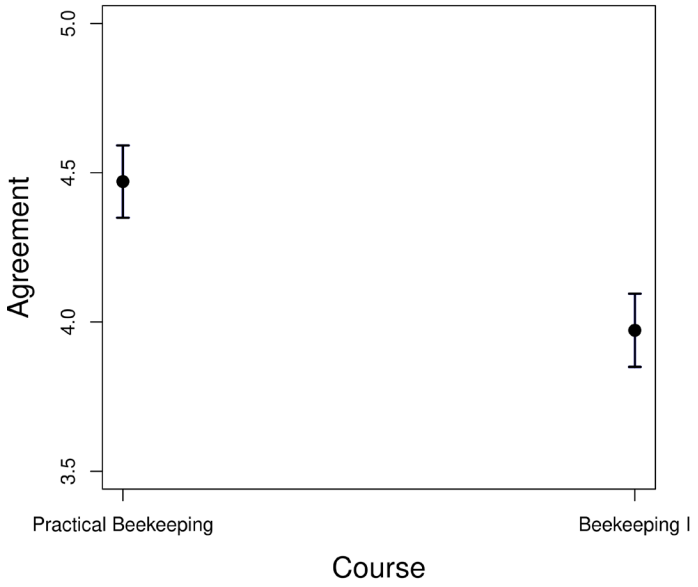

Figure 2

Average agreement in post-course assessment to question 6: "I am going to wear a full beekeeping suit if I open a honey bee hive." Practical beekeeping is the blended course and Beekeeping I is the online course. Dots are means and bars are S.E.

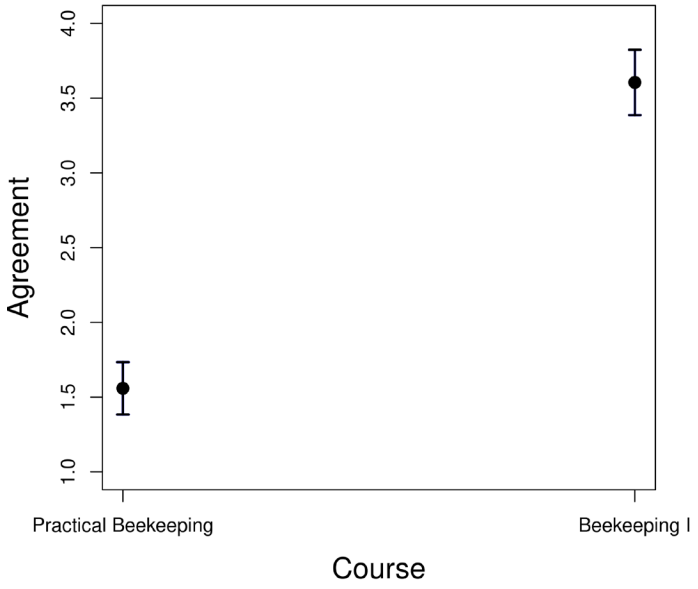

Table 3

Significant effects of response variables on questions asked in the examination for after students took courses. Significant differences at the 0.05 alpha level are bold.

Beekeeping attitudes	Response Variable	Estimate	S.E.	*t*-value	*p*-value
1. Essential for agric.	Intercept	5.58	0.5	11.12	<0.001
	Prior course (Y)	0.04	0.19	0.23	0.819
	Test Score (total num.)	-0.13	0.09	-1.51	0.136
	Current Course (Online)	-0.05	0.12	-0.39	0.701
	Beekeeping exp. (Y)	-0.28	0.18	-1.54	0.129
	Year in school (Sen./ GS)	-0.05	0.11	-0.41	0.681
2. Outcompeting natives	Intercept	1.52	1.08	1.4	0.166
	Prior course (Y)	-0.05	0.42	-0.12	0.909
	Test Score (total num.)	0.11	0.18	0.63	0.533
	Current Course (Online)	0.06	0.26	0.25	0.802
	Beekeeping exp. (Y)	-0.24	0.39	-0.62	0.537
	Year in school (Sen./ GS)	0.2	0.25	0.81	0.42
3. Ethical	Intercept	4.12	0.83	4.95	<0.001
	Prior course (Y)	0.04	0.32	0.14	0.89
	Test Score (total num.)	0.06	0.14	0.4	0.689
	Current Course (Online)	**-0.47**	**0.2**	**-2.4**	**0.018**
	Beekeeping exp. (Y)	0.07	0.3	0.22	0.828
	Year in school (Sen./ GS)	-0.01	0.19	-0.03	0.979
4. In-hive pesticides	Intercept	6.19	1.12	5.56	<0.001
	Prior course (Y)	0.15	0.35	0.42	0.676
	Test Score (total num.)	**-0.33**	**0.15**	**-2.26**	**0.028**
	Current Course (Online)	0.03	0.22	0.15	0.879
	Beekeeping exp. (Y)	0.13	0.34	0.39	0.698
	Year in school (Sen./ GS)	0.03	0.21	0.15	0.89
5. Nervousness	Intercept	-2.13	1.29	-1.65	0.103
	Prior course (Y)	**-0.92**	**0.43**	**-2.11**	**0.039**
	Test Score (total num.)	**0.51**	**0.17**	**3.03**	**0.004**
	Current Course (Online)	0.15	0.27	0.56	0.581
	Beekeeping exp. (Y)	0.14	0.41	0.35	0.728
	Year in school (Sen./ GS)	0.34	0.26	1.29	0.203
6. Wear beekeeping suit	Intercept	-0.57	1.48	-0.39	0.699
	Prior course (Y)	-0.6	0.5	-1.21	0.233
	Test Score (total num.)	0.26	0.2	1.32	0.191
	Current Course (Online)	**1.93**	**0.31**	**6.31**	**<0.001**
	Beekeeping exp. (Y)	0.13	0.48	0.27	0.792
	Year in school (Sen./ GS)	**0.61**	**0.3**	**2.05**	**0.044**
7. Being stung	Intercept	4.42	0.82	5.4	<0.001
	Prior course (Y)	0.1	0.26	0.39	0.697
	Test Score (total num.)	0.03	0.11	0.25	0.807
	Current Course (Online)	-0.1	0.16	-0.63	0.529
	Beekeeping exp. (Y)	-0.08	0.25	-0.32	0.75
	Year in school (Sen./ GS)	0.1	0.16	0.58	0.565

Table 3 cont.

Significant effects of response variables on questions asked in the examination for after students took courses. Significant differences at the 0.05 alpha level are bold.

Beekeeping attitudes	Response Variable	Estimate	S.E.	*t*-value	*p*-value
8. Want to learn more	Intercept	4.59	0.76	6	<0.001
	Prior course (Y)	0.1	0.24	0.42	0.68
	Test Score (total num.)	0.03	0.1	0.26	0.8
	Current Course (Online)	-0.07	0.15	-0.48	0.63
	Beekeeping exp. (Y)	-0.1	0.23	-0.41	0.685
	Year in school (Sen./ GS)	0	0.15	0.02	0.988
9. Desire to keep bees	Intercept	5.03	1.3	3.87	<0.001
	Prior course (Y)	0.67	0.41	1.63	0.108
	Test Score (total num.)	-0.09	0.17	-0.51	0.61
	Current Course (Online)	-0.08	0.25	-0.31	0.76
	Beekeeping exp. (Y)	-0.11	0.39	-0.28	0.784
	Year in school (Sen./ GS)	-0.27	0.25	-1.07	0.288
10. Future profession	Intercept	2.75	1.42	1.94	0.057
	Prior course (Y)	-0.54	0.45	-1.2	0.233
	Test Score (total num.)	0.02	0.19	0.12	0.908
	Current Course (Online)	-0.35	0.27	-1.28	0.207
	Beekeeping exp. (Y)	-0.1	0.43	-0.23	0.821
	Year in school (Sen./ GS)	-0.09	0.27	-0.32	0.75

Knowledge Gain Changes Amongst In-Person and Online Beekeeping Courses

Test scores were not significantly affected by any variable (prior course taken in beekeeping, current course, beekeeping experience, year in school; Table 4). When test scores were used as an explanatory variable, the questions regarding in-hive pesticides and nervousness were significantly affected by test score (Table 3). The question regarding in-hive pesticides was negatively correlated with test scores, and nervousness was positively correlated.

Perceptions of Working with Honey Bees Upon Completion of the Beekeeping Courses

When asked "How has this course changed your perceptions towards honey bees?" respondents that took the online course (*n* = 28) reported having increased appreciation (*n* = 8), increased knowledge (*n* = 8), and increased comfortability (*n* = 7) (Table 5). Respondents that took the blended course (*n* = 31) reported having increased appreciation (*n* = 9), increased knowledge (*n* = 3), increased comfortability (*n* = 7), and increased confidence (*n* = 3) (Table 5). Furthermore, of the respondents in the blended course that noted increased comfortability, several mentioned "honey bees to be less defensive than previously believed" (*n* = 5). Both groups reported outcomes of increased appreciation of honey bees, increased comfortability, and increased knowledge. However, a greater percentage (though not statistically significant) of online students

Figure 3

The average change in agreement with Question 2: "Honey bees harm the ecosystem by outcompeting native pollinators". Practical beekeeping is the blended course and Beekeeping I is the online course. Dots are means and bars are S.E.

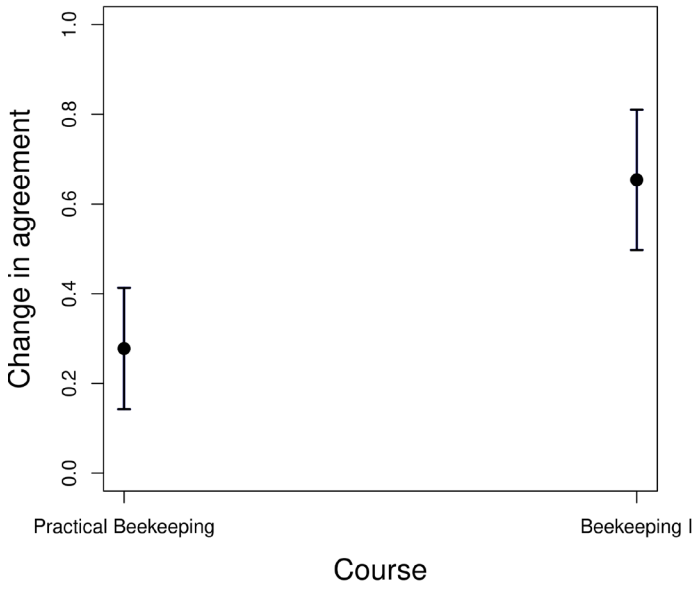

Figure 4

Effect of test scores on the change in Question 2. The significant effect of higher test scores leading to an increase in agreement with Question 2 was driven by Beekeeping I (online course), though there was no significant interaction between the two courses and test score.

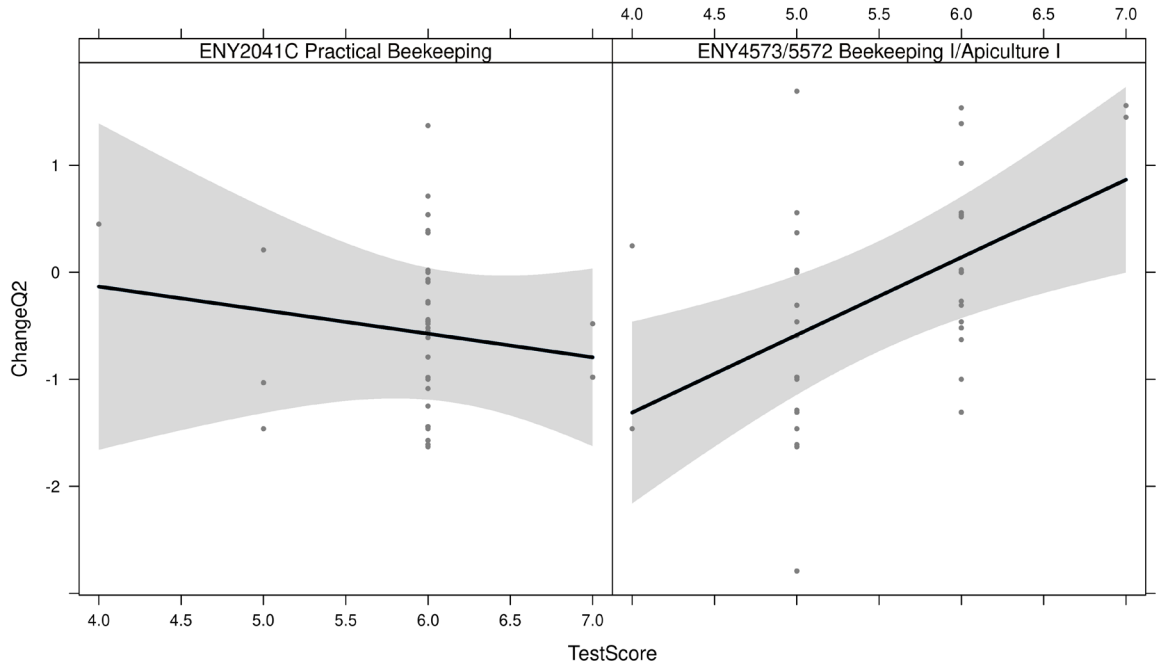

Table 4

Significance of fixed effect variables on the test score (continuous variable). Significant values at the alpha 0.05 value are in bold font.

Explanatory variable	Response Variable	Estimate	S.E.	t-value	p-value
Test Score	Intercept	7.46	0.17	45	<0.001
	Prior Course (Y)	0.34	0.31	1.11	0.27
	Current Course (Online)	-0.33	0.19	-2.77	0.082
	Beekeeping exp. (Y)	-0.24	0.3	-0.81	0.42
	Year in school (Sen./GS)	0.06	0.19	0.32	0.752

reported an increase in knowledge but a lesser percentage reported increased comfortability than in-person students.

When asked “Has this course changed the way that you will interact with honey bees in the future?”, respondents of the online course (*n* = 34) reported outcomes of increased comfortability (*n* = 10), the intent of future honey bee colony ownership (*n* = 11), and no change in intent (*n* = 4) (Table 6). Respondents of the blended course (*n* = 30) reported outcomes of increased comfortability (*n* = 10) and increased confidence (*n* = 5) along with the intent of future honey bee colony ownership (*n* = 12) (Table 6). An increase in confidence was noted by a higher percentage of students taking the in-person format (Tables 5, 7, and S3).

When asked “How will you apply knowledge/skills learned in this class to your personal lives?”, respondents of the online course (*n* = 31) reported the intent of future honey bee colony ownership (*n* = 10) and to educate others about honey bees (*n* = 8). They also noted the outcomes of better colony management (*n* = 5), increased knowledge (n = 5), and increased awareness of honey bees (*n* = 3) (Table 7). Respondents of the blended course (*n* = 28) reported the intent of future ownership (*n* = 16) and to educate others (*n* = 10) (Table 7). A larger percentage of in-person students reported intent of future honey bee colony ownership and intent to educate others.

When asked “How will you apply knowledge/skills learned in this class to your professional lives?”, respondents of the online course (*n* = 29) reported the intents of pursuing a future career in beekeeping (*n* = 3), pursing future hobbyist level beekeeping (*n* = 3), educating others (*n* = 3). They also noted the outcome of valuable workplace skills (*n* = 2). Others noted the uncertainty of how class knowledge will be applied to their professional lives (*n* = 10) (Table 8). Respondents of the blended course (*n* = 28) reported intentions of bettering beekeeping relations in their non-beekeeping career (*n* = 8), pursuing a future career in beekeeping (*n* = 6), participating in honey bee research (n = 3), and educating others about honey bees (*n* = 1). These students also noted the outcome of beneficial workplace skills (*n* = 5) (Table 8).

A larger percentage of students at the senior/graduate levels also reported increased confidence, intent of future

Table 5

Responses of Beekeeping I (online) and Practical Beekeeping (blended) courses to "How has this course changed your perceptions towards honey bees?" HB = Honey bees.

Response variable	Group	Answer	*f*	%
Course enrolled	Beekeeping I Online N = 28	Increased appreciation	8	28.6%
		Increased knowledge	8	28.6%
		Increased comfortability	7	25%
		HB less defensive	1	3.6%
	Practical Beekeeping Blended N = 35	Increased comfortability	15	42.9%
		Increased appreciation	9	25.7%
		HB less defensive	5	14.3%
		Increased knowledge	3	8.6%
		Increased confidence	3	8.6%
Prior course in honey bees taken	Yes N = 7	HB less defensive	2	28.6%
		Increased appreciation	1	14.3%
		Increased knowledge	0	0%
		Increased confidence	1	14.3%
		Increased comfortability	0	0%
	No N = 56	Increased comfortability	15	26.8%
		Increased appreciation	18	32.1%
		Increased knowledge	11	19.6%
		HB less defensive	4	7.1%
		Increased confidence	2	3.6%
Year in school	Freshman,sophomore, junior N = 23	Increased appreciation	7	30.4%
		Increased knowledge	4	17.4%
		Increased confidence	1	4.3%
		Increased comfortability	7	30.4%
		HB less defensive	4	17.4%
	Senior, graduate student N = 40	Increased comfortability	8	20%
		Increased appreciation	12	30%
		Increased knowledge	7	17.5%
		Increased confidence	2	5%
		HB less defensive	2	5%

ownership, intent to educate others, intent to improve relations in other career areas and intent of future research, indicating a potential correlation between course taken and student age (blended course taken aligns with upper-level student responses) (Tables 6-8). In response to application of knowledge, upper-level students responded at a larger percentage with the theme of better colony management, which aligns with online course responses (Table 7).

Although comparisons were made between students that had taken previous courses related to honey bees and students that had not (Tables 5-8), there were many more students that had not, so comparisons would likely not be relevant (Table 5: N = 7 vs. N = 57, Table 6: N = 10 vs. N = 60, Table 7: N = 8 vs. N = 49, Table 8: N = 9 vs. N = 60).

Discussion

We observed that the course delivery had a significant effect on students' attitudes toward several of the questions posed in the post-then-pre design assessment. Attitudes toward questions regarding ethics and the essential nature of keeping honey bees increased in agreement at the end of the semester for both courses except for Question 2 relating to the impact of honey bees on native pollinators. Additionally, attitudes related to nervousness around bees, protection and being stung changed positively overall in both online and in-person courses. Finally, all students showed an increase in interest and desire to learn more about honey bees regardless of the course structure. Therefore, we conclude that beekeeping education has an overall positive impact on students, regardless of whether they are participating online or with an in-person offering of a course.

Table 6

Responses of Beekeeping I (online) and Practical Beekeeping (blended) courses to "Has this course changed the way that you will interact with honey bees in the future?"

Response variable	Group	Answer	*f*	%
Current course enrolled	Beekeeping I Online N = 28	Intent of future ownership	11	31.4%
		Increased comfortability	10	28.6%
		No change in intent	4	11.4%
		Increased confidence	1	2.9%
	Practical Beekeeping Blended N = 35	Intent of future ownership	12	34.3%
		Increased comfortability	11	31.4%
		Increased confidence	5	14.3%
		No change in intent	0	0%
Prior course in honey bees taken	Yes N = 10	Intent of future ownership	2	20%
		Increased comfortability	3	30%
		No change in intent	0	0.0%
		Increased confidence	3	20%
	No N = 60	Intent of future ownership	21	35%
		Increased comfortability	18	30%
		No change in intent	4	6.7%
		Increased confidence	3	5%
Year in school	Freshman,sophomore, junior N = 26	Intent of future ownership	11	42.3%
		Increased comfortability	9	34.6%
		No change in intent	0	0%
		Increased confidence	1	3.8%
	Senior, graduate student N = 44	Intent of future ownership	12	27.3%
		Increased comfortability	12	27.3%
		No change in intent	4	11%
		Increased confidence	5	11.4%

In our research to inspect differences between course formats, we have revealed interesting dichotomies. First, students with hands-on beekeeping experience throughout the course were more likely to agree with ethical considerations of keeping honey bees, as stated in attitude Question 3. These students also maintained agreement with attitude Question 2, whereas the students in the online course increased in agreement with the notion that honey bees may be outcompeting native bees. We conclude that the ethical considerations of beekeeping practices were more favorably interpreted by students in the in-person course, in comparison to the online course, and students in the in-person course likely drove the overall positive attitude of Question 3 in Table 1. In the overall paired t-test, there was no significant change in attitude Question 2, which was likely a result of opposite directionality between the two courses.

Based on the result of attitude Questions 5 and 6 in the paired t-test, the overall effect showed increased comfort in being around honey bees in both course structures, though students in the blended course showed more comfort based on their response to attitude Question 6. Additionally, students further along in their degree were also more likely to wear less protective equipment. While our study does not reveal the cause of this comfort, it is possible that by being at the university longer, these students may have had more time to become comfortable around bees or interact with others who have been exposed to honey bees. There was also evidence that students who had taken prior beekeeping courses were less likely to agree to attitude Question 5 ("I feel nervous when I see a honey bee near me"). This is most likely due to their previous exposure to honey bees and additional knowledge on the topic.

Our findings show that students who scored lower on the test were more likely to agree that pesticides are necessary and that those who scored higher correlated with feeling nervous around honey bees is unexpected. It is likely, however, that these findings are simply due to the small sample size of the student participants and not an accurate reflection of the nature of students in beekeeping courses. Regarding the correlation between lower test scores and the agreement that pesticides are necessary, it could be that students that received lower scores missed some nuance in a complex topic. Exploration into student perceptions should be examined further. In general, test scores as a response variable were not significantly affected by any of the fixed effects.

Perception question 1 indicated increased comfort in students overall. This finding aligns with previous studies that showed similarities in knowledge acquisition between

Table 7

Responses of Beekeeping I (online) and Practical Beekeeping (blended) courses to "How will you apply knowledge/skills learned in this class to your personal lives?"

Response variable	Group	Answer	*f*	%
Current course enrolled	Beekeeping I Online N = 28	Intent of future ownership	11	39.3%
		Intent to educate others	8	28.6%
		Better colony management	5	14.3%
		Increased knowledge	5	17.9%
		Increased awareness	3	10.7%
	Practical Beekeeping Blended N = 29	Intent of future ownership	16	55.2%
		Intent to educate others	10	34.5%
		Better colony management	1	3.4%
		Increased knowledge	0	0%
		Increased awareness	1	3.4%
Prior course in honey bees taken	Yes N = 8	Intent of future ownership	6	42.9%
		Intent to educate others	1	12.5%
		Better colony management	0	0%
		Increased knowledge	2	25%
		Increased awareness	0	0%
	No N = 49	Intent of future ownership	21	42.9%
		Intent to educate others	17	34.7%
		Better colony management	4	8.2%
		Increased knowledge	5	10.2%
		Increased awareness	4	8.2%
Year in school	Freshman,sophomore, junior N = 20	Intent of future ownership	8	40%
		Intent to educate others	6	30%
		Better colony management	0	0%
		Increased knowledge	2	10%
		Increased awareness	1	5%
	Senior, graduate student N = 37	Intent of future ownership	19	51.4%
		Intent to educate others	12	32.4%
		Better colony management	6	16.2%
		Increased knowledge	3	8.1%
		Increased awareness	3	8.1%

online and in-person courses (Hoffman and Elmi, 2020, McKivigan et al. 2021), and corroborate findings from attitude questions. Perception question 2 also showed evidence for an increase in confidence for the in-person students, which aligns with a previous study that showed students taking an in-person course were more likely to report a tactile learning style (Brockman et al. 2020). This finding is interesting given that students in both courses responded similarly based on comfortability with honey bees, however only in-person students responded regarding confidence. Only one student in the online course responded with the theme of increased confidence.

Overall, our study showed that there were no differences in course performance outcomes between teaching honey bee focused courses in-person compared to online. Students taking an in-person course showed increased comfort in proximity to honey bees and responded more positively (in favor of honey bees) to ethical concerns. Students did not respond differently to questions regarding future careers or interest in honey bees, regardless of the course structure. Based on the results of our study, we would recommend pairing students with local beekeepers or requiring a field trip for hands-on experience in cases where online learning is necessary. Having some proximity to honey bees while taking honey bee related courses can improve comfort and performance in courses of this type.

Table 8

Responses of Beekeeping I (online) and Practical Beekeeping (blended) courses to "How will you apply knowledge/skills learned in this class to your professional lives?"

Response variable	Group	Answer	*f*	%
Current course enrolled	Beekeeping I Online N = 30	Uncertain	10	33.3%
		Intent to educate others	10	33.3%
		Intent on improving beekeeping relations in other careers	5	16.7%
		Intent of future beekeeping career	3	10%
		Intent of hobbyist beekeeping	3	10%
		Valuable workplace skills	2	6.7%
		Intent to volunteer	2	6.7%
	Practical Beekeeping Blended N = 29	Intent to educate others	12	41.4%
		Intent of improving beekeeping relations in other careers	8	27.6%
		Intent of future beekeeping career	6	20.7%
		Valuable workplace skills	5	17.2%
		Intent of future research	3	10.3%
		Intent to volunteer	3	10.3%
		Uncertain	2	6.9%
		Intent of hobbyist beekeeping	1	3.4%
Prior course in honey bees taken	Yes N = 9	Uncertain	2	22.2%
		Intent to educate others	3	33.3%
		Intent of improving beekeeping relations in other careers	3	33.3%
		Intent of future beekeeping career	2	22.2%
		Intent of hobbyist beekeeping	4	44.4%
		Valuable workplace skills	1	11.1%
		Intent to volunteer	0	0%
	No N = 50	Intent to educate others	19	38%
		Intent of improving beekeeping relations in other careers	10	20%
		Intent of future beekeeping career	5	10%
		Valuable workplace skills	7	14%
		Intent of future research	1	2%
		Intent to volunteer	6	12%
		Uncertain	5	10%
		Intent of hobbyist beekeeping	10	20%
Year in school	Freshman,sophomore, junior N = 20	Uncertain	1	5%
		Intent to educate others	6	30%
		Intent of improving beekeeping relations in other careers	2	10%
		Intent of future beekeeping career	3	15%
		Intent of hobbyist beekeeping	3	15%
		Intent to volunteer	3	15%
	Senior, graduate student N = 37	Intent to educate others	16	43.2%
		Intent of improving beekeeping relations in other careers	11	29.7%
		Intent of future beekeeping career	6	16.2%
		Valuable workplace skills	4	10.8%
		Intent of future research		
		Intent to volunteer	2	5.4%
		Uncertain	11	29.7%
		Intent of hobbyist beekeeping	1	2.7%

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