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An Analysis of Action Competence Among Biology Education Students in the Context of Education for Sustainable Development

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Abstract: Within the framework of developing Action Competence (AC) in Education for Sustainable Development (ESD), semester level is an important variable as it reflects students' learning experiences, engagement, and academic maturity, as well as its contribution to conceptual understanding, willingness to act, and self-efficacy among prospective biology teachers. This study used a quantitative descriptive approach with a cross-sectional survey design involving 81 biology education students who were enrolled in or had completed the Environmental Knowledge course. Data were collected using the Likert-scale Action Competence in Sustainable Development (ACiSD) instrument and analyzed through normality testing, descriptive statistics, and one-way ANOVA using JASP. Results showed that students' action competence toward ESD was in the high category (M = 74.87; SD = 9.42). All four indicators—conceptual understanding, willingness to act, self-efficacy, and outcome expectancy—also showed high scores across semesters. Although scores increased up to the sixth semester, ANOVA revealed no significant differences ($p > 0.05$), indicating that action competence development is more influenced by learning experiences than by semester level.

Keywords: Action Competence (AC); Biology Education Students; Education for Sustainable Development (ESD).

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Introduction

Human activities have contributed substantially to environmental degradation, posing serious threats to the sustainability of the earth and the future of coming generations (Klarin, 2018). This condition has stimulated the emergence of ESD as a global framework to address the impacts of human activities on the environment and climate change, emphasizing the need for a balanced integration of economic, social, and ecological dimensions (Putra & Nugraheni, 2024). The integration of ESD into biology education enhances students' conceptual mastery and fosters higher order cognitive skills necessary for addressing complex environmental challenges (Kusumaningrum et al., 2022). The integration of ESD within a Technological Pedagogical Content Knowledge (TPACK) framework highlights the necessity of embedding sustainability competencies as a core dimension of 21st-century biology teacher professionalism (Anwar et al., 2025a).

In this context, ESD plays a crucial role, as education serves as a key mechanism for developing sustainability competencies required to respond to these challenges (Purnamasari & Nurawaliyah, 2023). One of the core competencies in sustainable education is action competence, which encompasses individuals knowledge, willingness, and self efficacy to engage in concrete actions that support sustainability (Chen & Liu, 2020). Action competence is strongly associated with ESD as it emphasizes the capacity for critical and reflective thinking, as well as the ability to take action in response to sustainability issues, for prospective biology teachers, this competence serves as a fundamental basis for shaping educators who not only possess a solid understanding of biological concepts, but are also capable of fostering sustainability awareness and pro-environmental behaviors among students (Husamah et al., 2022; Lasino et al., 2023; Tristananda, 2018).

Ali & Anufriev (2020) demonstrated that the education and research dimension has a significant influence on improving campus environmental quality, highlighting the strategic role of universities in supporting the implementation of ESD. Through the integration of sustainability issues into teaching activities, research, and academic programs, universities can foster pro environmental awareness and behaviors among students, although students awareness of campus environmental policies remains relatively low. This finding is consistent with the study conducted by Hudi et al. (2022), which indicates that although students in accounting education and science education may not be familiar with the term ESD, they are nevertheless able to comprehend sustainability concepts through everyday practices. Meanwhile, 83,13% of Biology Education students at Universitas Islam Riau demonstrated positive perceptions of ESD.

In line with this, Erlina (2022) also emphasized that the implementation of sustainable development plays an important role in achieving the Sustainable Development Goals (SDGs) in higher education. Higher education institutions are therefore responsible for enhancing students' understanding and awareness of ESD. Each

academic semester reflects a distinct stage of learning experience, ranging from the acquisition of basic concepts to the ability to apply knowledge in real world contexts. Consequently, within the framework of developing action competence in ESD, the semester variable becomes a crucial aspect to be examined, as it provides insights into how students' learning experiences, engagement, and academic maturity evolve across semesters, and how these factors contribute to their understanding, willingness, and self-efficacy as prospective biology teachers.

In the context of higher education, academic semester is often used as an indicator of students' academic development, reflecting their cognitive, affective, and psychomotor maturity throughout the learning process (Anggraini & Nazip, 2022; Fatika et al., 2024; Hurlock, 2011). Differences in students' levels of understanding and readiness to implement ESD have been identified across semesters, with students in higher semesters demonstrating stronger sustainability competencies than those in earlier semesters (Juryatina et al., 2024). Briefly, this study refers to the concept of action competence proposed by Sass et al. (2021), in which Action Competence in Sustainable Development (ACiSD) is defined as the ability of individuals or groups to consciously act in addressing sustainability issues, rather than merely understanding them. Accordingly, the capacity for action constitutes a central element in various ESD concepts and models (Schönstein & Budke, 2023).

Although several previous studies have examined students' understanding and attitudes toward ESD, relatively few have investigated differences in levels of action competence based on semester or level of study. This is consistent with the findings of Chen & Liu (2020), who argued that action competence remains an emerging area of research within ESD, with limited empirical studies specifically exploring its development in higher education contexts. Similarly, Torsdottir et al. (2024) reported that the relationship between educational experiences and action competence has not been widely examined across different levels of study or academic semesters. In fact, each semester represents a distinct stage of academic development and learning experience, which may influence students' reflective abilities, willingness to act, and self efficacy in relation to sustainability issues. Therefore, this analysis is essential to determine whether progression across semesters corresponds with improvements in students' critical thinking and their capacity to engage in concrete actions within the ESD framework.

Methods

This study employed a quantitative descriptive approach using a cross-sectional survey design, aiming to obtain a comprehensive understanding of population characteristics through representative sample data (Maidiana, 2021). The research population consisted of 81 biology education students who were currently enrolled in or

had completed the environmental knowledge course. A total sampling technique was applied, whereby the entire population was included as the research sample.

The study was conducted from May to July 2025. Data were collected using a questionnaire administered through Google Forms and printed survey sheets, based on a Likert scale scoring system as presented in Tables 2 and 3. The research instrument used was the Action Competence in Sustainable Development (ACiSD) questionnaire, which had been tested for validity and reliability and was developed by Sass et al. (2021) based on the self efficacy dimension related to contributions to ESD. The instrument consisted of four indicators, each comprising nine statement items, as detailed in Table 1.

Table 1.
Indicators and Number of Items in the Action Competence Instrument

Indicator	Number of items
Conceptual Knowledge	9
Willingness	9
Capacity Expectations	9
Outcome Expectancy	9

This study employed academic semester as the primary independent variable to analyze variations in ESD related action competence across different stages of the undergraduate program, and this analysis is conducted across all indicators presented in Table 1. This demographic variable serves to collect essential background information about the respondents in order to ensure population representativeness, enhance the relevance of the research findings, and facilitate a more accurate generalization of the results (Susanto et al., 2024).

Table 1.
Likert Scale Categories and Action Competence Score Values for the Conceptual Knowledge, Willingness, and Outcome Expectancy Indicators

Statement	Score Value
Strongly Agree	5
Agree	4
Neutral	3
Disagree	2
Strongly Disagree	1

Table 2.
Likert Scale Categories and Score Values for the Self-Efficacy Indicator (Action Competence)

Statement	Score Value
Definitely (high capacity expectation)	5
Probably	4
Maybe	3
Probably not	2

Definitely not	1

Source: (Sass et al., 2021)

Data analysis was conducted in several stages. First, a normality test was performed on the final scores of the semester-level variable. Subsequently, descriptive statistical analyses were applied to the conceptual knowledge, willingness, capacity expectations, and outcome expectancy indicators. Finally, a one way analysis of variance (ANOVA) was conducted for each indicator to examine differences across semester levels. All statistical analyses were performed using the JASP software.

Table 3.
Categories of Action Competence in Sustainable Development (ACiSD)

Category	Score Range (0–100)
Very High	81 - 100
High	61 - 80
Moderate	41 - 60
Low	21 - 40
Very Low	0 - 20

Source: (DeVellis, 2016)

Results & Discussion

As prospective educators, biology education students are required to develop a comprehensive understanding of ESD in order to effectively promote sustainability values among future generations (Misriani et al., 2023). ESD extends beyond the transmission of knowledge related to sustainability issues, such as climate change and biodiversity, and places strong emphasis on the development of action competence, which refers to individuals capacity to critically evaluate alternative courses of action and to make informed decisions in addressing sustainability challenges (Chen & Liu, 2020; Hedefalk et al., 2014). Accordingly, the assessment of students action competence is crucial to examine not only their conceptual understanding of sustainability but also their readiness to engage in concrete and responsible actions.

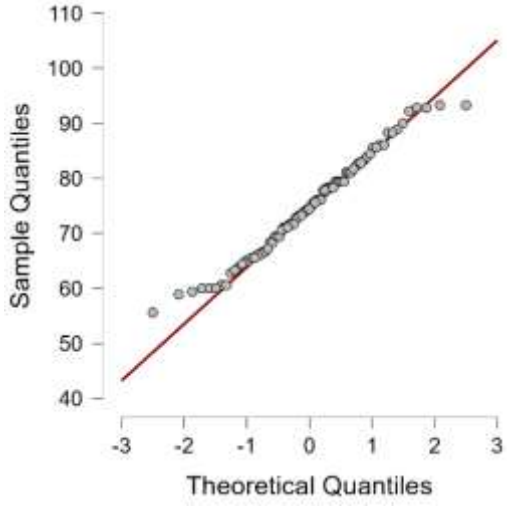
Based on this framework, action competence data in the present study were collected using a Likert-scale questionnaire. At the initial stage of analysis, descriptive statistics and normality tests were performed on the final action competence scores, as presented in Table 5 and Figure 1. Descriptive statistics were employed to summarize and describe the distribution of the data, while the normality test was conducted to determine whether the data met the assumption of normality as a prerequisite for further statistical analyses (Mark & Sampson, 2019).

Table 4.
Differences in Action Competence in Sustainable Development among Students Based on Final Action Competence Scores

	Valid	Missing	Mean	Std. Deviation	Kolmogorov - Smirnov	Minimum	Maksimum

Final Score	81	0	74,86	9,41	0,97	55,60	93,30

Figure 1.
Q-Q Plot of the Normal Distribution of Students' Final Action Competence Scores



Based on Table 5, the results of the descriptive statistical analysis of action competence scores among biology education students present an overall positive profile. The mean score of 74,87 out of a maximum scale of 100 indicates that students' level of action competence falls within the high category. Furthermore, the Q-Q Plot shown in Figure 1 reveals that most data points follow the diagonal line, suggesting that the distribution of students' action competence scores approximates a normal distribution and satisfies the assumption of normality. This interpretation is consistent with Field (2018), who stated that data can be considered normally distributed when the points on a Q-Q Plot align closely with the diagonal line without extreme deviations.

These findings are in line with the study conducted by Sinakou et al. (2019), which reported that science education students, who possess a deeper understanding of natural systems, tend to demonstrate a higher propensity to engage in sustainability related actions. The relatively high mean score reflects that students not only cognitively understand ESD concepts but have also internalized its values and exhibit a willingness to act as agents of change (Mahlaole, 2025).

Table 5.
Differences in Biology Education Students' Action Competence toward Education for Sustainable Development (ESD) Based on Final Score Data by Semester Level

	Semester	Valid	Missing	Mean	Std. Deviation	Minimum	Maksimum
Final Scores by Semester Variable	2	29	0	72,72	9,49	55,60	88,90
	4	11	0	76,10	9,12	60,60	93,30

	6	32	0	76,70	10,17	58,90	93,30
	8	9	0	73,70	5,63	65,60	82,20

The descriptive analysis shows that the action competence of biology education students across all semesters is in the high category, with mean scores ranging from 72.72 to 76.70. A slight increase is observed from semester 2 to semester 6, although the differences are relatively small. In semester 8, the mean score slightly decreases compared to semester 6 but remains within the high category. This decline may be explained by the smaller number of active final-semester students, as many have completed their coursework or are primarily focused on finishing their final projects.

From a pedagogical perspective, these findings can be interpreted through the lens of developmental psychology and transformative education. Students in the early semesters are typically still in the process of adapting to the higher education learning environment, and therefore tend to focus more on cognitive aspects and basic conceptual understanding. As students progress through the semesters, they are exposed to more diverse and contextual learning experiences, such as field practices, environmental projects, and research activities, which contribute to the development of action competence. This explains why the mean scores in semesters 4 and 6 are relatively higher than those in semester 2 (Hurlock, 2011; Husamah et al., 2022; Piaget, 2001).

Based on the analysis presented in Table 6, it can be concluded that although students across different semester levels demonstrate relatively high levels of action competence, semester level is not the primary factor influencing the development of sustainability competence. These findings suggest that the enhancement of action competence is more strongly determined by the quality of learning experiences and the extent to which the principles of ESD are meaningfully integrated into the learning process. This is consistent with the findings of (Sari et al., 2025), who emphasized that sustainability competence is more influenced by pedagogical approaches and the quality of learning experiences than by academic level alone.

ANOVA analyses were conducted on each Action Competence indicator conceptual knowledge, willingness, capacity expectations, and outcome expectance based on the model of Sass et al. (2021), to identify students' strengths and weaknesses across semester levels (Table 7).

Action competence of biology education students in Education for ESD conceptual knowledge indikator

Table 6.
Action Competence of Biology Education Students Conceptual Knowledge Indicator

	Semester	Valid	Missing	Mean	Std. Deviation	Minimum	Maximum
Conceptual Knowledge	2	29	0	71,87	10,47	51,10	91,10
	4	11	0	76,16	11,15	60,00	100,00

Indicator	6	32	0	79,37	10,48	60,00	100,00
	8	9	0	76,28	8,08	64,40	86,70

Descriptive analysis revealed that the mean scores for the conceptual knowledge indicator among biology education students were consistently high across all semesters, exceeding 70. Sixth semester students achieved the highest score (79,37), followed by eighth (76,29), fourth (76,16), and second semester students (71,88). These results indicate a strong understanding of sustainability concepts and the principles of ESD, demonstrating that the biology curriculum effectively develops students' conceptual competence in comprehending environmental, social, and economic issues holistically. Studies in Indonesia have confirmed that the implementation of ESD in higher education is not only theoretically relevant but also effective in enhancing students' sustainability competence, including their holistic understanding of environmental issues (Ferguson et al., 2022; Vilmala et al., 2025).

Action competence, closely linked to ESD, emphasizes critical and reflective thinking as well as readiness to act on sustainability issues. For pre-service biology teachers, mastering this competence is essential to foster sustainability awareness and behavior among students (Gurning & Selaras, 2025). The increase in scores from the second to sixth semester highlights the role of lectures, laboratory work, and field projects in enhancing students understanding of ESD (Husamah et al., 2022; Novidsa et al., 2020).

Sixth semester students superior performance reflects the cumulative effect of academic and field experiences that strengthen critical thinking on sustainability, aligning with Yolida et al. (2023), who emphasized the importance of integrating local and cultural contexts into environmental education. Overall, the high scores across semesters indicate that the biology program successfully develops foundational sustainability knowledge, though further reinforcement in affective and practical dimensions is needed to translate understanding into meaningful action. To examine differences in students' conceptual understanding of ESD across semesters, a one way analysis of variance (ANOVA) was conducted, as presented in Table 8.

Table 7.
One-Way ANOVA Test on the Conceptual Knowledge Indicator

Cases	Sum of Squares	df	Mean Square	F	P	Kolmogorov - Smirnov	
						Statistic	P
Semester	857,46	3	285,82	2,66	0,05	0,06	0,86
Residuals	8251,89	77	107,16				

Based on the results of the ANOVA test for the conceptual knowledge indicator, an F-value of 2,66 with a p-value of 0,05 was obtained. The p-value, slightly above the conventional threshold of 0,05, indicates that there are no statistically significant differences in students conceptual knowledge across semester levels. Nevertheless, the relatively high F-value (2,66) suggests a tendency toward differences in conceptual

understanding among semesters, warranting further attention to potential factors influencing these variations.

Students in higher semesters are assumed to have received greater exposure to course materials and more extensive field-based learning experiences related to sustainability issues (Baiquni & Astuti, 2018). However, students levels of understanding of the concepts of ESD appear to be relatively consistent across all semesters, indicating that students at different academic levels have developed a sound understanding of sustainability principles. Although differences between semesters were not statistically significant, the observed trend of increasing scores from the second to the sixth semester, as presented in Table 6, suggests that longer learning experiences contribute positively to strengthening students understanding of ESD concepts. Accordingly, the ANOVA results confirm that, despite the absence of significant differences between semesters, the biology learning process has consistently fostered strong sustainability understanding across all levels of students. This interpretation is supported by literature indicating that higher education institutions progressively promote sustainability competence through systematic integration of ESD into the curriculum, thereby enhancing students sustainability competencies over time (Wahyuni et al., 2024).

To assess Biology Education students' willingness to engage in sustainability oriented actions, a descriptive analysis was conducted on the willingness indicator across semester levels. Table 9 presents the mean scores, standard deviations, and minimum and maximum values for each group.

Action competence of biology education students in ESD willingness indicator

Table 8.
Action competency of biology education students on the willingness indicator

	Semester	Valid	Missing	Mean	Std. Deviation	Minimum	Maximum
willingness indicator	2	29	0	73,33	10,72	55,60	91,10
	4	11	0	79,40	11,27	62,20	93,30
	6	32	0	79,59	11,85	57,80	100,00
	8	9	0	74,07	7,55	64,40	88,90

Based on the descriptive statistical analysis presented in Table 9, the mean scores for the willingness indicator among biology education students were high across all semesters: 73,33 (Semester 2), 79,40 (Semester 4), 79,59 (Semester 6), and 74,07 (Semester 8). All mean scores exceed 70, indicating that students exhibit a high level of willingness to engage in sustainability oriented actions. The standard deviations ranged from 7,55 to 11,85, reflecting moderate variability in willingness among individuals within each semester.

These findings suggest that biology education students possess a strong intrinsic motivation to participate in sustainability related activities (Fatika et al., 2024). The

increase in mean scores from semester 2 to semester 6 reflects the development of students willingness in line with their psychological maturation, as early adulthood is associated with enhanced self awareness, social responsibility, and reflective capacity regarding the consequences of one's actions. According to Competente (2019), pre-service teachers act as change agents, fostering ecological awareness among students through action and reflection based pedagogy. Research in ESD highlights the importance of action competence as a core learning outcome, where willingness to act is recognized as a key motivational dimension of sustainability competence (Vidal & Kuckuck, 2025).

A oneway ANOVA was conducted to examine differences in students conceptual knowledge across semesters. The results are presented in Table 10.

Table 9.
One-Way ANOVA Test on the Willingness Indicator

Cases	Sum of Squares	df	Mean Square	F	P	Kolmogorov - Smirnov	
						Statistic	P
Semester	737,91	3	245,97	2,08	0,10	0,06	0,86
Residuals	9089,80	77	118,04				

Based on the results of the ANOVA test for the conceptual knowledge indicator presented in Table 10, an F-value of 2.084 was obtained, with degrees of freedom (df) = 3 between groups and df = 77 within residuals. The corresponding p-value = 0.10 indicates that, at the conventional significance level ($\alpha = 0.05$), there are no statistically significant differences in mean conceptual knowledge scores among the four semester groups.

Although there is some variation in the mean scores across semesters with an increase up to semester 6 followed by a slight decrease in Semester 8 the ANOVA results suggest that these differences are not strong enough to be considered statistically significant. University level students are generally in the formal operational stage, where their abstract, analytical, and reflective thinking abilities have matured (Santrock, 2019). This developmental stage likely contributes to the absence of pronounced differences across semesters, as students have achieved relatively similar cognitive maturity, particularly in processing complex concepts such as sustainability and ecological responsibility. Olsson et al. (2016) emphasized that action competence does not develop automatically through cognitive learning alone rather, it emerges through reflective experience, critical dialogue, and direct engagement in real world actions. Therefore, as future educators, biology education students are expected not only to understand sustainability theory but also to possess the capacity to integrate ESD values into biology teaching practices at the school level.

Table 11 presents the descriptive results of the capacity expectations indicator of action competence among biology education students, reflecting their confidence in making decisions and taking sustainability related actions.

Action competence of biology education students in ESD capacity expectations indicator

Table 10.
Action Competence of Biology Education Students on the Capacity Expectations Indicator

	Semester	Valid	Missing	Mean	Std. Deviation	Minimum	Maximum
Capacity Expectations Indicator	2	29	0	73,71	10,23	51,10	93,30
	4	11	0	74,54	10,67	60,00	97,80
	6	32	0	78,05	12,12	55,60	100,00
	8	9	0	73,83	8,53	60,00	88,90

Based on Table 11, the mean scores for the capacity expectations indicator among biology education students were high across all semesters, ranging from 73,71 to 78,05. The highest scores were observed in Semester 6, while the lowest were in Semester 2. This range indicates that, overall, students possess strong confidence in their ability to act and contribute to sustainability related issues. The standard deviations (SD) ranged from 8,53 to 12,12, reflecting some individual variability in self efficacy levels. The maximum score reached 100, suggesting that some students have achieved an optimal level of self efficacy within the context of action competence and ESD.

Piaget (2001) emphasizes that every human action involves two interrelated aspects: affective (emotional/motivational) and cognitive (thought/knowledge). Self efficacy falls within the affective domain and plays a crucial role in transforming attitudes and behaviors toward sustainability. Students with high selfefficacy are more capable of initiating actions, participating in environmental activities, and confidently communicating sustainability values within both academic and community settings. For biology education students as future educators, it is not enough to merely understand ecological and sustainability concepts theoretically they must also possess pedagogical self-efficacy to integrate ESD principles into biology teaching (Hedefalk et al., 2014). Teachers with high self efficacy tend to motivate students, inspire tangible actions, and foster ecological awareness through reflective and participatory teaching approaches. Therefore, developing action competence in biology education students requires a balance of knowledge, experience, and confidence. Through the integration of ESD approaches and reinforcement of self efficacy, students are expected to develop into critical, reflective, and action oriented biology educators capable of addressing global environmental challenges.

To examine whether there are differences in self efficacy levels among biology education students across semesters, a one way ANOVA was conducted. This test aimed to analyze the influence of semester level on the self efficacy indicator, a key component of action competence within the context of ESD. The results are presented in Table 12.

Table 11.
One Way ANOVA Test on the Capacity Expectations Indicator

Cases	Sum of Squares	df	Mean Square	F	P	Kolmogorov - Smirnov	
						Statistic	P
Semester	336,39	3	112,13	0,93	0,42	0,08	0,63
Residuals	9210,38	77	119,61				

Based on the ANOVA results presented in Table 12, an F-value of 0,93 with a p-value of 0,42 ($p > 0.05$) was obtained. The significance level exceeding 0,05 indicates that there are no statistically significant differences in self efficacy among students across semesters. In other words, students from early to advanced semesters exhibit relatively similar levels of confidence in addressing sustainability issues and making decisions related to sustainable actions.

The analysis in Table 12 suggests that the self efficacy of biology education students in acting within the context of sustainability is consistent from semester 2 through semester 8. This implies that students confidence in linking biology concepts with sustainability practices has been uniformly established across all academic stages. These findings can be explained through Piaget (2001) cognitive development theory, which posits that students in early adulthood are in the formal operational stage. Academic and social experiences at the university level contribute to the stability of students' self efficacy. At this stage, individuals are capable of reflective, logical, and abstract thinking, such that their confidence is no longer primarily dependent on semester level but rather on learning experiences and supportive social environments (Hurlock, 2011).

Although no significant differences were found across semesters, these results indicate that university level biology education has been successful in fostering relatively stable self efficacy across all academic stages. Project based learning, field research, and reflective activities can reinforce this stability by providing hands on experiences that enhance students confidence in linking biological knowledge with sustainable actions (Sudarto et al., 2025). Therefore, even in the absence of statistically significant differences between semesters, it is essential for higher education institutions to continue strengthening learning activities that maintain and develop students self efficacy, preparing them to become highly action oriented educators.

The following table presents descriptive analysis results for the outcome expectancy indicator, which reflects biology education students belief that their actions can generate positive impacts. The data are presented according to semester for the current academic year and provide insights into the distribution and trends of action competence levels across different student cohorts.

Action competence of biology education students in ESD outcome expectancy indicator

Table 12.
Action Competence of Biology Education Students on the Outcome Expectancy Indicator

	Semester	Valid	Missing	Mean	Std. Deviation	Minimum	Maximum
Outcome Expectancy Indicator	2	29	0	74,01	11,26	60,00	97,80
	4	11	0	77,26	8,43	62,20	88,90
	6	32	0	74,02	11,73	53,30	95,60
	8	9	0	73,82	9,79	62,20	93,30

The data analysis presented in Table 13 indicates that the average scores for students belief in the positive impact of their actions fall within the high category across all semesters, namely 74,01 in semester 2, 77,26 in semester 4, 74,02 in semester 6, and 73,82 in semester 8. These findings suggest that biology education students generally possess a strong level of confidence in the effectiveness of their actions in responding to sustainability issues, particularly in relation to pro environmental behaviors such as waste management, energy and water conservation, and participation in environmental conservation activities. The increase in scores in semester 4 compared to semester 2 reflects a strengthening of self confidence, which may be influenced by students' increased exposure to sustainability related content, learning experiences, and academic activities. Although a slight decline is observed in semester 8, the scores remain within the high category, indicating that students self confidence in acting for sustainability has been relatively well established and remains stable rather than fluctuating across academic levels.

Furthermore, these findings highlight the strategic role of biology education students as prospective educators in supporting the realization of sustainable development through the mastery of action competence. This competence is not only related to knowledge, but also encompasses the ability to think critically, reflect on values, and make effective decisions and actions in addressing environmental and sustainability challenges (Sass et al., 2021). With a high level of self confidence, students possess important psychological capital to function as agents of change, both in classroom learning contexts and in everyday life practices.

The results for the outcome expectancy indicator demonstrate that students possess a high level of confidence in their ability to generate positive impacts on sustainability. This is important because, as pre-service biology teachers, they are not only required to master scientific concepts but also to instill the values of ESD in students and to support the development of pedagogical competencies necessary for fostering sustainability values and behaviors (Anwar et al., 2025). Strong self efficacy encourages

students to be more proactive and innovative in designing biology lessons that foster environmental awareness and tangible actions (Akça, 2019). Thus, the analysis of the outcome expectancy indicator underscores that the development of action competence in biology education students serves as a fundamental foundation for producing educators who can act as change agents in promoting sustainable development within schools.

To examine differences in students belief in the positive impact of their actions across semesters, a one way ANOVA was conducted to assess the effect of semester on the outcome expectancy indicator of action competence within the ESD framework. The results are presented in Table 14.

Table 13.
One Way ANOVA of Biology Education Students' Outcome Expectancy

Cases	Sum of Squares	df	Mean Square	F	P	Kolmogorov - Smirnov	
						Statistic	P
Semester	95,71	3	31,90	0,26	0,85	0,10	0,37
Residuals	9300,14	77	120,78				

Based on the analysis presented in Table 14, the ANOVA results showed $F(3,77) = 0,26$, $p = 0,85$ ($p > 0.05$), indicating that there are no significant differences in action competence among students in Semesters 2, 4, 6, and 8. The Sum of Squares for the semester variable (95,71) is substantially smaller than the Residuals (9300,14), suggesting that the variation explained by semester differences is minimal compared to the variation within groups.

The findings of this study provide important implications for the education of prospective biology teachers. The results indicate that improvements in action competence do not automatically follow students' academic progression, even though students in higher semesters have been exposed to more learning content and practical experiences. This suggests that the development of action competence cannot rely solely on knowledge transmission, but requires learning experiences that promote reflection, action oriented skills, and the continuous internalization of values. These findings are consistent with Lohmann et al. (2021), who emphasized that action competence is developed through transformational learning processes, and are further supported by Sass et al. (2021), who argued that action competence is more strongly influenced by the quality of learning experiences than by the mere accumulation of knowledge.

Conclusion & Recommendation

Based on the overall analysis, it can be concluded that biology education students exhibit a high level of Action Competence in the context of ESD, with an average score of 74,87 out of a maximum of 100. Students in semester 8 displayed slightly lower average scores compared to Semester 6, yet they still fall within the high category. This finding is

consistent with the factual condition that fewer students remain active in Semester 8, as many have completed their studies or are focused on final projects or theses.

The analysis of the four action competence indicators revealed no statistically significant differences across semesters, as all ANOVA results showed significance values above 0,05. This indicates that students action competence does not develop linearly with academic progression, but is more strongly influenced by the quality of learning experiences. Therefore, biology teacher education should emphasize meaningful learning and the consistent integration of ESD principles to enhance students sustainability competencies at each academic semester.

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