ICCE 2023 Learning Outcomes of Computer Programming and Information Technology - Integrated Courses for Non-Computer Science Majors: Case Study of a Public Research University in Taiwan

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Abstract: This study investigates non-CS major students' performance in computer programming and Information Technology-integrated (ITI) courses at a Taiwanese research university. Non-CS students struggle in introductory programming due to syntax and logical thinking limitations, resulting in lower grades compared to advanced programming. Similarly, ITI course grades are lower due to subject-specific demands. Gender and entry channels impact outcomes, with females excelling in informal learning. Favorable results are seen in individual applications and Multi-star Projects. Challenges include different learning paces and cultural adjustments. Regression analysis shows Introduction to Computer Programming (ICP), Advanced Computer Programming (ACP) and gender significantly affect ITI performance, explaining 24% of its variance. Recommendations include diverse teaching methods, problem-solving guidance, practical programming, collaboration, and project participation to enhance skills.

Keywords: Computer programming, Information technology-integrated courses, learning outcomes, entrance channels, longitudinal study

1. Introduction and Key Questions

The 2016-2020 Information Education Blueprint aimed to enhance deep learning and digital citizenship through IT tools, aligning with Taiwan's emphasis on computational thinking for problem-solving (Kalelioglu et al., 2016). The "Higher education sprout project" achieved 60% participation by June 2020, indicating successful non-CS programming course implementation (Ministry of Education, 2020). However, non-CS students face challenges in programming due to logic, syntax, and abstract thinking (Weng et al., 2014). Therefore, the research questions for this study are as follows:

- Are there grade differences among non-CS students in ITI courses, including programming skills in other subjects?
- Do gender and entrance channels influence the learning outcomes of non-CS students in ITI and programming courses?
- Is it possible to predict non-CS students' performance in ITI courses using their programming course grades and relevant background factors?

2. Methodology

2.1 Participants and Computer Programming Implementation Courses Information

The participants in this study are non-information field professionals who have successfully completed three types of courses: ICP, ACP, and ITI courses. The total number of participants is 367. Among these students, 69% were male and 31% were female. Entrance channels included individual applications (39%), Multi-star projects (15%), exams (35%), and special programs/transfer/international admissions (11%). This reflects the Ministry of Education's admission policies and highlights effective recruitment and selection strategies.

According to the curriculum design of the individual school, the course is divided into the following three parts:

1. ICP Course: Students will learn basic concepts of computer programming, including syntax, fundamental logic, and programming skills.
2. ACP Course: Students will delve into more complex programming techniques and strive to achieve specific programming goals.
3. ITI Course: The ITI course integrates subject knowledge with program analysis, including topics such as statistics. This will enable students to apply computer programming skills to specific disciplinary areas and solve relevant problems.

Grades earned by students may be obtained repeatedly in these classes, and these grades will be represented through the calculation of average semester grades. Performance differences were analyzed using weighted adjustments: ICP (15%), ACP (25%), and ITI (60%) of Computer and Technology (CT) Grades.

2.2 Statistical Analysis Tools

For data analysis, descriptive statistics compare grade differences. An independent t-test assesses gender disparities in CT, followed by mean comparisons. One-way ANOVA explores diverse non-CS major backgrounds, with post hoc tests. ICP and ACP predict ITI grades. JASP 0.16 conducts all analyses.

3. Results

3.1 Analysis of Computer Programming and ITI Course Performance of non-CS Majors.

Table 1 displays a performance comparison of Non-CS students based on grades in ICP, ACP, and ITI courses using repeated measures ANOVA ($p<0.05$ or F-value=14.27). Results highlight a significant performance difference among these course categories. Post hoc analysis indicates superior performance in ACP compared to ICP and ITI courses. Meanwhile, ICP and ITI course grades were comparable, suggesting support is needed for students in comprehending unfamiliar subjects within their respective disciplines.

Table 1. *Comparison of course grade and background variables*

	F	P	Post hoc
Courses	14.27	<0.01	ACP > ICP & ITI grade
	T	P	Post hoc
Gender	-3.76	<0.01	Female >Male
Entrance channels	F	P	Individual Application Channel >Oversea & Transfer
	12.03	<0.01	Multi-star Project >Exam-based channel & Oversea& Transfer

3.2 To compare the learning effectiveness of the CT Grades among students with different background variables.

Historically, there existed a perception of gender-based inclinations toward literature and art, posing challenges in STEM fields for females (Wrigley-Asante, C et al., 2023). Gender's impact on CT grades was examined using a pair sample t-test (t-value=0.001<0.05), The results demonstrated that female non-CS students outperformed males, as presented in Table 1.

Entrance channels' influence on academic performance was investigated through one-way ANOVA (F value=12.03, $p<0.05$). Post-hoc analysis revealed higher grades for individual applications and "multi-star project" students compared to overseas and transfer students. "Multi-star project" entrants also outperformed exam-based entrants, as presented in Table 1. Notably, individual application and "multi-star project" students demonstrated stable IT and academic performance, while overseas and transfer students made additional efforts to reach similar levels.

3.3 The Relationship Between Student Variables and ITI Grade

Multiple regression analyses showed that ICP grades, ACP grades, and gender collectively explain 24% of the variance in ITI grades, which is statistically significant. Post hoc comparisons revealed significant contributions from ICP grades ($t=6.03$, $p<0.001$), ACP grades ($t=4.16$, $p<0.001$), and gender ($t=-3.1$, $p<0.001$) to the explanatory power. ICP grades had the highest influence ($\beta=0.32$), followed by ACP ($\beta=0.2$), and then gender ($\beta=0.15$). Entrance channel didn't significantly impact the model. Multicollinearity was assessed using VIF, with values well below 5 (ICP: VIF=1.21, ACP: VIF=1.21, Gender: VIF=1.02), indicating no multicollinearity issues, as presented in Table 2.

The regression equation is: ITI grade = 48.59 + (0.23) * ICP grade + (0.17) * ACP + (-3.53) * Gender. Gender is a dummy variable; when 0, it represents female students' influence, and when 1, it represents male students. Female students outperform male students by an average of 3.53 points in ITI grades.

Table 2. *Linear Regression of ITI Grade*

	Coef	Std err	T	p-value	VIF
Const	48.59	3.87	12.54	<0.001	
ICP	0.23	0.04	6.03	<0.001	1.21
ACP	0.17	0.04	4.16	<0.001	1.21
Gender (male)	-3.53	1.11	-3.1	0.002	1.02
Entrance channels	0.02	0.41	0.05	0.96	1.06

4. Conclusion and Recommendations

Non-CS students struggle in ICP and ITI courses compared to those skilled in ACP due to unfamiliar syntax and initial lack of logical thinking training. Females excel, challenging stereotypes. Individual applications yield better outcomes than transfers or overseas recruitment. Multi-star Projects outperform exams and overseas recruitment, showcasing diverse experiences. Regression analysis explains 24% of ITI grade variance; ICP grade, ACP grade, and gender influence ITI grade. Recommendations encompass diverse teaching methods, promoting practical programming, fostering collaboration, and encouraging participation in information competitions. Interactive learning environments and providing support for overseas students are essential to enhance the learning experience.

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