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Assessing Study Skill Needs for Information Technology and Computer Science Students in Technical and Vocational Universities

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ABSTRACT

Not a great deal is known about what study skills are essential for success in the science, technology, engineering, and mathematics' disciplines, particularly in information technology (IT) and computer science (CS) programs in the technical and vocational education (TVE) in Taiwanese higher education. Since TVE accounts for more than half of the post-secondary enrolments in the country, and with the increasing demand for IT and CS talents, we studied perceptions of the importance and competency of such skills to identify the students' needs and demographic factors influencing them. A survey was administered to 1398 students in IT and CS programs in Taiwanese TVE universities. General skills were seen as the most important one among the study skills examined, and students felt competent using them. The needs to manage time, perform quantitative/mathematical tasks, and delegate were identified and these needs were affected by institutional quality, gender, and academic achievement. The results might be useful for further investigation in this area and guiding future plan to improve student performance in TVE.

1. Introduction

Increasing the number of graduates in science, technology, engineering, or mathematics (STEM) programs, especially in the information technology (IT) and computer science (CS) disciplines, is a priority for higher education globally. This is especially the case in Taiwan where the percentage of graduates in STEM fields has dropped from 45 % in 1999 to 32 % in 2019 [[1,2]]. Moreover, the report stemming from household registration data predicted that the number of individuals with relevant education in such fields might be smaller over time as the estimation of the university-age population would be declined by approximately 40 % sooner than 2023 as compared to 20 years earlier [[3]]. In the past few years, Taiwan has had among the lowest birth rates in the world [[4]]. Because of these obstacles, the percentage of students with IT and CS majors has reduced to 22 % compared to 10 years ago that the regression of enrolment rate in these fields was much higher than the decrease (10 %) of total college enrolment numbers [[5]].

One possible cause for the above problem could be the content difficulty of the STEM curriculum [[6,7]], which might be partially due to the fact that many students enter university without adequate preparation for the satisfactory performance requirements placed on them [[8,9]]. Students tend to struggle in taking notes, writing reports, preparing presentations, and completing projects [[10,

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11]]. This is a real issue for less capable students, and even for some who excel [[12]]. Furthermore, undergraduates in technical and vocational education (TVE) do not well utilize study skills as their counterparts in research universities in Taiwan [[13]].

Study skills refer to "*activities necessary to organize and complete schoolwork tasks and to prepare for and take tests*" [[12], p. 264]. They are considered necessary for successful university outcome [[12,14]] and for students' achievement in STEM subjects [[15]]. TVE comprises more than half of the higher education population in Taiwan, and yet there has been little investigation of students' study skills in this sector. Like many other countries, retaining students in the STEM field is greatly highlighted in Taiwan. Recognizing the above concern and huge demand for information technology (IT) and computer science (CS) talents in Taiwan [[16,17]], this study investigated the study skill needs of IT and CS students in Taiwanese TVE universities.

2. Literature review

Despite the fact that researchers have been trying to understand the high dropout rates in IT and CS education, little research has probed into the study skills needed to complete study in the two programs. In contrast, there exists extensive research on STEM study skills; thus, the literature review included not only studies in STEM fields, but also research in IT and CS education. In this section, the nature of college students' study skills and its relationship with their academic success were explored first. Then, research on the study skills required by STEM, IT, and CS was reviewed to clarify the constructs of study skills in STEM courses. It is noted that in this study, STEM related majors/courses refer to programs or courses in the science, technology, engineering, and mathematics fields separately, rather than the concept of integrated STEM.

2.1. Study skills and university success

Study skills are tools that enhance learning efficiency and effectiveness [[12]]. Because individual learners adopt them in unique ways, conducting this area of research is complicated especially considering multiple approaches tailored to different tasks and disciplines [[18]]. For example, studies have shown that science and engineering students often rely on deep-memorizing strategies or focus on operational steps and procedures, whereas those in the Arts may stress learning for getting recognition or looking at topics from an overall point of view [[19]].

Another example relates to where students are in their college classification and environment. Compared to those first-year undergraduate students, third-year students may seek to understand the relationship of concepts, and to gain deeper meaning of content and ideas [[20]]. Furthermore, context is important, and students in unsupportive environments may gravitate to adopting surface techniques such as rote learning and receiving information passively [[21]]. A longitudinal study with measures of learning at intervals of four, eight, 16, and 30 months in a chemistry course in an Australian university found that students exhibited a consistent reliance on surface over deep processes [[22]], which underscores the fact that memorizing in science is a protective mechanism for keeping up with assignments rather than adopting other procedures.

The matter is further complicated through lecturers' expectations of university students. Studies show that lecturers expect students to be self-disciplined and self-motivated, and to be independent learners by the time they enrol at university, but these assumptions could be flawed, as such skills take extended periods of time to develop [[23–25]]. The increasing numbers of learning centers in academia with their role of supporting students suggest that what students bring to the table is different from what instructors expect, and the emergence of such learning centers may be an indication of a gap [[26]].

Another relevant question is the relationship between study skills and academic achievement in higher education. Studies discover that there is a link between the two elements mentioned above, but such associations vary considerably between variables [[21,27,28]]. A meta-analysis study grouped the skills of time management, study approaches and habits, leadership, problem solving and coping strategies, and communication into academic-related skills to examine its relationship with college outcomes [[12]]. They found that the category (academic-related skills) was associated with university retention, but the correlation to Grade Point Average (GPA) was small. Due to the restricted range of the predicted variable, the authors called for more probing into the linkages between study skills and students' performance. A reasonable conclusion drawing from the above discussion is that academic performance is affected by study skills, but the extent of such influence and its nature warrants further investigation.

2.2. Study skills in STEM-related disciplines

Theoretical models from sociological, psychological, economic, and ecological perspectives have proposed various factors related to students' retention in university [[29,30]]. Among them, student attrition in particular has long attracted interest. Findings from interviewing 335 American undergraduates, who either stayed in STEM or left to pursue another degree field, pointed out that the participating students faced the intellectual, physical, and moral challenges [31]. In STEM, assignments, problem sets, tests, lab work, and reports are often required by courses simultaneously, and of necessity to take precedence over other educational interests, personal relationships, social life, and so on. This may be more pertinent to women, leading to their leaving in greater numbers than other students, suggestive of the need to think about STEM from subgroup perspectives.

Learning science at the tertiary level is unique. In *Essential Skills for Science & Technology*, the authors highlight several skills such as being organized (time management, setting goals, planning), learning and researching (reading scientific literature, highlighting, reviewing information), attending lectures/tutorials (listening, taking notes), e-learning and research (searching for/sorting information), being assessed (examinations), critical thinking and argumentation, writing and presenting scientific material, and quantitative methods (problem-solving, mathematics) [[32]]. These 'essentials' came from the researchers' experience and the feedback of successful students at a university in Austria. To date, they have not yet been structured into a model or framework.

A study by two authors of this research team investigated the study skill needs of minority students in academic STEM disciplines at 15 universities in a large mid-western U.S. state [[33]]. Twenty-six skills were grouped into academic content, communication, leadership, coping and interaction, and team work categories. Academic skills were vital for understanding STEM subjects such as reading scientific and technical material, quantitative/mathematical skills, and problem solving [[34,35,36]]. Effective communication skills which enabled students to explain ideas in scientific writing or oral presentation were also fundamental [[32,37,38]]. Leadership skills were important for students to interact productively with others in science due to its increasingly collaborative nature [[39,40,41]]. Next were coping and interaction behaviours (stress management, conflict resolution) to alleviate tension [[42]]. Lastly, teamwork skills were critical because idea sharing is encouraged in STEM [[43]]. Participants rated the survey items in terms of perceived importance and competence for each skill; then the gap between importance and competence was calculated. Several skills with high importance and low competence were identified as needs, including managing time, dealing with stress, and analytical/problem solving. The information aided those involved staff in thinking about services to help students do well in the STEM fields.

It is worthy of mention that research in IT and CS uncovers several factors having influence on students' behaviour in their studies or retention in IT or CS education; these factors include demographics (e.g., gender, year of studies, race), motivation, family support, academic aspects (e.g., difficult learning material, mathematics, demanding examinations), learning environment (e.g., student-student interaction, student-faculty interaction, classroom climate), beliefs, and cultural stereotypes [[44–49,50]]. Although these studies provide some understanding of IT or CS retention, the need for further studies comes from the lack of research specifically probing into the study skills needed in these two disciplines.

Table 1 shows a comparison based on study skill categories from the above authors. It is noted that there is more than one skill in each category, and this table only presents a general view of the skill alignment by category. A closer look at the table found that the skills proposed by the authors were quite comprehensive and were generated from undergraduates in STEM majors [[33]]; thus, their skill framework was adopted in the current study.

2.3. Research context

The current effort extends the knowledge of previous research to IT and CS programs at TVE universities in Taiwan. Before moving on to the next section, it is worth briefly introducing higher education in TVE in Taiwan to better understand the subjects' background. In Taiwan, the education system above junior high school level diverges into two pathways: the general education system and the TVE system. The goals of TVE aim at providing basic and specialized programs to meet the demands of the industrial sector for skilled personnel. Approximately 80 % of graduates from vocational high schools directly attend university or college; among them, over 90 % remain in the TVE system and the rest of the graduates go to general higher education [[51]]. Overall, students at postsecondary TVE institutions account for 53 % of the student population at the same education level [[52]]. They are generally from 18 to 22 years old and study full-time. Among all domains in higher education in TVE, students in IT and CS comprise around 8 % of the total student population [[52]]. What study skills are relevant to their success attracted our attention.

In sum, this study was an exploratory effort and a first look at these concerns in Taiwan. Students' study skill needs were identified by discrepancy-based data which took into account the participants' perceptions of importance (desired status) and their current competence (present status) of the skills. The underlying assumption is that a need is there if ratings of high importance co-occur with low ratings in current competence to perform a skill [[53]]. The research questions are.

(1) What study skills are viewed by students as important and what are the participants' current competences to perform them?
(2) What are the study skills needs in terms of the discrepancies between their perceived importance and current competences?
(3) What variables affect the ratings for importance, current competences, and identified study skills needs?

Table 1
A comparison of study skill categories.

Study Skill Category	Zeegers et al. (2008) skills for science & technology	Robbins et al. (2004) academic-related skills	Altschuld, Lee, & White (2005) STEM study skills
Academic skills	Learning & researching Attending lectures/tutorials E-learning and research Critical thinking and argument Quantitative methods Being assessed	Study approaches and habits Problem-solving	Academic skills
Communication skills	Writing and presenting scientific material	Communication	Communication
Leadership skills	Being organized	Leadership Time-management	Leadership
Coping & interaction skills		Coping strategies	Coping & interaction
Team work skills			Team work

3. Methods

3.1. Sampling and data collection

Survey research approach was employed. Seven (5 private, 2 public) TVE universities with institutional rankings of top, middle, and low classes in northern Taiwan participated in the study [[54,55]]. The target population was first-, second-, and third-year undergraduates ($N = 1635$) majoring in information technology and computer science programs. Regarding the number of students, these are leading programs among TVE STEM majors in Taiwan. Instructors were contacted by email or phone to explain the study, solicit their cooperation, and schedule survey distribution in classes. Research team members administered and collected the paper survey with consent form at the scheduled time in class. In order to prevent the socially desirable responses, students were informed that the data collection was anonymous and the data would only be used for research purpose. In addition, the instructors were not in the classroom during the survey administration process to release students' response burden. The research team conducted data collection to ensure that the participants fully understood the survey purpose and were willing to provide their perspectives honestly. Students received a pen as an incentive for participation. The final sample size was 1,398, an 86 % return rate.

This study was a survey research which did not involve any intervention activity and all data were collected anonymously; therefore, it satisfied with the waiver approval from the ethical committee in Taiwan. In order to make sure all respondents fully understood the research information, they were required to fill in a consent form for allowing the research team to collect data before the survey administration. The form explained the purposes of the survey, the details that the respondents' obligation would entail, and their right. It also obtained respondents' permission for the researchers to use their information for research purposes.

3.2. Instrument

A survey about the perceived importance of and competence in study skills for academic success in STEM courses was developed and administered to the participants (see the instrument in the Appendix). The instrument was adopted from authors' study in 2005 [[33]], with minor modification. The two items ('Listening and note taking' and 'Critical thinking and creativity') in the original survey were split into four items: 'Listening,' 'Note taking,' 'Critical thinking,' and 'Creativity.' The experts in Taiwan reviewed the items and made minor changes to the wording for better translation from English to Mandarin. The final version had 28 study skills in five categories: academic skills, communication, leadership, coping and interaction, and team skills. The definitions of each category are presented in Table 2. Respondents judged the importance (How important is each skill to your academic success in STEM-related courses or tasks?) and current competence (How would you rate yourself on them?) on 5-point Likert scales from *very important* or *very good* (value code = 5) to *not very important* or *not very good* (value code = 1). Higher values represented greater importance or competence. The metrics were very similar and thus were seen as suitable for subtraction in the analysis of needs.

Principal component analysis (PCA) with direct oblimin rotation and Kaiser normalization was conducted to investigate the construct validity. PCA is appropriate for this study since this technique could reduce the dimensionality of large data sets and increase interpretability, while at the same time it could minimize information loss. The Kaiser-Meyer-Olkin measure was 0.97 and the Bartlett's test of sphericity was .00. Three components with eigenvalues greater than 1 accounted for 65 % of the variance. The largest (31 %) consisted of 16 items from the categories of 'leadership,' 'coping and interaction,' and 'team work,' and was renamed 'general skills.' The other two, 'academic skills' (8 items) and 'communication skills' (4 items), explained 21 % and 13 %, respectively. The reliability was high for the three components (Cronbach's alphas of the first, second, and third components were .92, .96, and 0.95, respectively) and the total items (Cronbach's alpha = .93). Accordingly, the original items were regrouped into three subsets (general skills, academic skills, and communication skills) for analysis.

3.3. Data analysis

Descriptive statistics (means and standard deviations) were calculated. Determining need rests on a subtraction of mean importance and competency scores from each other (desired status minus present status). The difference was examined by Means Difference Analysis (MDA), a useful technique for gap analysis [[53]]. When conducting MDA, means of importance and competence ratings for all items in a category are computed, and the gap between the two values is a threshold for looking at each individual item discrepancy; those that exceed the threshold values are classed as 'needs', in other words, potential gaps. A need is not there if ratings of importance are low in conjunction with high competence ratings [[53]]. The importance, competence, and discrepancy scores by scale category

Table 2
Definition of the study skill category.

Study skill category	Definition
Academic skills	Core skills by which knowledge and understanding is acquired, developed, reflected on, and represented, such as academic reading and referencing, which underpin more complex skills, such as critical thinking, problem solving, etc.
Communication skills	Abilities to convey information and ideas effectively, such as explaining basic ideas in written form or orally, etc.
Leadership skills	Skills people use when organizing or motivating other people to reach a shared goal, such as managing time, planning, etc.
Coping and interaction skills	Cognitive and behavioural strategies that people use to deal with stressful situations or difficult demands, such as assertiveness, stress management, etc.
Team work skills	One's abilities to build and manage a team, cooperate with others and be responsible to a group.

and item were probed by ANOVA to explore the effects of academic performance, year of study, institutional ranking, and gender.

Given the length of the full instrument, only highlights of the results are reported. Instances where analyses did not reveal findings of substance are briefly summarized in the text but not provided in the tables.

4. Results

4.1. Respondent characteristics

Male participants were the majority (85 %) and the proportion was close to the population proportion of these two programs in VTE universities in Taiwan [[56]]. Even though the proportion of female participants was small (15.1 %), the sample size (211) was acceptable; thus, the data were used to analyse the gender influence. There were relatively equal numbers of first-, second- and third-year students. Approximately one-fifth of the students were from top-ranked institutions; 45 % and 35 % of the participants were in middle and low ones, respectively. Self-reported academic performance (GPA for the last semester) fell into a normal distribution, and students were grouped accordingly into top, middle, and bottom groups via the upper and lower 33 % as cut-off points [[57]]. See Table 3 for detail demographics of the participants.

4.2. Perspectives of importance and current competence on study skills

The overall mean of importance was 4.00, with a limited range for the three categories from 3.90 to 4.02 (Table 4). Respondents rated the importance of general skills a little higher than they rated the importance of academic skills, with both significantly greater than their ratings for communication skills according to the repeated measures ANOVA ($F = 36.67$, $p < .001$) and post hoc analyses. Competence had a total mean of 3.32, with a range from 3.14 to 3.42 in the respective categories. Students perceived that they were most competent in general skills and least in communication skills ($F = 146.37$, $p < .001$). Moreover, according to the paired t tests, mean ratings of importance were always significantly higher than those of competence across the three categories; $t_{(1305)} = 34.37$, $t_{(1303)} = 27.43$, and $t_{(1307)} = 27.05$, $p < .001$ for category of general skills, academic skills, and communication skills, respectively.

No individual skills were rated low in importance, from 3.81 for multi-tasking to 4.23 for analytical/problem-solving skills (Table 5). Somewhat negatively skewed distributions were obtained. Competence scores were rated lower, with a slightly larger range (2.94–3.72). Respondents felt more competent in being responsible to a group ($M = 3.72$), following through on commitments to others ($M = 3.71$), and cooperating ($M = 3.61$) in the general skills category. They reported less competent in quantitative/mathematical skills ($M = 2.94$), explaining higher level ideas orally ($M = 3.05$), and written form ($M = 3.07$).

4.3. Needs indices for study skills

Subtracting the mean for competence from that of importance, all item gaps were positive and ranged from 0.37 to 1.01 in magnitude, indicating a number of needs. 'Managing time' had the largest MDA (see previous explanation), with 'trusting others' being the smallest. Twelve items (43 %) exceeded the threshold values, with 'managing time,' 'quantitative/mathematical skills,' and 'planning' being notable (Table 6).

4.4. Demographic effect on importance, competence, and identified needs

Effects of demographic factors on the ratings of importance, competence, and identified needs of study skills were examined to see whether students' perceptions differed by groups. Four demographic factors were tested, including students' academic performance, institution rating, gender, and year of study. First, the ANOVA and post-hoc test (Scheffé method) results of the effect of academic performance on the ratings of importance, competence, and discrepancies are listed in Table 7. High-performing students in contrast to lower-performing students saw skills as more important, and felt that they were more competent in them. This pattern was consistent across the three categories and was also observed across the total items, but was not noted for discrepancies (gaps).

Table 3
Demographic information (N = 1398).

Characteristic		n	%
Gender	Male	1186	84.9
	Female	211	15.1
Year of study	1st year	452	32.8
	2 nd year	478	34.6
	3rd year	450	32.6
Institutional ranking	Top	287	20.5
	Middle	625	44.7
	Low	486	34.8
Academic performance	Top	461	33.4
	Middle	435	31.5
	Bottom	483	35.1

Table 4
Descriptive data for importance and current competence per category.

Category	Importance		Current competence	
	M	*SD*	*M*	*SD*
General skills	4.02	.72	3.42	.66
Academic skills	4.01	.69	3.23	.63
Communication skills	3.90	.79	3.14	.81
Total	4.00	.65	3.32	.60

Table 5
Descriptive data for importance and current competence by item.

Item	Importance		Current competence	
	M	*SD*	*M*	*SD*
General skills				
Planning	3.96	.87	3.09	.93
Managing time	4.08	.90	3.09	.96
Multi-tasking	3.81	.94	3.16	.95
Delegating	4.01	.90	3.32	.93
Trusting others	3.94	.96	3.56	.99
Following through on commitments to others	4.12	.92	3.71	.92
Assertiveness	4.06	.90	3.39	.97
Conflict resolution	3.92	.95	3.35	.93
Negotiation	3.90	.94	3.34	.92
Flexibility	3.95	.90	3.40	.87
Stress management	4.09	.92	3.40	.98
Socializing with others	4.02	.97	3.46	.98
Adapting to new situations	4.00	.94	3.55	.93
Cooperating	4.17	.92	3.61	.90
Team building	4.10	.91	3.52	.92
Being responsible to a group	4.20	.90	3.72	.93
Academic skills				
Reading scientific/technical material	3.89	.89	3.13	.88
Listening	3.96	.86	3.33	.84
Note taking	3.90	.96	3.14	1.01
Critical thinking	4.01	.90	3.35	.90
Creativity	4.08	.93	3.21	.95
Synthesis and integration of ideas	4.18	.86	3.39	.91
Analytical/problem solving skills	4.23	.87	3.36	.90
Quantitative/mathematical skills	3.85	.95	2.94	.99
Communication skills				
Explaining basic ideas in written form	3.89	.87	3.24	.90
Explaining basic ideas orally	3.94	.89	3.20	.92
Explaining higher level ideas in written form	3.86	.89	3.07	.92
Explaining higher level ideas orally	3.90	.90	3.05	.94

Table 6
Items identified as needs based on MDA.

Category	Threshold value	Items exceeding the standard per category	MDA
General skills	.60	Planning	.87
		Managing time	.99
		Multi-tasking	.65
		Delegating	.69
		Assertiveness	.67
		Stress management	.69
Academic skills	.79	Creativity	.87
		Synthesis and integration of ideas	.79
		Analytical/problem solving skills	.87
		Quantitative/mathematical skills	.91
Communication skills	.76	Explaining higher level ideas in written form	.79
		Explaining higher level ideas orally	.85

Note: The threshold value is the gap between the averages of importance and the average of competence ratings for items in a category.

Table 7
ANOVA results by academic performance effect on importance, competence, and discrepancy.

Category	Importance	Competence	Discrepancy
General skills	$F_{(2,1302)} = 4.21$*(top > middle, bottom)	$F_{(2, 1371)} = 15.13$***(top > middle > bottom)	ns
Academic skills	$F_{(2, 1303)} = 11.52$*** (top > bottom)	$F_{(2, 1373)} = 30.86$***(top > bottom)	ns
Communication skills	$F_{(2, 1302)} = 8.43$***(top > bottom)	$F_{(2, 1371)} = 7.06$***(top, middle > bottom)	ns
Total	$F_{(2, 1303)} = 7.85$***(top > middle, bottom)	$F_{(2, 1373)} = 21.53$***(top > middle > bottom)	ns

Note: Students were grouped into top, middle, and bottom based on self-reported academic performance (GPA for the last semester). *$p < .05$, ***$p < .001$.

Table 8
ANOVA results for the institutional ranking effect on importance, competence, and discrepancy by category.

Category	Importance	Competence	Discrepancy
General skills	ns	ns	ns
Academic skills	$F_{(2, 1319)} = 11.53$*** (top, middle > low)	ns	$F_{(2, 1316)} = 4.58$** (top > low)
Communication	ns	ns	ns
Total	$F_{(2, 1319)} = 3.61$* (top > low)	ns	$F_{(2, 1316)} = 3.08$* (top > low)

Note: Three groups for institutional quality: top, middle, and low. *$p < .05$, **$p < .01$, ***$p < .001$.

In terms of the effect of institutional ranking, students from the top-ranked schools (Table 8) rated items, the academic-related skills in particular, as more important than those students from the low-ranked schools assessed. An analogous pattern was found on the discrepancy between the importance and the competence, with those associated with the top-ranked institutions being larger. This suggests that the learning environment might influence perceptions.

As for gender and year of study, the effects were minor. Males reported more competent in communication skills than females, particularly in explaining basic level ideas in written form ($t = 2.4$, $p < .05$) and in explaining higher level ideas in oral form ($t = 2.0$, $p < .05$), but no significance was detected for the other comparisons. The year of study was not significant for any of the importance and competence ratings or for the discrepancy scores.

In light of the group difference in identified needs, the 12 items with discrepancies exceeding the threshold values (Table 6) were looked at in relation to demographic characteristics. Table 9 contains the results from institutional ranking on 'planning,' 'managing time,' 'stress management,' 'creativity,' 'analytical/problem solving skills,' and 'quantitative/mathematical skills.' Greater needs were noted in students in the top-ranked than the bottom-ranked universities. Students with poorer academic performance had larger gaps between importance and competence on 'delegating' than their counterparts. The female participants reported a greater need for 'assertiveness' and 'quantitative/mathematical skills' than the male participants did.

Table 9
ANOVA results of demographic influences on items identified as needs.

Items Identified as Needs	Institution ranking level	Academic performance	Gender
Planning	$F_{(2, 1306)} = 5.37$** (top > low)	ns	ns
Managing time	$F_{(2, 1307)} = 19.69$*** (top > middle, low)	ns	ns
Multi-tasking	ns	ns	ns
Delegating	ns	$F_{(2, 1286)} = 4.68$** (bottom > top)	ns
Assertiveness	ns	ns	$F_{(2, 1309)} = 4.60$* (F > M)
Stress management	$F_{(2, 1312)} = 6.54$** (top > middle, low)	ns	ns
Creativity	$F_{(2, 1304)} = 4.64$** (top > low)	ns	ns
Synthesis and integration of ideas	ns	ns	ns
Analytical/problem solving skills	$F_{(2, 1308)} = 3.27$* (top > low)	ns	ns
Quantitative/mathematical skills	$F_{(2, 1306)} = 4.37$* (top > low)	ns	$F_{(2, 1309)} = 4.29$* (F > M)
Explaining higher level ideas in written form	ns	ns	ns
Explaining higher level ideas orally	ns	ns	ns

Note: Needs are based on the subtraction of means of importance and competence ratings. *$p < .05$, **$p < .01$, ***$p < .001$.

5. Discussion

For research question 1 (perceptions of importance and current competence), students assessed all items as high importance, a result that is not surprising and may be a measurement artifact because all skills included in the survey were chosen based on their importance for STEM-related study. The general skills category was rated slightly more important than the academic and communication skills. One explanation could be the learning environments in IT and CS. Students often have to participate in study communities, laboratories, team efforts, and group projects that rely on several general skills such as interpersonal cooperation, leadership, and teamwork [35].

As for the current competence ratings, the majority of skills were rated moderately, and the items in the general skills category were slightly higher than those in academic and communication categories. A further examination of competence rating for each item showed that students reported less competent in quantitative/mathematical skills which were fundamental to understand science. It indicated that TVE students lack enough quantitative/mathematical skills to support their study in the field of technology and computer science. Schools need to be aware of the issue and provide timely supports such as bridge programs, preparatory strategies, and tutors to meet students' study skill needs.

Participants' ratings on importance were greater than their competence ratings across categories, and the observed needs (research questions 2) tend to support the perception that some students were ill-equipped for higher education learning [[18]]. The most prominent item was 'time management.' Studying in STEM generally means that days on campus are highly structured with set times for lectures, laboratories, tutorials, and practical sessions, and so forth [[32]]. Schedules are tight and necessitate careful budgeting of resources for academic success. Taiwanese TVE participants had difficulties here, reporting that they were unable to effectively manage their time. Students may have limited time because many at Taiwanese TVE universities come from lower socio-economic status families and must work to cover their tuition and living costs [[58]]. Wisely using time is critical, and students may need help in learning how to manage and prioritize time effectively.

Another need was in 'quantitative/mathematical skills' where undergraduates in TVE are less competent than their counterparts in more academic focused institutions. This is notable in Taiwan since a major expansion of TVE universities increased the number of students at these universities and has resulted in attracting some students who are not ready for the tertiary work [[59]] or who might not even have junior high school mathematics proficiency [[60]]. Mathematics is critical for IT and CS, and without it there will be poor academic performance and increased drop-out rates [[61,62]]. Tutoring, academic advising, and pre-college bridge programs might somewhat ameliorate the problem [[63]]. Measures to reduce the gap are more common now, but remain a challenge for TVE institutions.

Earlier, a number of subgroup differences in importance and competence were discussed (Question 3). Students with higher academic performance (GPA) felt more competent and assigned the study skills as more important than students with lower performance. This could be anticipated given their academic success, but the linkage was not fully clear. In addition, the gap between the importance and competence in the delegating skill from lower GPA students was significantly larger than that from higher GPA students, indicating that students with lower academic performance had a greater need to improve their delegating skill.

For institutional ranking, students from the top-ranked TVE universities saw the study skills as more important than those in lower-ranked universities. This might be due to difference in school climate/institutional environment where the top universities usually have more constructive competition, with high expectations for learning [[64]]. Furthermore, students from the top-ranked institutions identified more skills (creativity, analytical/problem solving, quantitative/mathematical skills, planning, and managing time) being needed than their counterparts. These universities are more selective, and their students already have strong records and appear to have better capacity for self-monitoring their strengths and weaknesses. Lower strata universities may not be able to fully attenuate this disparity, but can employ strategies to enhance students' learning skills. Because institutional ranking consists of many factors that might not directly relate to individuals' study skills, it is suggested that the possible causes be explored in the future.

Compared to female students, male students reported more competent in explaining basic level ideas in written form ($t = 2.4, p < .05$) and explaining higher level ideas in oral form ($t = 2.0, p < .05$). The results align well with the argument that studying in science involves masculine forms of language [[65]]. Consequently, characteristics associated with femininity are negatively valued and make females to be disadvantaged in STEM [[29]]. Another plausible explanation may come from how males and females see their abilities in science. Women often underestimate what they can do, while men are more likely to overestimate their ability [[66]]. Self-reported performance might have caused some bias in the results.

Finally, no differences were found among the first-, second- and third-year students. The results do not resonate with the proposition by a longitudinal study about the effect of class level and being slightly older on learning [[22]]; that is, as students aged they tend to adopt more deep learning than surface learning approaches. Perhaps one reason is that there are not as many courses that challenge students to improve higher level skills (e.g., synthesis, integration of ideas, problem solving) in the junior year as they should be [[67,68]]. Capstone courses at the end of the learning process tie together ideas and promote more sophisticated study skills, but such courses are not prevalent in Taiwanese universities [[68]]. This issue was not addressed in this study but might be a consideration for future research. Lastly, as commented by a publication on improving teaching and learning, learning cannot be divorced from the institutional environment in which it is imbedded [[69]]; thus, institutional quality may be playing a greater role than suspected.

6. Lessons learned

What has been learned must be viewed from the perspective that this was an exploratory study done for the first time in the Taiwanese technical and vocational education context. As such, we feel that it points the way toward more in-depth and penetrating investigations in the future. This could be done not by asking TVE students about general STEM study skills but about those specific to the required courses in IT and CS. Those courses would have to be reviewed, the study skills required for them determined, and then reflected in survey questions. Research such as this is more involved, but could be insightful and worth the effort.

Another lesson was that this research might be generalized to other similar contexts and areas beyond IT and CS in the TVE STEM environment in which it was done. Comparison studies across different fields and even countries would be of value. For example, a study found that high-achievers at a top university in Asia tended to keep class notes focused on test preparation and to write down all of the instructors' words [[53]], whereas shorter and more condensed notes are emphasized in the Berkeley study guide [[70]]. Contextual influence is at play and should be looked at in detail.

As a further consideration, while the current study worked well for students, how other actors (faculty, administrators) in TVE see the skills and needs thereof was not investigated. Information from these groups is worthwhile and should be sought given that they are the core of program delivery at universities.

Pushing needs further, if the identified needs in this study indicated that some students enter higher education unprepared for the demands of IT and CS courses, what supportive services and guidance in universities are there to provide needed assistances for students to be successful? What should high schools or primary schools be doing to foster study skills in general and IT/CS in specific? Prevention is the best cure.

Related to the above idea, institutional ranking was found to be a factor in the perception of skills needed. Students in top-ranked universities of science and technology seemed to be better at self-monitoring and more aware of their study skill deficiencies than others. A positive learning climate may account for some of what was observed, but more studies in this respect would be beneficial. Universities should be cognizant of this subtle, almost intangible impact on student learning, and promote a climate that leads to student achievement in IT and CS.

There are several limitations to our research that should be noted. The study only included selected students' self-report survey data, and lacked qualitative data and teachers' viewpoints. Due to this limitation, it is not appropriate to draw any firm conclusions for policy or practice based on the current data. Fourth-year students were not included, which would have increased variability. It might have been valuable to look at alternatives to Means Difference Analysis to see if the results would be the same. Factors such as students working outside of school or teaching methods were not studied, and follow-ups were not done with open-ended questions or interviews to obtain better perspectives on such variables.

Lastly, a translated instrument saves time, money, and effort and allows for cross-cultural comparison, but may have downsides in terms of validity [[71]]. Items should have had a 'not applicable' option, and asking how often skills are used might have produced better understanding. Yet, as a final note, we posit that the overall results are useful for thinking about information technology and computer science learning in technical and vocational universities, and can spur thoughts about strategies and new directions.

Data availability statement

The authors do not have permission to share data.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix. Study skills instrument

Extent to which the skill is **important** to your academic success in STEM-related courses or tasks. not very important ◀▶ very important	**Study Skills**	How would you **rate yourself** on this skill? not very good ◀▶ very good
	Academic skills	
1 2 3 4 5	Reading scientific and technical material	1 2 3 4 5
1 2 3 4 5	Listening	1 2 3 4 5
1 2 3 4 5	Note taking	1 2 3 4 5
1 2 3 4 5	Critical thinking	1 2 3 4 5
1 2 3 4 5	Creativity	1 2 3 4 5
1 2 3 4 5	Synthesis and integration of ideas	1 2 3 4 5
1 2 3 4 5	Analytical/problem-solving skills	1 2 3 4 5
1 2 3 4 5	Quantitative/mathematical skills	1 2 3 4 5
	Communication Skills	
1 2 3 4 5	Explaining basic ideas in written form	1 2 3 4 5
1 2 3 4 5	Explaining basic ideas orally	1 2 3 4 5
1 2 3 4 5	Explaining higher level ideas in written form	1 2 3 4 5
1 2 3 4 5	Explaining higher level ideas orally	1 2 3 4 5
	Leadership Skills	
1 2 3 4 5	Planning	1 2 3 4 5
1 2 3 4 5	Managing time	1 2 3 4 5
1 2 3 4 5	Multi-tasking	1 2 3 4 5
1 2 3 4 5	Delegating	1 2 3 4 5
1 2 3 4 5	Trusting others	1 2 3 4 5
1 2 3 4 5	Following through on commitments to others	1 2 3 4 5
	Coping and Interaction Skills	
1 2 3 4 5	Assertiveness	1 2 3 4 5
1 2 3 4 5	Conflict Resolution	1 2 3 4 5
1 2 3 4 5	Negotiation	1 2 3 4 5
1 2 3 4 5	Flexibility	1 2 3 4 5
1 2 3 4 5	Stress management	1 2 3 4 5
1 2 3 4 5	Socializing with others	1 2 3 4 5
1 2 3 4 5	Adapting to new situations	1 2 3 4 5
	Team Skills	
1 2 3 4 5	Cooperating	1 2 3 4 5
1 2 3 4 5	Team building	1 2 3 4 5
1 2 3 4 5	Being responsible to a group	1 2 3 4 5

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