

Two Decades of Computing at the University of Belize

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ABSTRACT

Computer science became a distinct academic discipline in the early 1950s. The first computer science degree program was founded in Belize around 45 years later, under the auspices of the nascent University College of Belize, which would subsequently become the University of Belize. We present a twenty-year synopsis of a degree program created in 1998 to build an undergraduate curriculum using the surge of computing in the country of Belize as a catalyst coupled with the recognition of the importance of computing for national development. The four-year undergraduate degree program has resulted in steady student enrolment over the past two decades featuring a female student population consistent with female enrolment in similar computer science programs globally. The study details the origins, development efforts, successes, challenges, and recommendations for the program's future development.

BACKGROUND

The Information Technology (INT) degree programs at the University of Belize represent a set of computer science/information technology degree programs introduced by the Faculty of Engineering and Information Technology over twenty years ago. The program's original mission statement was: "to provide students with an organised setting in which to conduct guided experimentation with and practical explorations of the physical machinery, the coded program, the designing strategies, the critical analyses and the ever-important human interaction that characterises the true computer scientist" (University of Belize, 2001). This study briefly describes the evolution of the INT degree programs, now housed within the Mathematics, Physics and Information Technology Department of the Faculty of Science and Technology. In addition, it discusses what has worked and what needs to be evaluated or attempted differently. This study utilised University of Belize enrolment data (Garcia, 2021).

In the late 1990s, the University College of Belize launched an initiative that gave birth to the INT degree programs. The goal was to meet the growing demand for computing professionals within Belize. The process began with the identification of and consultations with stakeholders in Belize. Selected stakeholders included representatives from the University College's departments and the private, government and quasi-government sectors. The University College held a series of meetings to apprise stakeholders about the proposed program and solicit from them what the stakeholders believed the goals and objectives of the final program should be. The consultations yielded the goals and objectives of the program, and the resulting program sequence included courses deemed relevant to the role of Computer Science in Belize's development (University College of Belize, 1998). The Associate degree in Computer Science West (ACSW), the precursor of the now INT degree programs, was born (University of Belize, 2001).

The program went through several changes from 1998 to 2000. There were pre-1998 spillovers of the Computing (CMP) program, and the Information Technology program (ITE) was short-lived. The Associate in Information Technology West (AITW) program was created in 1998, followed by the Bachelor in Information Technology West (BITW) and Bachelor in Information Technology (BINT) programs the following year. The Associate in Information Technology (AINT) and the Bachelor in Information Technology (BINT) established in 2000 as the then Department of Engineering and Information Technology's two-plus-two INT degree program regularised and normalised the disparate programs. In 2006, the BINT program underwent an extensive review with the participation of internal and external stakeholders, the University's administration, other university departments, and the Information Technology faculty, resulting in an updated program that addressed current advances in technology and shifts in technology use and deployment (University of Belize, 2006). Since 2006, the program has undergone three additional program reviews to ensure that it remains abreast with the developmental needs of Belize and emerging technologies. Figure 1 shows the enrolment in the degree programs for the period 1998 to 2017.

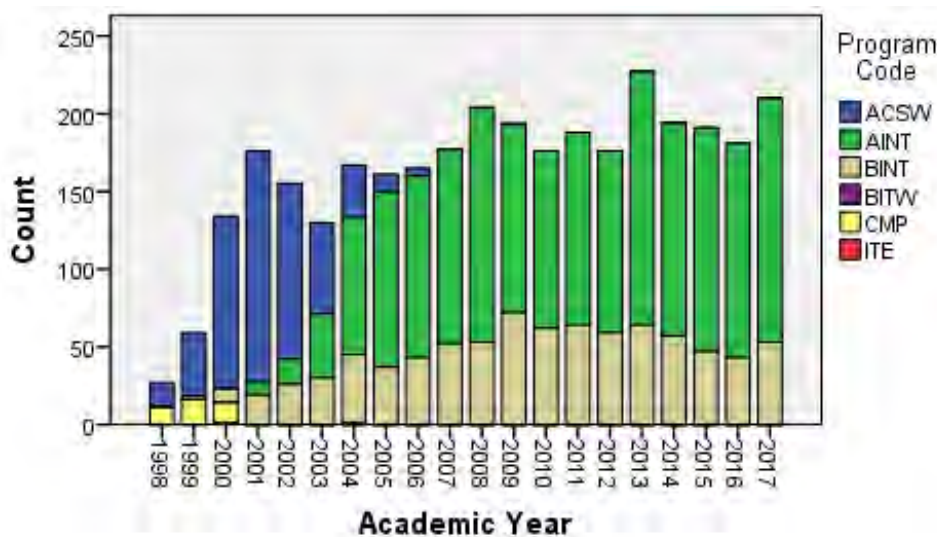


Figure 1. Enrolment in the degree programs

Program Philosophy

Creating a new degree program is not only challenging an endeavour but an exciting academic initiative that requires adequate preparation based upon a clear, unambiguous vision. Answers to specific fundamental questions are crucial in developing such a vision. Chief among these is the purpose of the degree, the intended target audience and the overarching values of the program. In regards to intended goals, forging new relationships across academic institutions and communities would be reasonable. However, of greater importance to the Engineering department was building a self-sustaining program that engendered excitement for both its faculty and students while simultaneously addressing the needs for national development. Notwithstanding all this, the underlying motivation to create the degree program was, first and foremost, to meet the developmental needs of Belize by providing an avenue for the development of the technological skills of the country's most important resource, its people.

As Belize continued to develop, its demand for technological skills and resources increased. It became evident that it was in Belize's best interest to cultivate those skills locally rather than import them. In so doing, not only would the economic growth and prosperity of the country be enhanced but, to a great extent, assured. To keep abreast of the current demands and changes of an ever-evolving field, it was then necessary to continually review and revise the program to ensure its success and credibility (University of Belize, 2006). Therefore, at the inception of the four-year BINT degree program, the Department, after careful deliberation, made a conscious decision to offer both the Associate of Science and the Bachelor of Science programs instead of only the four-year Bachelor of Science program. The basis of this decision was pervasive factors related to individuals wishing to pursue a career in computing and the requirements of the Information Technology Industry and other stakeholders for IT professionals at two distinct levels (University of Belize, 2015).

Over two decades later, the consensus is that these choices were correct. Students have graduated and successfully managed to assimilate into a wide range of careers that include software engineering and development, hardware and infrastructure deployment, and system administration. However, beyond these traditional positions, graduates have also acquired jobs in niche areas of computing such as cybersecurity. A notable theme common among all these garnered occupations is human-centred computing (Jaimes et al., 2007). This theme stems from the fact that while the BINT is more aligned with a Computer Science degree, it does not forgo the inclusion of those academic components that highlight the interaction between persons and their settings and how digital means facilitate that interaction.

It is not possible to discuss a program's philosophy without considering the terms interdisciplinary and multidisciplinary. To label a new program as genuinely interdisciplinary suggests that the program represents an altogether new field of inquiry derived from combining elements from different academic disciplines. In contrast, a multidisciplinary program combines discipline-specific aspects without compromising the academic disciplines themselves, for example, mathematics and computer science (Heikkinen & Räsänen, 2018). A prospect that has been the topic of many departmental conversations and meetings is creating a new discipline at the undergraduate level. While this prospect is tempting, there is consensus that there is a genuine risk that doing so could make students less employable in a field that generally favours traditional occupations (CompTIA, 2021). For this reason, choosing between a conceptual, knowledge-based program versus a purely interdisciplinary one has proven challenging. However, a critical deciding factor has been that the industry almost always prefers an administrator or software engineer instead of someone with hybrid knowledge. So, as long as employers emphasise disciplines in their employment practices, we concluded that our priority for the foreseeable future is to maintain our multidiscipline-specific program and eventually become a truly interdisciplinary program.

Program Composition

The Associate in Information Technology (AINT) and Bachelor in Information Technology (BINT) Program Descriptions are available via the web (University of Belize, n.d.). The evolution of the degree programs from their initial Computer Science track to the Information Technology track resulted from the changing requirements and needs of the IT industry and other stakeholders. The name of the degree programs changed from Computer Science to Information Technology, but the strong Computer Science core still exists. Modification to other program content reflects and incorporates the technical changes within the IT profession, the changes in computing and communications technology, and the growing cultural and economic importance of computing in our society.

The initial four-year Bachelor of Science degree program incorporated as the first two years of its program sequence the two-year Associate of Science degree. The program evolved into the current Associate of Science in Information Technology (AINT) degree and the Bachelor of Science in Information Technology (BINT) degree. The sequences for these programs were last revised in 2019 and have been in effect since August of that year. The BINT two-plus-two program is a seamless integration of the two distinct degree programs (AINT/ BINT) into a single 138 hour (minimum) program sequence (University of Belize, 2019). The program composition includes General Education Core, Support Core, and Professional Core courses (see Figure 2).

General Education Core (GEC) is 30 hours and includes composition, social and behavioural sciences, Spanish, and History. Support Core (SC) is 21 hours and includes algebra, trigonometry, three semesters of calculus, technical writing, and linear algebra. Professional Core (PC) is 87 hours and includes programming, data structures, software engineering, programming language concepts, operating systems, computer organisation, human-computer interaction, web design, computer networking, and telecommunications. The Professional Core includes 12 hours of computer science and information technology electives such as advanced database management, advanced web technologies, mobile application development, digital logic and signal processing, computer and network security, advanced networking, and practical electronics. Also, as part of the Professional Core, students are required to complete a capstone work experience course (3 hours) at the Associate level; and a seminar course (3 hours) and a capstone senior internship course (12 hours) at the Bachelor level.

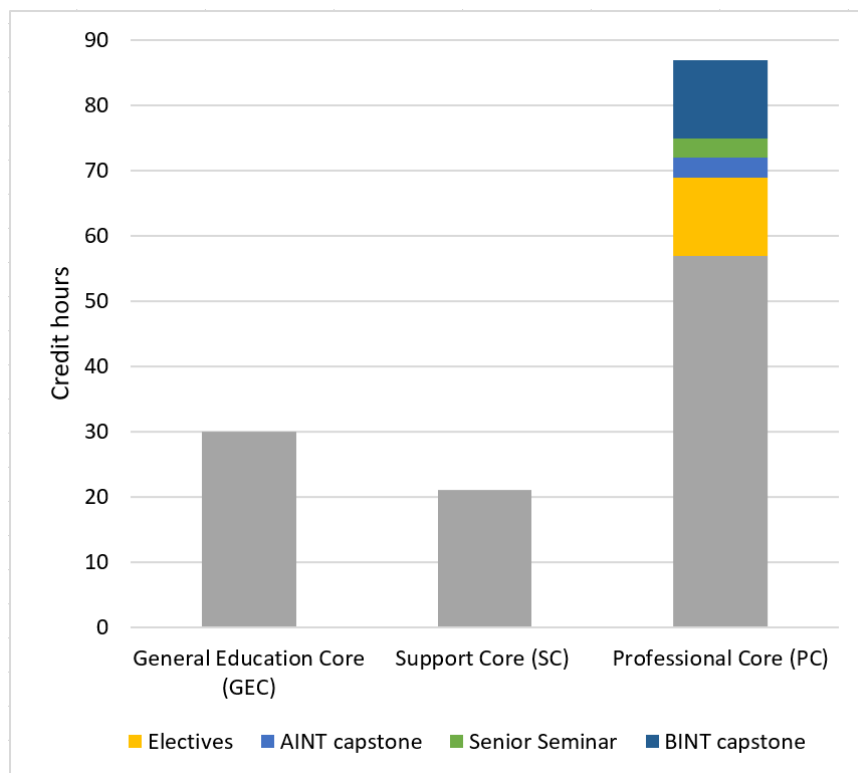


Figure 2. Program requirements

APPROACH

The study involved the review of unpublished internal documents relevant to the inception, development, and operation of the INT programs of the University of Belize for the period 1984 to 2021. An integrative literature review was conducted primarily on computer science and information technology degree programs and the relationships that such programs have with students and industry. The data source for this study was an unpublished transactional dataset of student records from 1998 to 2017 from the University of Belize. Columns utilised from the dataset included student id, program, enrolled semester, year, course code, graduation date, and gender. The dataset had 26,164 transactions that represented aggregates of 3289 enrolments, 1285 students, and 376 graduates. Descriptive statistics generated from the data focused on program enrolment, graduates, and gender distribution.

PROGRAM REVIEW AND EVALUATION

Objective introspection of the program reveals what things done right, areas that need improvement, and overall program performance for 1998 to 2017. The review and evaluation of the program use both qualitative and quantitative analyses, with a particular focus on enrolment, graduates, and gender diversity.

Qualitative Assessment

The program assessment process relies on frequent feedback generated from faculty, students, staff and the institutional infrastructure, which is then carefully reflected upon for appropriate response. This system of obtaining feedback, followed by reflection and planning, and then taking action serves as the basis by which the BINT program determines whether it is successfully meeting its objectives. In particular, student feedback obtained through various means, including interactions with the Registrar's Office, faculty, and student-led organisations centred on computing, is essential. The Department also has ongoing reviews to ensure the alignment of the BINT program with industry needs relevant to Belize. In so doing, the quality of graduates has risen to such heights that employers actively seek AINT and BINT students because of their skills in computing administration, software development, and hardware and software systems deployment. Below are notable changes that have taken effect as a direct consequence of having conducted program reviews and internal assessments by faculty.

At an early stage of the program's development, the Department determined that students graduating from the program lacked practical experience. This lack of practical experience was because while the program offered many courses in computer science, it did not provide that many information technology courses and the proper facilities needed to conduct practical experience were either significantly deficient or non-existent. As a result of this determination, changes in program offerings included courses such as Basic PC Repair and practical-oriented networking and administration courses. In terms of facilities, there have been improvements, but still not at the desired level where for example, separate facilities for networking and security are available.

Early and subsequent reviews of the Bachelor degree program identified areas where the program lacked the breadth of the information technology used globally and the critical aspects of information technology practice in modern organisations. Subsequent modifications to the program sequence introduced courses in the subject areas of website design and implementation, web application development, Internet technologies, graphical user interfaces, and network security.

Observations stemming from conversations with stakeholders early on revealed that students graduating from the program did not possess the expected well-developed analytical, problem-solving and engineering skills required of a professional who engineers quality information technology systems. Adding Systems Analysis, Software Engineering, System Engineering, and Network Engineering courses into the program sequence addressed this deficiency.

Quantitative Assessment

Table 1 shows enrolment of the four major degree program implementations, by gender, from the years 1998 through 2017. The degree program implementations in chronological order are (1) CMP – pre-1998 to 2000, (2) ACSW – 1998 to 2009, (3) AINT – 2000 to present, and (4) BINT – 1999 to present. The table columns for each of the degree programs are defined as follows: "M" for male, "F" for female, "Total" for the total student enrolment, and "%F" indicates the degree of gender diversity. This indicator is a quotient of the number of females divided by the number of males. This quotient or percentage represents the proportionality of females to male enrolment, so a quotient of 100 indicates an equal number of males and females enrolled in the program. A more detailed study of diversity in the AINT and BINT programs is warranted but is outside the scope of this study.

Table 1. Enrolment by gender for the degree programs

	CMP				ACSW				AINT				BINT			
	M	F	Total	%F	M	F	Total	%F	M	F	Total	%F	M	F	Total	%F
1998	8	3	11	38	11	5	16	45								
1999	9	7	16	78	29	12	41	41					1	1	2	100
2000	5	8	13	160	54	57	111	106					7	2	9	29
2001					90	59	149	66	6	2	8	33	13	6	19	46
2002					81	32	113	40	10	6	16	60	20	6	26	30
2003					45	14	59	31	27	14	41	52	21	9	30	43
2004					25	9	34	36	65	23	88	35	30	14	44	47
2005					9	2	11	22	85	28	113	33	25	12	37	48
2006					5	0	5	0	91	26	117	29	30	13	43	43
2007									102	23	125	23	36	16	52	44
2008									125	26	151	21	38	15	53	39
2009									105	16	121	15	51	21	72	41
2010									98	16	114	16	47	15	62	32
2011									105	19	124	18	49	15	64	31
2012									92	25	117	27	45	14	59	31
2013									117	46	163	39	51	13	64	25
2014									109	28	137	26	43	14	57	33
2015									119	25	144	21	37	10	47	27
2016									116	22	138	19	38	5	43	13
2017									134	23	157	17	43	10	53	23
Total	22	18	40	81.8	349	190	539	54.4	1506	368	1874	24.4	625	211	836	33.8

For the four major degree program implementations, Figure 3 shows the enrolment trends for the years 1998 to 2017. Enrolment in the AINT program has been consistently increasing over the years, with significant peaks in 2008 and 2013. The BINT program also had a consistent increase until 2013 but then experienced a steady decline until 2017, when it again recorded a rise in numbers. The BINT program recorded its highest enrolment number in 2009. Note that the AINT program consistently recorded a significantly higher number of enrolled students over the enrolment exhibited by the BINT program.

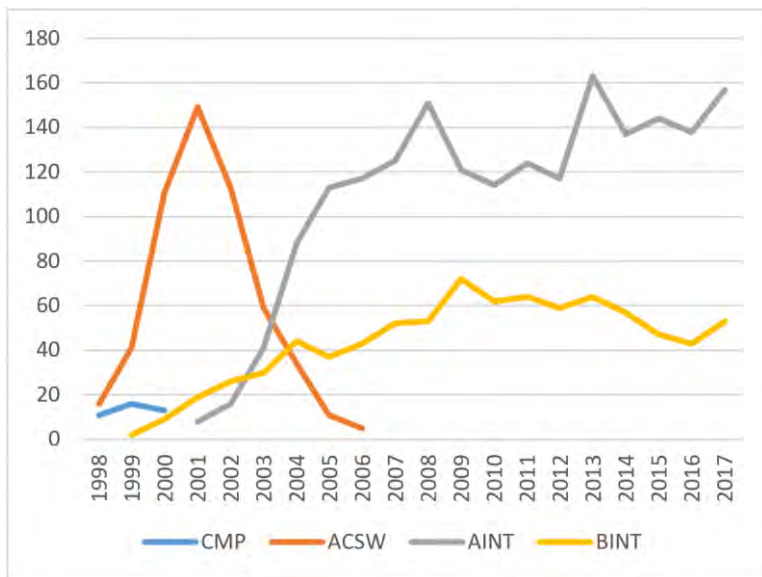


Figure 3. Total enrolment trends from 1998 to 2017

Figure 4 shows the number of students that graduated from 2000 to 2017 from the ACSW, AINT, and BINT programs. Since introducing the ACSW program, there has been a steady increase in graduates, with 376 students graduated. There were significant peaks in 2006, 2011, and 2016. Note that there were no graduates for 1998 and 1999 because the two-year ACSW program had just launched in 1998. The ACSW program accounted for 17% of the graduates, while the AINT and BINT programs accounted for 39% and 44%, respectively. This 5% difference favouring the BINT program does not hold when comparing the total Associate versus total Bachelor degree program graduates. The Associates then accounts for 56% of the total graduates, increasing 8% over the Bachelors.

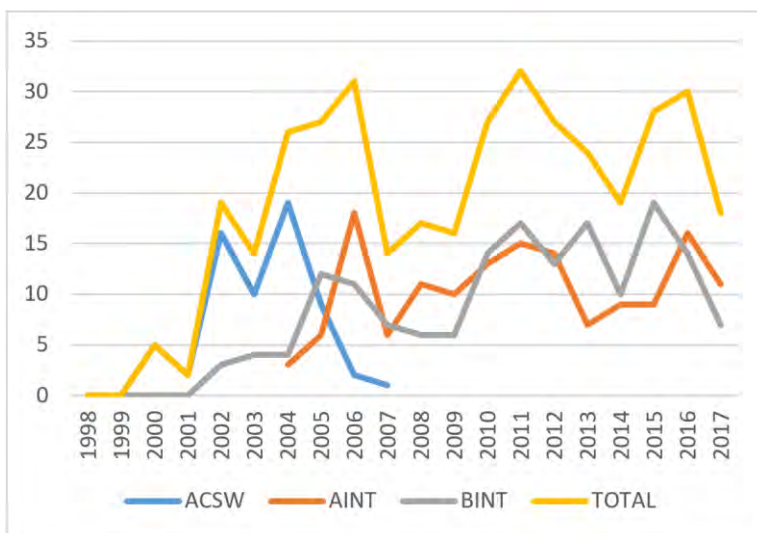


Figure 4. Graduates from 1998 to 2017

Figure 5 displays the relative gender ratios for the program implementations of CMP, ACSW, AINT, and BINT. The charts represent the sum enrolment for males and females from 1998 to 2017 obtained from Table 1. In the earlier CMP and ACWS programs, there were significantly higher percentages of female students than the subsequent AINT and BINT programs – CMP was 81.8%, ACSW was 54.4% compared to AINT's 24.4% and BINT's 33.8%. AINT peaked in 2002 at 60%, and BINT peaked in 2005 at 48%. Both programs experienced a steady decline in female enrolment after peaking. After 2003 the BINT consistently had more females enrolled than the AINT program except for 2013 and 2016.

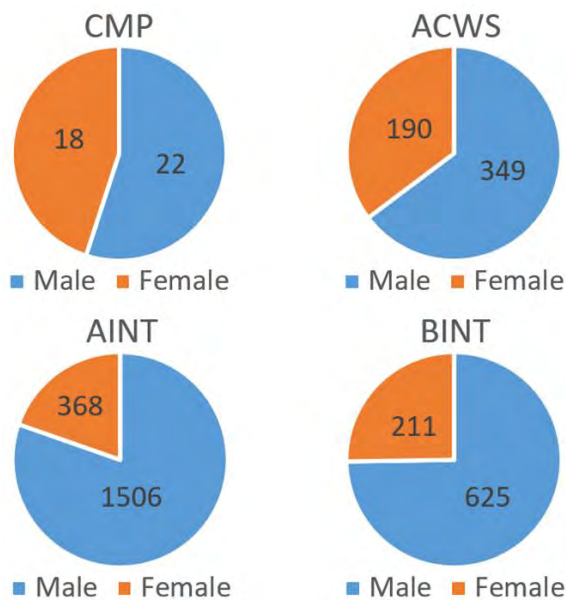


Figure 5. Gender ratios for the programs

Program Successes

Throughout the years, the Department has systematically undertaken efforts to improve the programs it offers. Such improvements have led to the inclusion and removal of courses and enhancements to existing courses to ensure that delivered content is viable and relevant. Taking such measures has been instrumental in developing a sustainable and academically mature program, as shown in Figure 3. Furthermore, the program basis is a well-balanced academic foundation underpinned by an ever-evolving, solid undergraduate computer science/ information technology curriculum. The inclusion of math, computer science/information technology electives also serves to better prepare students for advanced studies or immediate entrance into the workforce. (Kapoor & Gardner-McCune, 2018).

The Department launched a comprehensive initiative to solicit input from its key stakeholders to assess the efficacy of its programs and the calibre of its graduates. This initiative proved successful on two fronts. First, it allowed the program to realign itself with workforce demands, emphasising the needs of Belize. Second, it forged a new relationship between the Department and its business stakeholders based on the mutual benefit resulting from a successful program. An unintended consequence of this partnership has been the increase in opportunities for students to undergo experiential learning and subsequent permanent placement in jobs after that.

There has also been a significant jump in the overall retention rate of students. As the program evolves, its importance to the growth and development of the country has also become more pronounced. The demand for IT graduates has grown significantly over the years, a fact that has not gone unnoticed. The general population has become more aware that technology-related skills are now premium and provide the best opportunity for securing good-paying jobs. Also significant is that the percentage of females enrolled in the BINT program is comparable to other computer science degree programs globally (Computer Science.org, 2021).

Students who have completed the degree are qualified to work in a broad array of technology occupations. These occupations include computer programmers, computer technicians, network technicians, web admins, web developers, web designers, systems analysts, system administrators, database administrators, and network administrators (University of Belize, 2016). There is a high demand for AINT and BINT students by industry. Many students are offered employment during their respective capstone work experience and internship at the AINT and BINT levels.

Program Challenges

Lack of adequately developed infrastructure for specialised learning laboratories used for hands-on experience for non-theoretical subjects such as networking and cybersecurity. Such facilities are essential for delivering content that involves physical activities such as installation, configuration, and experimentation involving hardware components and digital infrastructure. A deficiency of qualified and experienced lecturers and tenure-track faculty to cover the span of offered courses, particularly in advanced areas of Information Technology / Computer Science.

While the BINT female enrolment may be comparable with other programs globally, the reality is that the gender imbalance is significant. This lack of diversity in computing programs is globally recognised and has been the topic of intense discussion and research (Gagnon et al., 2019). Therefore, the program must explore and identify how more females may be encouraged to study computing.

There are limited research opportunities for all students and collaboration opportunities between senior students and their counterparts from other faculties on joint initiatives that would benefit from interdisciplinary research that relies on shared knowledge.

Program Comparison

Since the regularisation of the Bachelor of Science in Information Technology in 2001, the Department determined that it was necessary to offer both the Associate and Bachelor degree programs. The basis of this determination was the needs analysis of students wishing to pursue a career in computing, and the stated requirements of the Information Technology Industry and other stakeholders, for two distinct levels of computing professionals. Like many two-plus-two programs, students find that the program is cost-effective and flexible, and it provides options for early entry into the workforce. It is essential to highlight that, unlike most two-plus-two programs, the AINT and BINT are provided at the same institution, making the transition from the associate program to the bachelor program easy and translating into program curricula that are solid, synergetic, and synchronised with each other (Mott & Lehrer, 2013).

Unlike some degree programs where the choice between an Associate degree and a Bachelor degree can significantly impact employment prospects (Peters & Belkin, 2014), an Associate of Science in Information Technology degree does not reduce employment opportunities in the field of computing. It may, at times, provide quicker access to the job market than the Bachelor of Science in Information Technology degree (Carnevale et al., 2020). This fact is primarily because information technology is one of the primary industry drivers. As a result, both Associate and Bachelor degree graduates from the field of computing are in high demand (Camp et al., 2017). As a result, placement and employment rates are high (over 90%) for graduates of both degree programs since they typically service distinct tiers based on industry needs. This level of employment for the program's students is in line with global trends. The growth rate for computing occupations is typically higher than the average growth rate of all other occupations (Fayer et al., 2017).

The rising costs of tuition and unemployment rates can make the prospect of investing in an Associate degree or Bachelor degree feel like a risky gamble (Abel & Deitz, 2014). However, based on the relationship Information Technology has with Industry (Martynov et al., 2019), for prospective students of the Associate of Science in Information Technology degree or a Bachelor of Science in Information Technology, the difficulty usually associated with the decision making process is not as substantial. Much of the concern is alleviated because the chances of obtaining placement or work prospects are about identical for both the Associate and Bachelor of Science in Information Technology degrees. Again, this is consistent with other programs globally.

In Belize, the University of Belize is one of two tertiary institutions with a degree program in Computer Science/ Information Technology. Given that the scope of this study focuses on a two-decade progress report on the BINT program, it would prove beneficial to undergo, in the future, a review of other computing programs offered in the country of Belize.

The BINT program, as it currently stands, does not support a hybrid curriculum (Benvenuti et al., 2018) at the Bachelor level. Instead, it focuses primarily on developing students that have achieved a discipline-specific foundation who, upon graduating, will have the required competency to embark on any number of specialisations. Upon completing the BINT, degree students pursue higher education online or enrol in foreign institutions to pursue Master of Science and Doctoral levels degrees in application design, information systems, and security. As the BINT program continues to advance and change, the development of advanced level degree programs is the next step in its natural evolution (Rude et al., 2018).

DISCUSSION AND CONCLUSION

The desired outcomes for its graduates and the skill acquisition of those graduates after four years heavily influence creating a new program. Where possible, the BINT program has aligned with the needs of students and industry stakeholders (Mardis et al., 2018), but even so, inevitably, tradeoffs are unavoidable. Unfortunately, course offerings have no perfect configuration that ensures the right balance of interdisciplinary information technology credits versus professional core credits. There is also the challenge of whether to focus exclusively on software or hardware. Considering all these factors, we have chosen a path that emphasises computer science/ information technology fundamentals that provide a clear direction for computing through foundational courses in software development and hardware deployment. The results of this approach have produced graduates that possess a solid foundation centred on computing technologies. This approach ensures that upon degree completion, students will have at their disposal a wide range of career choices from which to choose. These include Computer Programmer, Computer Technician, Network Technician, Web Master, Web Designer, Systems Analyst, System Administrator, Database Administrator, and Network Administrator.

Unlike many other fields of study where program content can be essentially static, program content is dynamic in computing because of the constantly evolving technology and emerging theories that shape and drive the discipline (Stewart, (2014). As a result, the Department is continually reviewing the program sequences of the Associate degree and Bachelor degree programs to ensure that they provide the best possible foundations for student success in computing. These reviews include comparing and evaluating the pros and cons of having a purely Computer Science track versus an Information Technology track. Also under consideration is embedding certification content (e.g. CompTIA, Cisco, Microsoft, etc.) into the sequence. The inclusion of certifications can improve both the marketing of the program and the employment of its alumni (Carnevale et al., 2020).

In recent years, several individuals and organisations, local and international, interested in establishing some form of Information Technology (IT) business have approached the Department. They have, on numerous occasions, cited Belize's geographic location, language and diversity as an ideal combination. However, these individuals state, and quite accurately so, that the country lacks technically skilled persons. The number of IT graduates alone is a crucial factor. For the last ten years, on average, about 28 students graduated per year (University of Belize, 2021), of which over 90% had guaranteed employment simply because they were filling existing occupation voids in industry. This average is a far cry from what a company wanting to make a significant investment will require in terms of necessary technical human resources. They can hardly rely on a trickle of graduates when their demands for skilled individuals is so high and ever-increasing. So, these companies have no recourse but to move elsewhere, despite any inclination of wanting to do business in Belize. Unfortunately, each time we lose such opportunities, we are preventing employment and the growth and development of a critical sector of society - a sector that has the potential to propel Belize forward and help move it into an era of prominence.

We don't have to look hard to see the positive effects investing in information technology has on a country. Singapore (Gunasilan et al., 2021), India (Surana & Sagar, 2020), and the Philippines (Albert et al., 2018) are great examples. For example, an examination of Singapore's education system reveals that its strength lies in the fact that students of all intellectual abilities have access to quality education but notably its concentration on science, technology, engineering, and mathematics (STEM) (Yiannouka, 2015). Emphasis on STE education and the efficient and effective utilisation of frontier technologies have positively impacted the economies of these countries.

Therefore, the University of Belize and the Government of Belize must think long term. Immediate financial returns should not be the driving force. Instead, like Singapore, they must find ways of providing quality educational access to the masses, particularly in computer science and information technology, which can radically transform Belize. The returns on human investment are far greater than any other investment. The BINT program has been contributing, is contributing, and has the immense potential to contribute even more to the future development of Belize.

Ethics and Consent: Ethics committee approval is not required as it does not involve clinical research on humans and does not contain retrospective studies in accordance with the Law on Protection of Personal Data.

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