Computer Science Education in the Face of Unconventional Odds: Case Studies from the Arab World

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ABSTRACT

Computer Science has been aggressively evolving at unprecedented rates over the past decade. Not only have breadth and depth been the key players in the dynamics of the domain, but interdisciplinarity has also been playing a major role in this evolution. The credibility of undergraduate Computer Science education has been challenged with zero sum game dynamics in curricula, an increasing sentiment amongst employers that undergraduate education had not been duly preparing graduates for the workforce, and resistance to professional licensure in many areas of the world. Prominent alternative channels of learning, many of which lack formalism and credibility have been evolving. As curricular guidelines are being developed for the next decade by the CS2023 ACM/IEEE/AAAI taskforce, this paper attempts to emphasize how Computer Science education is happening in a specific yet diverse area of the world, namely the Arab World. While it is not possible to document all the details, representative regions of the Arab World are used to make the case. Innovative examples of practices to neutralize some of the aforementioned challenges are highlighted, as well as how they compare with other state of the art in various regions of the world. The intent of the paper is to expose to the broader audience of Computer Science education how such practices exist in various regions of the world, and open up opportunities for the broader community to share thoughts on how to make Computer Science education more adaptive and inclusive in a highly aggressive ecosystem of computing.

KEYWORDS
Innovations, Computer Science, Arab World, CS2023

1 Introduction

The three most prominent bodies in computing, namely IEEE, ACM, and AAAI have teamed up to form a taskforce of worldwide experts in computing to envision how the guidelines of computing education CS2023 will look like. Built on CS2013, the new guidelines are intended to cater for a worldwide audience, capture state-of-the-art happening in computing education, and have a glimpse into the future of computing education. As the state-of-the-art guidelines are intended for a global audience, it is critical to expose the landscape of computer science education happening around the globe. Many computer science programs around the world are designed while benchmarking themselves against worldwide standards and accreditation criteria, such as the Accreditation Board for Engineering and Technology (ABET). There is a huge variance in the ecosystems surrounding such programs, including language barriers, economic differences, and most importantly, varying demographics.

The Arab World is composed of extremely diverse cultures spanning the Atlantic Ocean in the west to the Gulf in the East. The region is characterized by a huge variance in the abundance of resources that support the education system. For example, according to ABET, Egypt being the most populous nation of the Arab world has about four computer science ABET-accredited programs while Lebanon which is about fifteen times smaller in population has about six.

Countries in the region have historically been affiliated to extremely diverse educational systems, in particular, French, British, and US educational systems. In an attempt to familiarize the worldwide community with practices happening in computer science education around the world, this paper attempts to expose some of the ecosystems surrounding computer science education in the Arab World. In particular, computer science education in four prominent regions of the Arab World are discussed, namely Egypt being the most populous and central region of the Arab World, the Levant region in the North East, the Gulf region in the East, and last but not least, Northwest Africa. A glimpse is provided about the nature of the ecosystems of education in each of those regions, with some examples of how computer science education is conducted, some of the innovations that are
happening in delivery given the exponential growth happening in the domain, and the constraints imposed on the size of curricula in undergraduate education.

2 Egypt

Egypt is the most populous country in the Arab world with a population of more than 103 million [1]. It is a young nation with approximately thirty five percent of its population below eighteen years old. In 2021, the total number of enrolled students in Egyptian universities was around 2.5 million students in about sixty universities with almost equal percentage of males and females (47.36% males and 52.64% females) [2]. The number of graduates in 2020 reached around 480,000 graduates [2].

Computer science education in Egypt dates back to the late 1970s and early 1980s with the offering of computer science undergraduate programs at the American University in Cairo, Cairo University and other universities [3, 4]. In the 1980s, autonomous departments for Computer Science and Computer Engineering were established under schools of sciences and engineering in different universities [3, 4]. In the mid-1990s, dedicated schools of computer science were established [5, 6]. Nowadays, computer science programs in Egypt attract some of the top students engaging in university education. There are more than 50 schools of computer science in public, private and national non-profit universities [7]. Other programs have specialized concentration programs in Cyber Security, Digital Multimedia, Software Engineering, Bioinformatics and Artificial Intelligence. A larger than usual demand is driven by higher than average salaries in the domain [8].

To cope with the recent advances in Artificial Intelligence (AI), many computer science schools in public universities in Egypt started to offer special programs dedicated to AI [6, 9]. Multiple universities in Egypt have recently offered undergraduate data science programs or concentrations (for example, at the American University in Cairo and the German International University) [10, 11]. This is almost at the same time of establishing professional diplomas in data science and big data technologies at other universities [12, 4, 13].

The Computer Science program at the American University in Cairo represents one model of a program in Egypt that is adapting with agility to cope with very rapid changes in the field. The program has been structured with a vision to be Student-Oriented, Popular, Research Intensive, Industrially Aligned, Technologically-current, and Experiential (SPRITE) [14]. The program is supported with a very rich liberal arts education adopted by the university, focusing on providing students with the skills and the vision needed to tackle societal problems. It is co-offered with a counterpart computer engineering program in the same department to stimulate cross-specialty and systems-based collaboration. At least sixty-six required credit hours of computing courses along with very strong mathematical foundations are part of the study program. The program attracts some of the best students attempting to venture into sciences and engineering.

In addition, the program promotes essential research skills of students through projects assigned in multiple courses. Senior capstone projects are designed to have a research component that leads in many cases to publications. As part of the capstone project, sessions on research and entrepreneurship are given to students. About half the capstone projects are co-supervised by key industrial partners to wean students into the industrial landscape. The program requires students to undergo a “micro co-op” eight-week-long industrial training with a very high expectation of technical rigor. Students are incentivized to start their internships as early as their second year of education and this is enabled through an early-maturity pedagogical approach, which helps students get exposed to the latest technologies used in the industry. Above and beyond, world-class faculty members who have an interest in working within the Egyptian community are selectively hired to create world-class graduates. Each batch of graduating students are given the opportunity to pitch their key skillsets to employers through professionally video graphed one-minute videos that are promoted by the program.

Finally, over the years, alumni of the program have taken leading roles worldwide in academia as well as the industry. As a result of the experiential aim of the program, many world-renowned startups were established by alumni of the program. It is noteworthy that other Computer Science programs in Egypt adopt similar strategies focusing on boosting the research skills of the students in addition to requiring industrial training as a graduation requirement.

Overall, the Egyptian government has established multiple initiatives to provide computer science training in advanced fields including AI and data science. In 2019, the Egyptian government established the National Council for Artificial Intelligence with the task of outlining the national AI strategy of Egypt [15]. In 2020, the Egyptian government launched the Digital Egypt Builders initiative with the target of training 1000 university students, who are majoring in either computer engineering or computer science, on practical aspects of AI, data science and cybersecurity [16]. Finally, in 2021, and in partnership with Amazon Web Services (AWS), the Egyptian government trained 500 individuals on using AWS big data and data analytics tools [17].

3 The Levant

The Levant region consists of Lebanon, Palestine, Syria, Jordan, and Iraq, including a total of 2 million university students. With the lack of accurate statistics, we hypothesize that about 400 thousand students are enrolled in CS/E and related IT disciplines, amounting to almost 20% of the total student body (according to combined international students’ statistics from [18]). A person working as a CS/E professional in the Levant, namely in Lebanon, Jordan, or Palestine, earns around USD 2,500, where salaries range
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from USD 800 (lowest) to USD 5,500 (highest) [19] (cf. Table 1). The primary type of CS/E industry is software development.

<table>
<thead>
<tr>
<th>Table 1. Number of university students, including CS/E students</th>
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<tbody>
<tr>
<td>Lebanon</td>
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<tr>
<td># of university</td>
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<tr>
<td>students</td>
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<tr>
<td># of CS/E students</td>
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<tr>
<td>(estimated [1])</td>
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<tr>
<td>Average salary</td>
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<tr>
<td>for CS/E</td>
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<tr>
<td>graduate (in USD)</td>
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Most renowned universities in the Levant are national public institutions, to the exception of Lebanon which boasts a private educational sector that rivals its public counterpart. Lebanon’s private universities mostly follow the American and French models, and include some of the top higher education institutions in the region. In the following, we describe the case of the Lebanese American University (LAU), one of the Levant’s most prestigious universities, and how it applies innovative practices to tackle the main challenges facing CS/E education.

The Lebanese American University (LAU) was founded as the American School for Girls in 1835, and the institution evolved into a full-fledged university in 1973, and later became the Lebanese American University in 1995. It currently boasts three campuses in Byblos and Beirut housing seven academic schools and more than 300 faculty and 8,000 students. Founded in 1995, the School of Engineering (SOE) offers B.E. degrees in computer, electrical, and mechatronics engineering, with M.S. degrees in computer and electrical engineering. The B.E. degree covers 150 credits and typically spans over 5 years of study. The SOE has established and is initiating a battery of innovative solutions to promote CS/E education, which can be mirrored in other universities in the region.

Collaboration with industry: The SOE has established strong collaborations with major industry partners in the CS/E sector, offering select students internships working on state-of-the-art projects and technologies, and providing feedback regarding the most recent technological trends in the market. The latter is essential in the fast changing and dynamic field of CS/E, where academia must always keep-up with the latest frameworks, programming languages, and software and hardware design practices in industry. SOE has established a strong collaboration with BMW Group since 2018 [25] targeting the fields of software development, robotics, and artificial intelligence. This has allowed more than 110 top students to conduct their internships at the automotive giant’s main seat in Munich [26]. SOE has also initiated and organized a joint LAU-BMW Workshop Day on Vision Intelligence and Robots Applications (VIRA 2018-21) [27], allowing LAU-BMW interns to present their projects. BMW Group has also donated to LAU a special edition 2020 hybrid electric i8 Boxster, to use for collaborative academic and research projects. High-impact hackathons and competitions are organized frequently with industrial partners for exposure and experience sharing, e.g.: First Lego League (FLL) 2019 international robotics championship [28], organized for the first time in the MENA region (1,000 participants); National Education Robotics Day (NERD) Open 2018 (400 participants); NERD National 2019 (700 participants) [29]; LAU CASE Competition 2022 in collaboration with IBM (410 applicants) [30]; and BMW Group Beirut AI Hackathon 2019 in collaboration with Nvidia and Oracle (hosting 74 participants from 8 universities in a 24-hour machine learning hackathon).

- **Opportunities**: Acquiring regular feedback and updates of the learning material according to the latest trends in the field.

Providing state-of-the-art computation facilities: Addressing the need for computation resources, LAU’s academic and research body will soon have access to high-performance computing through a project initiated by the Geneva-based European Organization for Nuclear Research (CERN) to donate and help set-up a Tier-2 data center in Lebanon [31], as part of its High-Performance Computing for Lebanon (HPC4L) project [32]. It will be governed by a consortium of Lebanese universities in addition to the National Council for Scientific Research (CNRS-L). LAU will lead the system administration, offering a unique learning experience for undergraduate and graduate students.

- **Opportunities**: Allowing advanced projects and research on computationally expensive tasks (e.g., deep learning, big data training, computer vision, simulation and optimization, etc.).

Promoting student entrepreneurship and experiential learning: Student entrepreneurship is central in CS/E due to this field’s fast changing and evolving nature. In this context, LAU has recently launched the Vertically Integrated Project (VIP) framework in Fall 2021, thanks to a grant from the US Department of State Middle East Partnership Initiative (US-MEPI). Designed by Georgia Tech, the VIP consortium includes 44 academic institutions from 13 countries [33], the majority of which are based in the US, allowing student teams from across the disciplines to collaborate on innovative projects [34]. LAU expanded the VIP framework to a VIP+ model, incorporating an entrepreneurship component that falls under the MEPI Tomorrow Leaders’ College to Work Pipeline (TLF) [35], encouraging them to innovate and create their own startups. This initiative was spearheaded by the dean of the SOE: a computer engineering faculty who specializes in computer vision and machine learning, where most current VIP teams are developing projects revolving around CS/E. A related initiative includes the launching of the LAU Fouad Makhzoumi Innovation Center (LAU FMIC) in 2020, providing an incubation hub which aims at fostering student entrepreneurship endeavors.

- **Opportunities**: Promoting experiential learning by allowing students to develop projects, supervised by faculty, coached
by graduate students, and co-mentored by industry partners. Top projects are incubated to prepare for startup building.

**Promoting undergraduate research:** SOE has launched undergraduate research courses in every engineering program, namely in computer, mechatronics, and electrical engineering, and a research methods course in the honor's program. The former allows motivated students to get a foretaste of research activities. Since 2018, more than 40 undergraduate students have participated in research projects, most of them publishing their papers in international conferences or journals. Many projects are funded by CNRS-L research grants awarded to the supervising faculty.

- **Opportunities:** Most of the best senior students from the Levant region travel to North America or Europe to complete their graduate studies. Establishing an undergraduate research course will allow tapping into their research potential early-on, while training them for the graduate research world.

**Encouraging student initiatives:** motivating students to launch academic and professional clubs, allowing them to highlight their scientific and social talents, and engage in extra-curricular projects, workshops, boot camps and other initiatives [36, 37]. SOE currently houses 5 clubs revolving around CS/E, including IEEE student chapter, Google Developer Student Club (DSC), Robotics club, Artificial Intelligence club, and Logistics Automation club.

**Promoting CS/E at high-school level:** In addition to efforts conducted at university level, there have been certain efforts to further promote and solidify CS/E education at the high school and middle school levels in Lebanon, such as the introduction of computer science classes in the middle school classes (or cycle 3) of 553 of the 875 public schools according to the Center for Educational Research and Development [38]. While most private schools already offer CS courses, nonetheless, a CS education bill was recently passed by the Lebanese Parliament in 2022 making CS education compulsory in all high schools in the country, mandating the need to overhaul the curriculum to adapt to the requirements of modern education systems [39]. Moving in the direction of universities and schools without borders, following an agile stackable credentials model, would be the next evolutionary step in further improving CS/E education in the Levant.

- **Challenges in the Levant:** the main challenge remains political and societal unrest, which is undoubtedly hindering the advancement of academic and industrial efforts, namely in CS/E. Another big challenge is the lack of resources and reliance on student tuition to advance CS/E education, which is extremely limiting and fragile.

- **Opportunities in the Levant:** primarily the large number and high concentration of CS/E students, their high levels of education and the potential that they represent for the market. By building strong ties with industries in the developed world, the Levant’s CS/E graduates can easily grab their share of the global market which is in dire need for skilled software engineers, programmers, AI, and big data professionals.

### 4 The Arabian Gulf

Countries which are members of the Gulf Cooperation Council (GCC) are Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates. The education sector in these countries has grown and changed in the last two decades to address local and global challenges. CS programs have been at the core of this growth.

<table>
<thead>
<tr>
<th>Country</th>
<th>Examples of universities offering an undergraduate CS program</th>
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<tbody>
<tr>
<td>Bahrain</td>
<td>University of Bahrain, British University of Bahrain</td>
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<tr>
<td>Kuwait</td>
<td>American University in Kuwait, Kuwait University</td>
</tr>
<tr>
<td>Oman</td>
<td>Sultan Qaboos University, German University of Tech. in Oman</td>
</tr>
<tr>
<td>Qatar</td>
<td>Qatar University, Carnegie Mellon University in Qatar</td>
</tr>
<tr>
<td>Saudi Arabia</td>
<td>King Abdul Aziz University, King Saud University, King Fahd University of Petroleum and Minerals, Effat University</td>
</tr>
<tr>
<td>United Arab Emirates</td>
<td>UAE University, Khalifa University, NYU-AD, Birmingham University of Sharjah, University of Sharjah</td>
</tr>
</tbody>
</table>

in line with the new emerging interest in fields such as Artificial Intelligence, Robotics, Data Science, Cloud Computing and Cyber Security. Table 2 shows examples of public and private universities offering undergraduate CS programs.

The majority of the offered undergraduate CS programs in the GCC countries align their program offering with the ACM/IEEE 2020 computing curricula. ABET accreditation of CS programs is usually targeted in addition to accreditation by the local authorities within each country. Some of the programs are offered as a single track while other programs include one or more concentrations/specializations. For example, the CS programs at the UAE University and King Saud University [40, 41] provide students with a basket of elective courses to choose from but do not offer any concentrations. On the other hand, the programs offered by Khalifa University [42] and Effat University [43], for example, offer two concentrations, Artificial Intelligence and Cybersecurity. The majority of offered CS programs are composed of a curriculum between 120 and 140 American based credit hours.

**Innovations and Future Directions in offering CS programs, the Case of the UAE.**
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The offering of undergraduate CS and related degree programs in the UAE is diverse including offerings of parallel programs such as BSc in AI and BSc in Data Science or Big Data Analytics which have substantial commonalities with a mainstream CS program. The UAE Ministry of Education (MoE) Commission for Academic Accreditation (CAA) accredits programs based on a very rigorous set of criteria and standards. The CAA Standards [44] introduced certain requirements to be fulfilled by computing programs making them more innovative and accommodating of new emerging trends. For example, the Standards mandates that AI and Data Science, as relevant to each discipline, be covered either as separate courses or as modules infused into other courses. In addition to the AI and Data Science requirements, the Standards mandates that all computing programs offer a 12-week Internship experience and that at least 50% of the program’s contact hours of CS major courses have either associated labs or applied components.

Looking at the CS program [40] at the UAE University specifically, we can identify a few distinguishable innovative characteristics. The program requires all students to complete a course on the 4th industrial revolution which introduces students to emerging computing topics and related problems. This course also includes a technical English language tutorial component to enhance students’ technical communication skills. In addition, all students complete a course called "Entrepreneurship in IT", which is tailored to enhance students’ skills in IT based venture creation and related areas of interest. Students, through this course, can link with the UAE University science and innovation park which acts as an incubator. The program also offers the students a "Special Topics in Computer Science" course which can have different content each offering depending on special requests. New proposed changes to the program are being studied to enhance future offering. This incorporates more flexibility and adaptability to enable graduates to meet the fast-changing business and market requirements landscape in the UAE in various areas of interest such as Space, AgriTech, Biotech, Energy, Healthcare and Cyber Security. The new proposed changes to the CS program include:

- a minimal core of CS courses with tailored math courses
- creating specialization tracks relevant to market needs
- embedding ethics as modules throughout the curriculum
- embedding AI throughout the curriculum in addition to offering other advanced related courses (computer vision, LNP, Computational Analysis, Bioinformatics...et. [42])
- introduce what the College calls "Technopreneurship". A technology-based entrepreneurship program to help students develop entrepreneurial and technology-based mindset and skills to bring their ideas to life. The program will start as early as the first year of studies and continue seamlessly throughout the students’ academic journey. This can replace what is commonly known as the capstone project.
- allowing students to complete a minor from another discipline to broaden their breadth knowledge.

5 Northwest Africa

The Maghreb’s population is estimated at 105 million inhabitants with 88% living in three countries: Algeria (44 million), Morocco (37 million) and Tunisia (12 million) [45]. The number of students enrolled in technology-related post-secondary studies exceeds 253,000 out of 1,447,000 higher education enrollments in Algeria [46], 40,000 out of 1,170,000 in Morocco [47] and 26,000 out of 234,000 in Tunisia [48].

Higher education is offered through a network of university and non-university public and private institutions, which mainly follow the three-cycle License-Master-Doctorat (LMD) structure recommended by the Bologna Process [49], delivering 3-year bachelor’s (180 credits over 6 semesters), 1-year or 2-year master’s (up to 120 credits over 4 semesters) and doctoral degrees. Each semester lasts 14-16 weeks and is worth 30 credits, with a credit being 20-30 hours of student work per semester. Exceptions are engineering schools which offer 5-year degrees (300 credits over 10 semesters) and institutions following the Anglo-Saxon system which deliver 4-year bachelor’s degrees (136 credits over 8 semesters, where one credit is worth 45-50 hours per semester). Public universities adopt an open access policy while public engineering schools and private institutions follow a rigorous selection process. All high-school graduates have the right to free-of-charge public university education, but admission to specific programs depends on available spots, and the student’s preferences, grades and geographical location. Most programs are delivered in French as it is widely used in the private and public sectors.

Post-secondary programs in computer science are delivered mainly by universities and engineering schools. Top programs in Algeria include those offered by the École Nationale Supérieure d'Informatique, Houari Boumediern University of Science and Technology and Oran 1 University. In Morocco, the leading institutions are AI Akhawayn University (AUI), the École Nationale Supérieure d’Informatique et d’Analyse des Systèmes (ENSIAS) and Mohammed VI Polytechnic University (UM6P). In Tunisia, prominent schools include the École Nationale des Sciences de l’Informatique, l’École Supérieure des Communications de Tunis, l’École Nationale d’Ingénieurs de Sfax, and l’École Nationale d’Ingénieurs de Sousse.

There are three main challenges that face computer science education today in the Maghreb. First, all private and public institutions operate under the pedagogical authority of the Ministries of higher education, thus institutions have little governance in putting in place truly transformational innovations. The only exception is AUI in Morocco which was established by a special royal degree [50] that grants it total autonomy in delivering educational programs that are officially recognized, independently from the Ministry of Higher Education regulations. Second, the sluggish economy and stiff bureaucracy lead to fewer highly qualified and lucrative positions and thus a severe brain-drain. In Morocco alone, 600 qualified computer professionals leave the country every year [51]. Third, despite the
high number of student enrollment and growing interest in technology, computing programs have a very limited number of spots due mainly to budgetary constraints and a shortage of qualified computing faculty.

Countries have launched several initiatives to improve the higher educational ecosystem, but many failed due to a blurry vision, absence of close monitoring, lack of funding or political divergences. To overcome these difficulties, governments have established national advisory bodies to help the Ministries of Higher Education identify and implement the right strategies. Such bodies include the Conseil National d’Education et de Formation (CNEF) in Algeria [52], the Conseil Supérieur de l’Education, de la Formation et de la Recherche Scientifique (CSEFRS) in Morocco [53] and the Conseil Supérieur de l’Éducation et de l’Enseignement (CSEE) in Tunisia [54]. In 2023, a new national plan PACTE ESRI 2030 [55], has been launched in Morocco to accelerate the transformation of higher education, including the adoption of innovative curricula [56].

Acknowledging the strategic importance of emerging fields such as Artificial Intelligence and Cybersecurity, academic institutions are establishing specialized educational and research programs such as l’Ecole Nationale Supérieure d’Intelligence Artificielle in Algeria [57], the UM6P AI Movement [58] and Center for Cybersecurity and Privacy [59] in Morocco, and a number of educational programs in Tunisia. Governments are also setting up national strategies and legal and regulatory frameworks around these topics [60, 61, 62]. Besides, Morocco has strengthened its digital sovereignty with a world-class data center and supercomputer [63].

While computer science programs in the region train students to be able to work in R&D, enterprises or at the end of the value chain running computing projects, most graduates embark in the last two career tracks and many move into project management. The best and brightest are often hired by R&D centers overseas such as Amazon, Facebook, Google, IBM, Microsoft, and Oracle. The reason is the lack of such opportunities locally. Hopefully, this trend is being limited with the opening of new R&D labs such as the Oracle Research Lab in Casablanca [64] and the growing startup ecosystem.

In terms of innovation in computer science education in general, three institutions particularly stand out: AUI and UM6P in Morocco, and the University of Sousse in Tunisia.

As a liberal arts institution, AUI has tailored its Bachelor of Science in Computer Science, accredited by ABET since 2009, to provide a solid training in computer science with the option to minor in non-technical fields. All core computer courses have practical labs, and an optional complementary training is offered during the last semester to equip students with hands-on practical experience in hot areas such as cybersecurity, distributed systems or big data analytics. Students can receive credit for courses taken elsewhere, including online, provided they are offered as credit courses within a university. Some professors have cautiously experimented with stackable credentials allowing students to take some course modules through online platforms but the student assessment is conducted by the professors themselves, to ensure that students achieve the Intended Learning Outcomes for each course. Students are required to complete one internship and one capstone project, and can combine both to conduct a more extensive project in industry or engage in a research thesis.

As a research-focused institution, UM6P designed its undergraduate program to prepare students to embark on innovation-driven careers. The School of Computer Science offers an undergraduate program that teaches students fundamental concepts in CS and equips them with practical skills through learning-by-doing modules, leveraging state-of-the-art computing facilities and a digital learning lab. Courses in distributed systems, big data analytics and cybersecurity are taught in the final two years of study by professors who conduct research in these areas. Students have to undertake two internships in industry, two applied projects within the university and a one semester capstone project in a company or research laboratory. Students are also encouraged to engage in entrepreneurial activities thanks to a rich startup ecosystem which includes an entrepreneurship academy, a business incubator, an accelerator program and an investment firm [65].

The University of Sousse has also invested in many initiatives to encourage pedagogical innovations in its undergraduate computer science program. The learning lab supports professors in delivering MOOCs and designing courses based on peer-evaluation and flipped and hybrid classrooms [66]. The university also offers “co-construction” degrees that are co-designed with local industry, and government and non-government organizations to better align educational requirements with local market needs [67].

The Maghreb region offers unique opportunities in computer science undergraduate education. It is a powerhouse of youth talent with an increasing interest in the English language. It boasts a strategic geographic location, making it a bridge between Africa and the rest of the world. It enjoys a pleasant climate and low cost of living which can be very attractive to expatriate faculty and international students [68]. Governments are also investing into the internationalization of higher education by offering dual degrees, exchange, and capacity-building programs such as Erasmus+ [69] and Horizon Europe [70], as well as the establishment of transnational programs such as Ecole Centrale Engineering School [71] and Cardiff Metropolitan University [72].

6 Conclusion

With an ever-expanding knowledge in the computer science domain, academic programs are finding it very challenging to provide enough know-how and experiential training that can support the transition of students gracefully into the job market. As curricular guidelines are being developed for the next decade by the CS2023 ACM/IEEE/AAAI taskforce, it is important to highlight to the world how computer science education and innovative practices are happening around the world. In this
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paper, we presented how universities in four regions of the Arab World countries are adapting fast to enable computer science students to be better prepared for the job market. The region is characterized by significant diversity, and a very good representation of gender-balance in the computer science domain. Better practices from Egypt, the Levant, the Arabian Gulf and Northwest Africa were presented demonstrating how diverse the Arab World is in terms of its educational systems, as well as in the various innovative approaches taken by both public and private universities to prepare computer science graduates for the job market.

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