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# Aligning Academic Efforts with Key Industries: A Case of Computing at the University of Namibia


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***Abstract*—Preparing future graduates for the workplace should involve linkage with industry. Ultimately, students gain valuable insight into real-life projects, preparing them for future careers. However, universities in some developing countries lag in their initiatives to promote industry-academia collaboration. In this paper, we explore how to strengthen academic efforts at the University of Namibia (UNAM) with the assistance of industry in Namibia. In the study, we analyse: 1) current practices of industry collaboration worldwide published in ACM and IEEE digital library through a scoping review, and 2) students' capstone projects conducted in the final year of the Bachelor of Science (Honors) in the computing discipline in 2020 - 2022 at UNAM. The analysis from the scoping review found six (6) different University-Industry Collaboration initiatives employed in universities worldwide.**

**Additionally, the review of current students' theses indicates that they are not aligned with all four key industries in Namibia: Mining, Tourism, Fisheries, and Agriculture. Hence, we contextualised the analysis by reflecting upon the economic drivers and demands of the country. The preliminary outcomes of this study allowed us to propose the incorporation of the Conceive, Design, Implement, and Operate model in the computing degree programme that UNAM can adopt in developing an effective curriculum that aligns with the demands of the key relevant industries in Namibia. The aim is to support the development of new talent that will promote the country's economic growth. Reflecting on this process can also benefit other universities in developing countries by assisting them in contextualising their curricula and addressing their local and national requirements.**



***Keywords—Computing, University-Industry, CDIO model***


## I. Introduction

Technological advancement has contributed to the demand for computing professionals. As a result, employees continuously search for suitable candidates because talent is scarce, and newly employed graduates often need more skills for the workplace [1]. Universities are, therefore, constantly seeking approaches to effectively apply theory to practice by working closely with industry. Simultaneously, the industry has acknowledged the value of collaboration, has embraced the idea, and aims to establish a more intense knowledge economy [2], [3]. While strong relationships exist between universities and industry in developed countries, poor collaboration culture prevails in most developing countries, which deters University-Industry Collaboration (UIC). Establishing a close UIC is reportedly sluggish and challenging in developing countries, despite the number of activities taking place at their universities and in the industrial sectors [4].

Moreover, universities in developing countries tend to copy initiatives designed for industries in developed countries instead of paying attention to the type of graduates and expertise their countries need to support their growth, exacerbating the situation [5]. Learning and teaching at African universities present unique challenges, hence the need to contextualise to fit in with African realities [6]. Therefore, African universities must understand the different industries' demands to provide their students with appropriate experience and skills to enhance their career prospects [7].

### *A. Background*

This study focuses on Namibia, a developing country located in the southwestern part of Africa [8]. Namibia's economy is primarily export-driven, with mining, tourism, fishing and agriculture as key sectors [9]. Recently, green hydrogen, renewable energy, oil and gas, the chemical industry, transport and logistics have started to provide investment and development opportunities [9].

Despite three prominent universities in Namibia [10], the University of Namibia (UNAM), Namibia University of Science and Technology, and the International University of Science and Management, the youth unemployment rate remains high, at 46% [11], necessitating the strengthening of UIC to prepare students for better career perspectives.

#### *1) University of Namibia (UNAM)*

This study focuses explicitly on UNAM, founded in 1992, with four faculties and twelve campuses country-wide [12]. UNAM recently transformed its curriculum, merging the three computing degree programmes: Computer Science, Information Technology, and Information Systems, into a Bachelor of Science in Computing. On average, the lecturer-student ratio in the first- and second-year classes is 1:80 but drops in the third and fourth years to 1:40. Currently, old computing programmes ending in 2025 are running concurrently with the new programme implemented in 2023 [12].

#### *2) Computing graduates at UNAM*

Computing students enrolled in the old curriculum at UNAM could graduate without industrial exposure because it is outside the curriculum requirements [12]. However, students who recognise the value of industry exposure work closely with industry during their capstone course or seek internship opportunities to gain industrial experience. UNAM recognised the importance of UIC in its new curriculum and introduced a Work Integrated Learning (WIL) course with the new curriculum, which will be offered in 2025. The WIL course includes a mandatory internship component to provide students with real-world computing experience.

#### 3) *CDIO Model*

The Conceive, Design, Implement, and Operate (CDIO) model provides a learning environment that enables students to actively connect formal knowledge with real-life experiences [14], [15], making it a popular choice for universities to equip students with industry-relevant skills. The CDIO model classifies projects into three levels: level 3 projects focus on course-specific knowledge and capabilities, level 2 projects cater to the knowledgeability of a curriculum group, and level 1 projects aim to develop significant learning and professional capabilities [15]. A typical professional training program includes two level 1 projects, the cornerstone and the capstone projects [15]. Over 160 universities worldwide have implemented the CDIO model. Among those universities, only the University of Pretoria and the University of Johannesburg have implemented the CDIO model in their engineering courses in Africa [15].

## II. RESEARCH DESIGN

The investigation of our study has two phases. Firstly, we explored the practices of UIC worldwide conducted in 2012-2023, focusing on CE through a scoping review. Secondly, we reviewed theses for the Bachelor of Science (Honours) in computing-related disciplines (see [16]), written within the students' capstone course conducted between 2020-2022 at UNAM, to identify the level at which students were exposed to the relevant industries in Namibia. To guide our study, we defined the following research questions:

RQ1: What are the current UIC initiatives implemented in computing-related disciplines at universities to equip students with the requisite skills for the job market?

RQ2: How can the computing department at UNAM ensure that its curriculum is aligned with local industries, thus equipping its students with relevant skills needed for the job market?

The study further contextualises the outcomes of the review by reflecting upon the economic drivers and demands of the country, including Namibia's four key industries, as noted above. The preliminary outcomes of this study allowed us to detect specific actions that UNAM can take to improve the computing curriculum.

The remainder of this paper is structured as follows. In Section III, the methodological steps following the execution of the scoping review are presented, together with analyses of students' theses. Section IV presents outcomes of the study. Section V analyzes the outcomes, and they are discussed in Section VI. The conclusion and plans for future work are presented in Section VII.

## III. METHODOLOGY

In this section, we first describe the scoping methodology used to review the practices of UIC worldwide. We describe the review process of the theses from the Bachelor of Science (Honors) in Computing-related disciplines at UNAM.

### A. *Scoping review methodology*

As UIC is a broad area, a scoping review was deemed appropriate because it examines how research on a given topic has been conducted and identifies knowledge gaps [17]. A scoping review resembles a systematic literature review as a protocol informs both to ensure the literature search is exhaustive, transparent, and replicable [17]. Subsequent sections detail the stages used in this study based on the guidelines provided by Arksey (2005) [17].

#### 1) *Inclusion/Exclusion Criteria*

The eligible materials included peer-reviewed articles published between 2012 and 2023 in English, focusing on UIC initiatives for undergraduate programs to enhance knowledge transfer in any of the five computing disciplines: software engineering, computer science, information technology, information systems, and computer engineering [18]. Studies that did not meet these criteria were excluded. Those studies include those conducted solely with postgraduate students, presented in posters or workshops, or short articles with insufficient information about the studies.

#### 2) *Search Strategy*

The literature review was searched from the Association for Computing Machinery (ACM)[18] and the Institute of Electrical and Electronics Engineers (IEEE) [19] digital library databases. The databases were considered relevant to the study as they cover most of the literature in the computing field.

The search strings were formulated from the identified keywords: "computing," "universities," "industry," and "collaboration", whose synonyms were considered and grouped into sets. The resulting search string was ((universit* OR academia) AND (industr* OR firm*) AND ("software engineering" OR "computer science" OR "information technolog*" OR "information systems" OR "computer engineering")) AND (collaboration OR bridg*) AND undergrad*. The search included two wild cards: " " to specify the exact phrases and * to match words with stem variation [18], [19]. The search also combined keywords by including the AND operator to return articles with all specified keywords and the OR operator to return papers with any specified keywords [18], [19].

The search was conducted in the abstracts of articles published in the ACM digital and IEEE libraries. Limiting the search to abstracts was based on a pilot search, as the title search yielded too many articles, which would not be easy to filter fast. Table 1 presents the number of hits per database.

*Table 1:Number of articles in the review*

| Databases | Count | Include | Exclude |
|---|---|---|---|
| **ACM Digital Library** | 40 | 8 | 32 |
| **IEEE** | 10 | 6 | 4 |
| **Total** | 50 | 14 | 36 |

*3) Screening Process*

The screening process is summarised in Figure 1 and begins with the authors applying the search string to the databases. The returned articles were exported to an Excel workbook. Fifty-eight articles were initially identified, with forty from ACM and eighteen from IEEE. Meetings were held among the authors to screen the articles based on the inclusion and exclusion criteria.

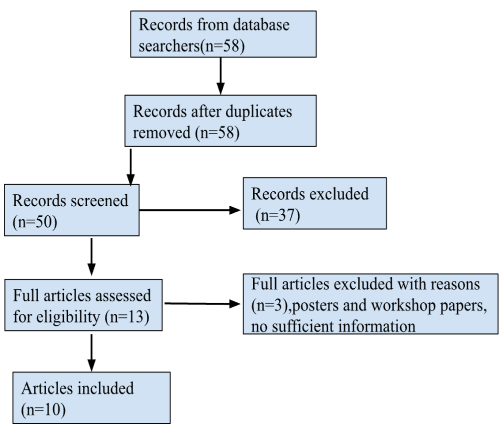


*Figure 1: Prisma flow diagram*

The first author removed eight duplicates, as some articles published in IEEE were found in the ACM database. The authors then applied the inclusion and exclusion criteria, and eight articles from IEEE and two from ACM were ultimately included in the review.

*4) Charting the data*

Once the final list of articles was agreed upon, the files were uploaded on Google Drive. The coding was done based on approaches corresponding to RQ1. The following information was charted for each article: author and titles, year of publication, UIC initiatives, methodological approaches, and authors' defined skills outcome.

### *B. Analysing the research thesis conducted in the Capstone Course*

We analysed graduate computing theses carried out at UNAM between 2020 and 2022. Theses from the capstone course document the rigorous, high-level project that requires students to integrate and apply the knowledge and skills acquired during their four-year study. The course emphasises experiential learning and stresses the importance of incorporating real-world projects into the curriculum, aiming to bridge the gap between university education and industry expectations. Specifically, we examined whether the theses undertaken by UNAM students during this period were geared towards addressing challenges in Namibia's key sectors of Agriculture, Fisheries, Mining, and Tourism.

## IV. Outcomes

*1) Results from the scoping review*

All articles retained in this review were published between 2012 and 2022. The majority of the articles were conference articles and journal articles. Different studies identified different skills students need to improve, and hard and soft skills were identified for improvement. The dominant learning approach was Project-Based Learning (PBL), although other learning approaches were also identified in different studies.

The review has acknowledged the implementation of diverse UIC initiatives. Although spearheaded by universities in most cases, the industry recognises the demand for competent graduates. The industry has addressed the knowledge gaps by creating specialised centers to improve student competencies in specific areas.

For example, a High-Performance Computing (HPC) center was developed to teach and inspire students to prepare them for interdisciplinary work in the HPC discipline [20]. The initiative involved students participating in a Student Cluster Competition (SCC), a microcosm of professional HPC centers. At the SCC, students pursue careers in the HPC field by providing experiential learning and engagement with the community, which can complement a robust parallel and distributed computing (PDC) curriculum. In a similar study, students were incentivised to learn how to effectively program a graphic processing unit, addressing industry skills gaps not part of their regular curriculum [21]. In another study, Pizard (2022) [22] developed an Evidence-Based Software Engineering (EBSE) course to bridge the gap between academia and industry by balancing research of practical relevance with academic rigour. The study taught EBSE using evidence-based scenarios created in collaboration with practitioners. In another study, the industry provided educational experiences through a complementary training program (CTP) to train undergraduate students to promote research, technological progress, and human resource training [23].

This review also found joint projects between universities and industries. In a study by Venson (2016) [2], a university and a government agency collaborated on a joint project involving the development of practical and academic activities aligned with students' capstone projects, where students worked closely with academic lecturers and industry supervisors. In another study, Harrell, Nam, Larrea, Keville, and Kamalic [19] conducted a UIC joint project over two sequential years. In the first sequence, students worked on a client-based project integrated with learning design and other related topics. Another client's project followed this, which is a more advanced independent year-long project. In the first year, students are scaffolded until they can work without guidance to prepare for the second year, where they work on projects independently.

This review also found that universities seek cross-border collaborations with other universities or industries. For example, in a study by Shipepe et al. (2021) [24], UNAM, a Finnish university, and a few companies collaborated to offer a course taught by academic lecturers from partner universities and guest lecturers from industry. The review also found that students worked on projects guided by academic and industry-guest lecturers. In some cases, UIC happened through industry visiting, where lectures incorporated real-world problems and challenges into seminars [25]. In other studies, students participated in out-of-class learning activities, such as visiting industry practitioners, to gain practical experience related to their coursework [20]. The scoping review also identified self-sponsored projects guided by industry experts [26]. Employing technology, such as games, is also visible in this review, where gamification is employed to teach industry skills [27]. Collaborations in different spaces have also been identified in this review, where universities combined face-to-face and online teaching methods to carry out some of these collaborations [24], [25].

*B. Results from the computing theses*

Forty-nine students registered for theses between 2020 and 2022 at UNAM. Figure 2 depicts theses registered in 2020, according to challenges in the respective sectors.

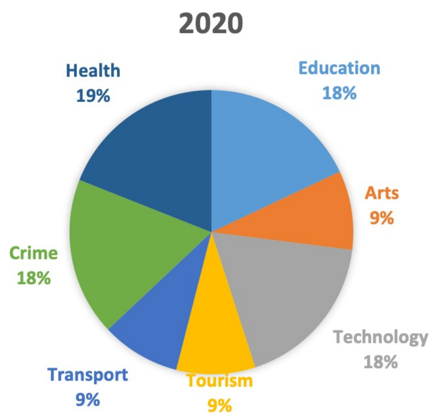


*Figure 2: Theses registered in 2020*

In 2020, eleven students registered for theses; of those only 9% researched topics to solve problems in one of the key sectors, Tourism. Most students (18%) were interested in research topics to solve problems in Education, Technology, and Crime, while the least (9%) solved challenges related to Transport and Arts. Notably, no student researched projects aimed at addressing challenges within the other three key sectors: Mining, Agriculture, and Fisheries.

Figure 3 depicts theses registered in 2021, according to challenges in the respective sectors.

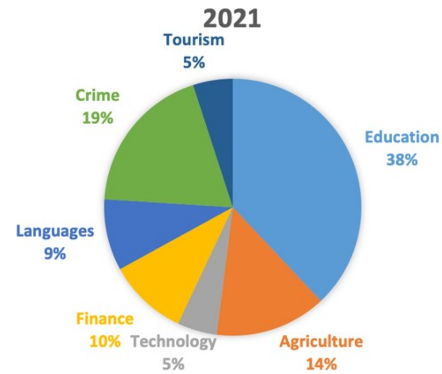


*Figure 3: Theses registered in 2021*

In 2021, twenty-one students registered for theses; of those, 14% researched topics to solve problems in Agriculture, and 5% researched topics to solve problems in Tourism. Most students (38%) were interested in research topics to solve problems in Education, while the least (5%) solved challenges related to Tourism and Technology. Notably, no student-researched projects aimed at addressing challenges within the other two key sectors: Mining and Fisheries.

Figure 4 depicts theses registered in 2022, according to challenges in the respective sectors.

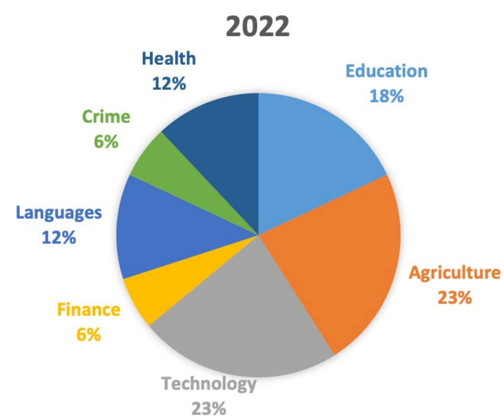


*Figure 4: Theses registered in 2022*

In 2022, Seventeen students registered for theses; of those, most students (23%) were interested in research topics to solve Technology and Agriculture problems, while the least (6%) solved topics related to Finance and Crime. Notably, no student researched problems aimed at addressing challenges within the other three key sectors: Mining, Tourism, and Fisheries.

## V. Analysis

### A. Scoping review methodology analysis

The results from the review show that UIC initiatives continue to evolve to meet industry's and academia's changing demands [2]. We identified Six (6) UIC categories used to enhance UIC, depicted in Figure 5.

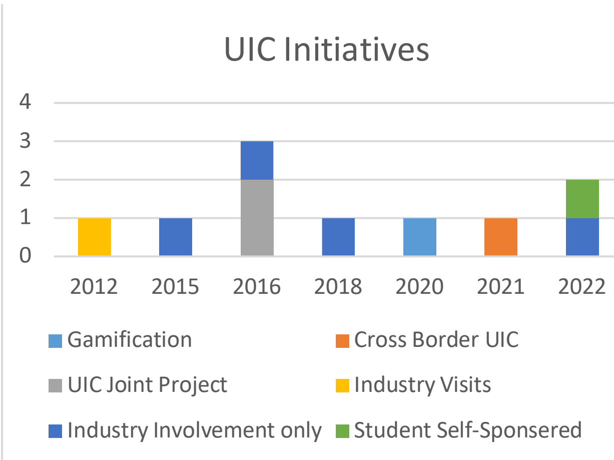


*Figure 5:* UIC initiatives

The Six (6) UIC categories are defined below as follows:

- *UIC Joint Projects* - projects usually formed by collaborating universities and industries. Students work on a project with the guidance of the lecturer and industry supervisor during a course, normally in their third year, followed by an industrial project in their final year of studies [2], [14].
- *Student self-sponsored projects* - projects initiated and funded by students without any external sponsorship or support. Industry professionals normally guide these projects, but students take full responsibility [26].
- *Cross Border UIC*- projects that form from initiatives to promote UIC in different countries [24].
- *Industry Involvement Only* - initiatives that involve industry to transfer knowledge to students. For example, the industry offers courses to fill specific demands [20], [22], [23], [21].
- *Industry visits* – initiatives where students visit companies or organisations to gain first-hand experience and insights into their operations, culture, and practices [25].
- *Gamification*- projects that involve the application of game principles design to non-game contexts through UIC [27].

We further reviewed the number of times the UIC initiatives were published and found that 38% of the publications featured initiatives proposed by the industry. UIC joint projects involving initiatives that combined courses and capstones were found in 23% of the publications. It was also found that 15% of the publications involved cross-border collaborations. The remaining initiatives, student-self-sponsored, involving gamification concepts and industry visits, are each recorded in 8% of the publications. Figure 6 depicts the number of initiatives per publication included in this study.

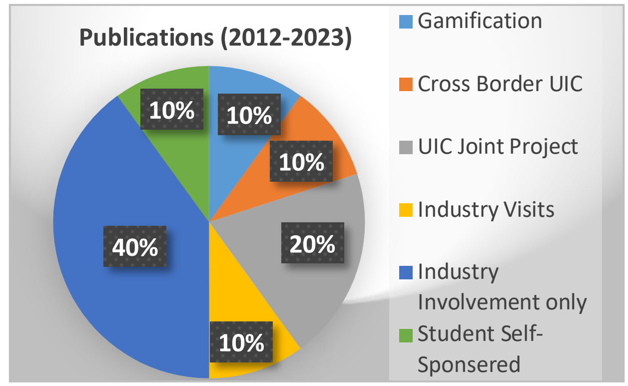


*Figure 6:* Number of publications

While not explicitly identified in all studies in this review, graduates are observed to lack both practical and soft skills. The authors defined those skills differently and identified the following skills: cognitive skills, intellectual growth, team knowledge specialisation, task credibility, task coordination, GPU programming, and HPC skills [20] [21], [28] lacking among graduates.

The review also found that various learning approaches were used to enhance UIC initiatives in different studies. These approaches include the project-based learning approach [24], transactive memory system learning approach [28], test approach [27], evidence-based scenarios [22], and approaches based on the organisational improvement model [2].

The analysis found that students showed more interest in solving challenges related to social issues like education, health, crime, technology, arts, transport, and languages. These challenges are not related to key industries in Namibia. Little interest in key industries in Namibia was, however, visible. In 2020, students solved challenges in Tourism. In 2021, students solved challenges in Agriculture and Tourism, and in 2022, students solved challenges in Agriculture.

## VI. Discussion

The demands of the computing industry are constantly changing in response to technological advancements. As a result, universities collaborate with industry to address knowledge gaps as identified in the scoping review, for example, in [20], [22], [23], [21]. These collaborations involve initiatives that adapt curricula and teaching methods to prepare graduates for a seamless transition into industry. While not explicitly identified in all studies in this review, graduates are observed to need both practical and soft skills [20] [21], [28]. Students' skills could, however, still benefit from further development through industry or academic collaborations, such as cornerstone or capstone projects, among many others.

At UNAM, computing students are mainly exposed to industrial practices through the capstone course, whose product is a thesis document. Despite this effort, there have been complaints about graduates' lack of competencies in the Namibian industry [29], prompting an analysis of the past theses conducted by students in the capstone course, mainly focusing on the involvement of key industries: Agriculture, Fisheries, Mining and Tourism.

The analysis found that students solved challenges to address social challenges like Education, Health, Crime, Technology, Arts, Transport, and Languages. Only a few students solved challenges related to two key industries: Tourism and Agriculture. No student research was done on projects in areas related to the other two key industries: Mining and Fisheries. Furthermore, it was found that the challenges solved during capstone projects were either self-selected by the students or suggested by the supervisors.

Based on the preliminary outcomes of this study, specific actions can be identified that UNAM can adopt to develop an effective computing curriculum that aligns with the demands of Namibia's key industries. To contextualise the analysis of this study, we reflected upon the economic drivers and demands of the country by adopting the CDIO model.

The CDIO model has features that can inspire the UIC, which can be integrated across the computing curriculum at UNAM to assist in solving some of the problems dealing with how computing is taught [15]. The CDIO model can be contextualized into the computing programme as follows:

*Conceive* - Increase the value and relevance of the computing programmes by implementing a sequential UIC programme that exposes students to the industry in the third and fourth years of their studies. In the third year, students will work in teams on client-based projects integrated with learning design and other related topics. Students could then advance to work with a different client on a more challenging year-long independent project to hone their skills [14]. UNAM could also strengthen collaboration with key industries, Agriculture, Fisheries, Mining, and Tourism from the onset. Furthermore, UNAM could seek partnerships with key local industries for collaboration opportunities by introducing Co-op programmes and internships.

*Design* - Introduce the PBL approach, and work on solving real-world problems relevant to the industry partners. Students should work closely with industry partners by co-designing applications to gain hands-on experience. The Computing degree should be designed flexibly enough to allow constant updates to meet the ever-changing demands of industry partners.

*Implement* - Provide students with the necessary support to complete projects in their third year (team projects) and fourth year (independent capstone projects) by implementing those projects in the industry. UNAM should seek assistance from industry to mentor students and for resources.

*Operate* - Provide an opportunity for students to engage in discussions with industry partners for students to implement their projects in the real world for operation.

Implementing the CDIO principles at UNAM can differ based on the specific projects and the level of collaboration among the stakeholders involved, considering factors such as culture in cross-border collaborations.

Table 2 provides a high-level overview of how the CDIO principles can be incorporated into the UIC initiatives that UNAM can set in motion.

| | UIC Joint Projects | Cross Border UIC | Student self-sponsored projects |
|---|---|---|---|
| Conceive | UNAM and industry partners collaborate to identify project ideas | UNAM, partner universities and industry from different countries collaborate to identify cross-border project ideas | Students independently identify project ideas |
| Design | UNAM and industry partners collaborate to design projects | UNAM, partner universities and industry partners from different countries collaborate to design cross-border projects | Students design projects with guidance from the university or industry supervisors |
| Implement | University and industry partners work together to implement projects | UNAM, partner universities and industry from different countries collaborate to implement cross-border projects | Students implement projects with guidance from the university or industry supervisors |
| Operate | University and industry partners work together to maintain the project | UNAM, partner universities and industries from different countries collaborate to maintain cross-border projects | Students maintain projects with guidance from the university or industry supervisors |

Table 3 provides a high-level overview of how the CDIO principles can be incorporated into UIC initiatives likely to be initiated by external entities within UNAM.

| | Industry Involvement Only | Industry visits | Gamification |
|---|---|---|---|
| Conceive | Industry professionals identify project ideas to be addressed within their organization and give it students | Industry professionals provide opportunities for students to visit their workplaces and students learn from those visits | Students identify project ideas to work on by applying gamification techniques with the guidance of industry and university |
| Design | Industry professionals provide project design guidelines to students. | Industry professionals share design insights on projects within their organization during those visits | Students apply gamification techniques to learn the design process |
| Implement | Industry professionals provide project implementation guidelines to students | Industry professionals show students how to implement projects during those visits | Students apply gamification techniques to learn project implementations |
| Operate | Industry professionals provide project operation guidelines to students | Industry professionals show students how to during those visits maintain projects | Students apply gamification techniques to learn project operations |

## VII. Conclusion and Future Work

Computing education faces challenges that require several UIC initiatives to address them. We presented a scoping review on UIC initiatives used to align educational programmes with industry demands. These studies found that strong student-industry supervisor relationships, fostered by a robust UIC, can enhance students' perspectives of securing employment or continuing their projects with the same company after graduation. This, in turn, could encourage students to explore entrepreneurial ventures, contributing to job creation and addressing Namibia's high unemployment rates. We also analysed the computing students' theses at UNAM. We found that most students solved challenges related to social issues, and very few focused on key local industries, Agriculture and Tourism. Due to a lack of accountability for the completed students' projects, we could not determine the extent of collaboration with the Agriculture and Tourism sectors.

We, therefore, recommend adopting the CDIO model into the UNAM computing curriculum as it promotes a student-centred learning approach. This integration will foster critical thinking and problem-solving skills among students, which are essential for success in today's rapidly evolving industry [15]. Furthermore, incorporating the CDIO model into the computing curriculum will provide graduates with a competitive edge in the industry and contribute to the overall economic growth of Namibia.

We suggest implementing the PBL approach in the third-year class at UNAM, guided by the CDIO model, to adequately prepare students for the capstone course in the fourth year of their studies. Additionally, we aim to strengthen partnerships with key industries, enabling students to work closely with industry on independent projects in their capstone course. The insight gained from our research may prove valuable to other universities in developing countries that aim to align their education with local industry demands. For future work, a study to further explore implementing one of the UIC initiatives will be conducted. Further, conduct a study on students' career paths and their chosen thesis topics to provide a more comprehensive analysis.

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