Reflections on Cyberethics Education for Millennial Software Engineers

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Abstract—Software is a key component of solutions for 21st Century problems. These problems are often “wicked”, complex, and unpredictable. To provide the best possible solution, millennial software engineers must be prepared to make ethical decisions, thinking critically, and acting systematically. This reality demands continuous changes in educational systems and curricula delivery, as misjudgment might have serious social impact. This study aims to investigate and reflect on Software Engineering (SE) Programs, proposing a conceptual framework for analyzing cyberethics education and a set of suggestions on how to integrate it into the SE undergraduate curriculum.

Keywords—cyberethics; millennial software engineer; undergraduate degree program; curriculum guideline.

I. INTRODUCTION

The current technological revolution, being a critical engine of the digital transformation of the economy, is impacting all disciplines and industries. The so-called “Digital Economy” is considered the single most important driver of innovation, competitiveness and growth of countries [1]. In this context, it is also a consensus among nations that taking advantage of technology to advance social and economic inclusion, and to promote sustainability and peace, is paramount and will demand a “transformation of societies” [2].

Software engineers investigate problems, and propose and develop software to tackle such societal challenges. They are creating the foundations that enable and govern our online and increasingly our offline lives, from software-controlled cars to digital content consumption. In fact, software helps shape, not just reflect, our societal values [3].

Software is a key component of solutions for 21st Century problems [4]. These problems are complex and unpredictable, which is typical of “wicked” problems [5]. They are difficult to define and are never entirely solved, as improvements can always be made [6].

To be able to work on problems not seen before, while applying the right knowledge and judgment, software engineers must think and act more systemically and more adaptively, so they can build up experience over time to make sense of world challenges.

As the complexity of problems continues to increase, the complexity of software intensive systems or systems of systems also increases [7]. Therefore, there are serious challenges to educating millennial software engineers, which requires continuous innovation in educational systems and curricula delivery [2], [7].

Moreover, the design of software systems comes with a special set of responsibilities to society that are much broader than those described in existing codes of ethics for computing professionals [8]. While the potential return on investment in technology is usually high, the increasing pace of technological innovation raises ethical questions about its development and use [9]. Information and Communications Technologies (ICT) bring ‘predictable’ and ‘less predictable’ ethical issues [10]. Unintended consequences of technology [11] need to be investigated and a precautionary principle [12] applied.

Do millennial software engineers, the current dominant generation of workers, understand the ethical choices and related unintended consequences that the solutions for the 21st century might generate? Are they prepared to investigate and co-design solutions with other stakeholders to ensure better solutions for all? From algorithms, data science, AI, cloud computing to digital business models and services design, there are a number of ethical decisions a software engineer is (or not) going to make while designing systems.

This paper aims at investigating these questions about how millennial software engineers are trained to deal with computer ethics issues. We developed a conceptual framework based on Brey’s “disclosive” method for cyberethics, as it provides the major components for cyberethics decision-making, and the most important 21st Century cybertechnologies to support our investigation. We analyze the ACM/IEEE Software Engineering Guidelines and the curricula of the top two Brazilian SE undergraduate programs. We end the paper with a set of suggestions that might be integrated into the SE undergraduate curriculum, as well as conclusions and recommendations for future studies.

II. CYBERETHICS

A. Global and Regional contexts

Edward Snowden’s revelations on the Five-Eyes mass surveillance alliance, starting in 2013, are examples of how technology can be used to concentrate economic power and create global monopolies [13].
These revelations had profound impacts on society’s perception of ethical issues in the digital age, increasing the importance of cyberethics. Despite that technology has great potential of freeing people from manual and repetitive labor, it also brings other troubling concerns, requiring from human understanding and accountability [14].

Considering this context, countries are launching large-scale initiatives focused on addressing cyberethic issues. For instance, in the United States, several foundations and funders recently announced the Ethics and Governance of Artificial Intelligence Fund, which will support interdisciplinary research to ensure that AI develops in a way that is ethical, accountable, and advances the public interest [14].

The European Union is currently discussing the creation of a European agency for robotics and AI. They aim to preserve human dignity and integrity while developing artificial intelligence and robots [15].

In Brazil, Marco Civil (the Brazilian civil rights framework for the Internet) aims to protect human rights, including ensuring freedom of speech and expression, protecting privacy and personal data, ensuring equitable access to information, and promoting an open, competitive online marketplace, partly by guaranteeing net neutrality [13].

B. What is cyberethics?

According to Moor [16], computer ethics is the “analysis of the nature and social impact of computer technology and the corresponding formulation and justification of policies for the ethical use of such technology”

Tavani [17] argues that cyberethics is a more appropriate and accurate term, connoting the social impact of computers and cybertechnology in a broad sense and not merely the impact of that technology for computer professionals. He defines cyberethics as the “study of moral, legal, and social issues involving cybertechnology.” Cybertechnology, in turn, comprises the entire range of computing and communication systems, from stand-alone computers to privately owned networks and to the Internet itself.

Moor [16] explains that computers are essentially a malleable, universally applicable tool, so the potential applications for human action and consequent ethical issues are novel and almost limitless [17], [13]. Some of these actions might generate what Moor calls “policy vacuums”, because we have no explicit policies or laws to guide new choices that are only possible through cybertechnology. These vacuums, in turn, need to be filled with either new or revised policies [17].

According to Patrignani [19], we are living in a policy vacuum era and nobody questions technologies. Scenarios for their use change and evolve rapidly and there are no policies addressing these new situations. Therefore, we might assume that whoever is designing new technologies is going to be especially responsible for any unintended consequence.

Policies are “rules of conduct, ranging from formal laws to informal, implicit guidelines for actions” [16]. Policies can range from formal laws to informal guidelines [17]. However, this will not always work, because sometimes the new possibilities for human action generated by cybertechnology also introduce “conceptual muddles” [16]. In these cases, we must first eliminate the muddles by clearing up certain conceptual confusions before we can frame coherent policies and laws [17].

In addition, Brey [20], [21] believes that because of embedded biases in cybertechnology, the standard applied-ethics methodology is not adequate for identifying and acting on cyberethics issues. Brey argues that the standard ethics method tends to focus almost solely on the uses of technology [17]. The standard method fails to pay sufficient attention to certain features and practices involving the use of cybertechnology that have moral import but that are not yet known [20].

Many practices involving computer technology are morally nontransparent because they include operations of technological systems that are very complex and difficult to understand for laypersons and that are often hidden from view for the average user [21]. They also involve distant actions over computer networks by system operators, providers, website owners and hackers and remain hidden from view from users and from the public at large [21].

C. Making cyberethics decisions: Brey’s “disclosive” method

To address aforementioned caveats on cyberethics decision-making, Brey proposes a “disclosive” method for cyberethics [20]. The aim of disclosive ethics is to identify such morally opaque practices, describe and analyze them, so as to bring them into view, and to identify and reflect on any problematic moral features of cybertechnologies [21].

Brey describes the methodology for computer ethics: it must first identify, or “disclose”, features that, without proper probing and analysis, would go unnoticed as having moral implications. Therefore, we need computer scientists (or software engineers) because they better understand computer technology (as opposed to philosophers and social scientists) [20].

Social scientists are also needed to evaluate system designs and make them more user-friendly. Philosophers can determine whether existing ethical theories are adequate to test the newly disclosed moral issues or more theory is needed. Finally, computer scientists, philosophers, and social scientists must cooperate in applying ethical theory in deliberations about moral issues [20].

Tavani [17] summarizes Brey’s disclosive method in the three following steps.

Step 1 Identify a practice involving cyber-technology, or a feature in that technology, that is controversial from a moral perspective. 1a. Disclose any hidden (or opaque) features or issues that have moral implications. 1b. If the ethical issue is descriptive, assess the sociological implications for relevant social institutions and socio-demographic and populations. 1c. If the ethical issue is also normative, determine whether there are any specific guidelines, that is, professional codes that can help
resolve the issue. 1d. If the normative ethical issues remain, proceed to Step 2.  
Step 2 Analyze the ethical issue by clarifying concepts and situating it in a context. 2a. If a policy vacuum exists, proceed to Step 2b; otherwise continue to Step 3. 2b. Clear up any conceptual muddles involving the policy vacuum and proceed to Step 3.  
Step 3 Deliberate on the ethical issues. The deliberation process requires two stages: 3a. Apply one or more ethical theories to the analysis of the moral issue, and then go to step 3b. 3b. Justify the position you reached by evaluating it against the rules for logic/critical thinking.

III. Conceptual Framework for Analyzing Millennial Software Engineers Education for Cyberethics

To be able to analyze millennial software engineers' education under the lens of cyberethics, we derived a conceptual framework from 1) Brey's "disclosive" method on cyberethics decision-making and 2) the required pieces of knowledge to apply it, which should be provided by 3) a certain Software Engineering curriculum. Figure I illustrates our conceptual framework.

Despite that we provide a number of required knowledge pieces, this paper focuses only on cyberethics and practices, as well as the usage of already available SE/CS professional codes. We reviewed the literature on cyberethics to identify the most relevant technical and nontechnical components that are crucial for Software Engineers in the 21st century, as they might exhibit controversial issues from a moral perspective. We took advantage of our previous 15 years experience in global software development companies to refine and complement this list of relevant cybertechnologies.

In 2011, the Etica project, funded by the European Commission, analyzed 100 technologies, 70 application examples and 40 artifacts to synthesize the emergent ICTs coming in 10 to 15 years. The emergent technologies are high-level socio-technical systems that have potential to affect the way humans interact with the world [22].

They highlighted 11 ICTs: Affective Computing, Ambient Intelligence, Artificial Intelligence, Bioelectronics, Cloud Computing, Future Internet, Human-machine symbiosis, Neuroelectronics, Quantum Computing, Robotics, and Virtual/Augmented Reality.

We found that some additional components must be part of the list of cybertechnologies. For instance, despite that Data Science, Social Media, and Mobile are not emergent, they are structuring technologies for the necessary hyper-connectivity that enables the Digital Economy. Rapid advances in technology can boost whole business models [23], which means that digital business models can have enormous impact on society and the economy. As customers expect increasingly faster, cheaper, and better products and services, practices involving Design Thinking and Experience, Product and Services Design become crucial for software companies competing against the already known experiences customers have with the Facebooks, Apples, and Amazons of the world [23]. Finally, software security and technological social impact are must-have components.

After removing ICTs that we considered too futuristic (e.g., neuroelectronics or human-machine symbiosis), we ended with a list of 9 crucial cybertechnologies for the 21st century that are relevant to this study. For didactic purposes, we divided the critical into two groups: technical and non-technical components. The technical components are: 1) Data Science; 2) Cloud Computing; 3) Algorithms; 4) Artificial Intelligence; Robotics; 5) Internet; Internet of Things; Mobile; Social Media; 6) Secure Software Engineering. The non-technical components are: 7) Experience, Product and Services Design; Design Thinking; 8) Digital Business Models; Economics; 9) Software and Society; Cyberlaw.

Table I presents the nine suggested components, a summary of their moral controversies and key references.

IV. An Analysis of the SE Curriculum

In this section, we analyze the ACM/IEEE Curriculum Guidelines for Undergraduate Degree Programs in Software Engineering [42], as well as the top two Brazilian Software Engineering Programs for evidence of ethics as an interdisciplinary approach addressing the needs of the future. More specifically, we searched for topics related to ethics in the ACM/IEEE Software Engineering Education Knowledge (SEEK) and in the two Brazilian SE undergraduate courses to check if the teaching of Ethics is one given appropriate attention in millennial software engineers’ education. For this purpose, we performed a search for some Ethics-related topics presented in syllabi of this discipline, such as “Ethics”, “Society”, “Sustainability”, “Environment”, “General Systems Theory”, “Complex and Adaptive System”, “Law”, “Legal”, “Social” and “Humanity”.

Ethics is one of the most valued concepts presented in the ACM/IEEE Computing Curricula. In addition to explicitly citing the Software Engineering Code of Ethics and Professional Practice [43], the Curriculum Guideline number 15 states that “Ethical, legal, and economic concerns and the notion of what it means to be a professional should be raised frequently.” Moreover, the Ethics word appears 19 times.

The proposed SEEK, which is inspired in the SWEBOOK [44] and describes the body of knowledge that is appropriate for software engineers, suggests 467 hours of fundamental content for the design, implementation, and delivery of the educational units that make up a software engineering curriculum. However, there was only one Ethics-related topic, named “Professionalism” with 6 hours, which corresponds to 1.3% of the total content, which seems to be an inconsistency. Although there are no Curriculum Guidelines for Undergraduate Degree Programs in Software Engineering provided by the Brazilian Computer Society, the Computing Curriculum Manuscripts described by the Brazilian regulatory agency (Ministry of Education of Brazil) indicate that the word
ethics appears 9 times. Moreover, the Brazilian government documents are clear about software engineers’ skills required to make sound ethical choices: “To be able to investigate, understand and structure the features of application domains in diverse contexts considering ethical, social, legal and economic issues, individually and/or as a team.”

Since undergraduate degree programs in Software Engineering are relatively new in Brazil and there are few quality indicators for a more accurate selection, we focused our research on the top two Brazilian Software Engineering programs (5 Stars) according the Student Guide 2016 [45], the most popular university ranking guide of the nation. So, the study sample consists of analyzing the pedagogical project of these courses: University of Brasília (UNB) and Federal University of Goiás (UFG). The analysis was mainly based on searching for the word ethics on the course syllabi.

The SE program of the University of Brasília has a work load of 3,480 hours and its undergraduate students must be able to “be oriented to act as a social transformer, aiming at social welfare and ethically evaluating the social and environmental impact of their interventions.” However, there is only one compulsory ethics-related course named “Humanity and Citizenship” with 60 hours, which corresponds to 1.72% of the total content. This course aims to “Introduce the concepts of humanities, social sciences and citizenship to foster the critical view and awareness of the humanistic, social, ethnic-racial, political, economic, ethical and environmental issues involved in the professional action of the engineer.” There are also two other optional courses that reflect an ethics perspective: “Information, Communication and the Knowledge Society” and “Productivity and Professionalism in Software Engineering”.

The SE program of the Federal University of Goiás has a work load of approximately 3,000 hours and, according the pedagogical project, the former students must be able to “develop an active and ethical posture”. However, there is only one mandatory Ethics-related course named “Ethics, Norms, and Professional Posture” being 64 hours in length, which corresponds only to 2.13% of the total content. This course introduces the following topics: “Notions of ethics. A Code of ethics for software engineers. Overview of international norms and standards, laws and local resolutions relevant to Software Engineering. Nomenclature used by the area according to IEEE Std. 12207-2008. Conflict resolution. How to prepare for and behave in meetings. Hygiene aspects. Presentation aspects. Aspects of conduct. Entrepreneurial attitudes. Entrepreneur instruments (business plan and others). Techniques for identifying opportunities and procedures for opening a business”, which contains many other unrelated topics.

V. INTEGRATING CYBERETHICS INTO THE SE CURRICULUM

A. Institutional level

Software engineering professors are in the best position to spark a dialogue about being a professional in a community that shares the same weighty responsibilities [3]. They, therefore, must be prepared to conduct a controversial and relevant dialogue with students. Professors need to collaborate with ethicists, complex systems scholars, professional societies and a number of other discipline representatives in order to keep themselves updated.

Therefore, the institution must create the necessary conditions to foster this community. Cooperation among
TABLE I

| Cybertechnologies                      | Controversial practices or features, from a moral perspective                                                                 | References |
|----------------------------------------|------------------------------------------------------------------------------------------------------------------------------|------------|
| Data Science                           | Discoveries in data mining, propensity and group privacy.                                                                        | [24]       |
| Cloud Computing                        | Consumer privacy, reliability of services, data ownership and technology neutrality.                                               | [25]       |
| Algorithms                             | Inconclusive evidence leading to unjustified actions, inscrutable evidence leading to opacity, misguided evidence leading to bias, unfair outcomes leading to discrimination, transformation effects leading to challenges for autonomy and traceability leading to moral responsibility. | [26]       |
| Experience, Product and Services Design; Design Thinking | Participatory design conflict, amount of time and energy required by successful integration into design team and tension between firm grounding contexts and abstracted model of design. | [27]       |
| Artificial Intelligence; Robotics      | Machine learning, bias in natural language processing and robots as sexual partners, caregivers, and servants.               | [28]       |
| Digital Business Models; Economics     | Intellectual property rights, economic market impact and customer relationship.                                                 | [29]       |
| Internet; IoT; Mobile; Social          | Individual privacy preferences, access controls, emergent social conventions and infrastructures for government surveillance. | [30]       |
| Software and Society; Cyberlaw         | Cryptocurrency, net neutrality, proprietary code and content and freedom of speech.                                               | [31]       |
| Secure Software Engineering            | Purposeful human errors injection, software piracy and software development for espionage, extortion, vandalism and theft. | [32]       |

software engineers, corporations, social scientists, ethicists, philosophers, faith leaders, economists, lawyers, and policymakers will shape cyberethics’ policies for the 21st century.

Institutions need to establish an ethical-oriented culture, incorporating cyberethics in their strategic plans, allocating resources for related initiatives, and designing curricular and extracurricular activities for all students, faculty and staff [46].

B. Curricular level

At the curricular level, we need to consider that different strategies should be considered in designing the academic curricula to integrate cyberethics content. The incorporation of content in cyberethics through stand-alone subjects (specific courses) or embedded subjects (different courses) constitutes one of the principal current debates of how to teach ethics [46].

Based on related studies [3], [47], we recommend the embedded subjects approach, as knowledge from different disciplines can allow for a more holistic understanding of controversial cyberethics issues. This means that cyberethics should be integrated into different SE courses. Stand-alone disciplines can be added to guarantee the commitment of a certain number of credit hours in the curriculum.

Following the proposed conceptual framework, we suggest a mapping of cybertechnology technical (Table I) and non-technical components (Table II) to the ACM/IEEE SEEK units and to the disciplines of the top two Brazilian SE Programs, also expressing their workload. It is possible to observe that these components have an interdisciplinary approach, increasing the number of courses in which cyberethics debates can take place.

Adding cyberethics content in the ACM/IEEE SEEK expands the ethics program to 66.8% of the total content, instead of the previous 1.3% (Professionalism- 6 hours), and in the top two Brazilian SE Programs extend the ethics-related topics on average to 37.8%, instead of previous 1.9% (Ethics, Norms and Professional Posture - 64 hours and Humanity and Citizenship - 60 hours). Regarding content, we recommend that professors pursuing integrating cyberethics into their disciplines analyze the most prominent controversies in cybertechnologies from our conceptual framework (Table I).

C. Instrumental level

At this level, instructors need to set specific learning objectives and decide on the pedagogical tools to be used. A number of methodologies can be used. In this phase, we confirm research findings and recommendations on assessing millennial generation’s learning preferences and learning styles [3], [48]–[50]. We thus provide some concrete advice based on these studies and our own teaching experience.

According to Wilson and Gerber [49], millennials are decidedly active learners. They have a hypertext mindset, which diminishes the applicability of a lecture-style training format. They are also multitaskers with a propensity for innovation fueled by curiosity, discovery, and exploration. Factors such as shorter attention spans, low boredom tolerance, and necessity of hands-on elements contribute to the millennial generation’s active learning style.

Millennials expect to have choices, so the learning process should provide opportunities for creating their own learning or meaning within courses, a form of active involvement through self-tailoring. Case studies, hypotheticals, role-playing, storytelling, simulations, journaling, activity
of the SE curriculum proposed by the ACM/IEEE SE conceptual framework for cyberethics and conducts an analysis presented in isolated courses. This study presented a systems and curricula delivery since ethics concerns are however, there is still open challenges in the educational area involves evaluating additional SE curriculum guidelines from different countries and investigating cultural factors influencing cyberethics. Finally, future studies may aim to determine a strategy to introduce cyberethics in any SE-related course as a fundamental feature of millennial software engineers’ instruction.

VI. CONCLUSION

Millennial Software Engineers must think and act ethically in order to deal with critical issues of the new century. However, there is still open challenges in the educational systems and curricula delivery since ethics concerns are presented in isolated courses. This study presented a conceptual framework for cyberethics and conducts an analysis of the SE curriculum proposed by the ACM/IEEE SE Curriculum Guidelines, as well as the top Brazilian SE undergraduate programs. Suggestions on how to introduce this theme as an interdisciplinary curriculum approach are also provided.

Logs, and teaching approaches are common tools of contemporary education that lend to millennials’ preference for tailored classes.

Finally, common feature of contemporary classes involves decreasing the amount of content from courses, because students have greater and continuous access to content. Content-mastery is less crucial than thoughtful processing and critical analysis. This could be achieved by a deeper exploration of materials.

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| Cybertechnologies (technical components) | Related ACM/IEEE SEEK units (hours) | Related disciplines of top 2 BR SE Programs (hours) |
|----------------------------------------|------------------------------------|---------------------------------------------------|
| Data Science                           | Modeling foundations (8); Design strategies (6); Detailed design (14); | UFG - Concurrent Software Development (64); Networks and Distributed Systems (64); Operating Systems (64). UNB - Programming for Parallel and Distributed Systems (60); Computer Network Fundamentals (60); Operating Systems Fundamentals (60). |
| Cloud Computing                        | Construction technologies (20); Architectural design (12); Detailed design (14); | UFG - Introduction to Programming (64); Algorithms Fundamentals and Data Structures (64); Software Development for Web (64). UNB - Data Structures II (60); Analysis of Algorithms (60); Techniques of Programming in Emerging Platforms (60). |
| Algorithms                             | Computer science foundations (120); Problem analysis and reporting (5); Analysis fundamentals (8). | UFG - Computer Architecture (64); Software Architecture (64). UNB - Embedded Systems Fundamentals (60); Theory of Digital Electronics I (60); Computer Architecture Fundamentals (60). |
| Artificial Intelligence; Robotics      | Construction technologies (20); Construction tools (12); Architectural design (12); Engineering foundations for software (22). | UFG - Software Architecture (64). Integration of Applications (64); Software Development for Devices (64). UNB - Software Architecture (60); Embedded Systems Fundamentals (60). |
| Internet; Internet of Things; Mobile; Social Media | Construction technologies (20); Architectural design (12); Detailed design (14); Computer and network security (8); Introduction to Computer Systems (60). | UFG - Secure (64); Networks and Distributed Systems (64). UNB - Computer Network Fundamentals (60); Operating Systems Fundamentals (60). |

| Cybertechnologies (non-technical components) | Related ACM/IEEE SEEK units (hours) | Related disciplines of top 2 BR SE Programs (hours) |
|---------------------------------------------|--------------------------------------|---------------------------------------------------|
| Experience, Product and Services Design; Design Thinking | Eliciting requirements (10); Types of models (12); Process concepts (3); Design strategies (6). | UFG - Software Requirements (64); Human-computer Interaction (64); Software Engineering Methods (64). UNB - Software Requirements (60); Human-computer Interaction (60); Software Development Methods (60). |
| Software and Society; Cyberlaw             | Software quality concepts and culture (2); Group dynamics and psychology (8); Security fundamentals (4); Professionalism (6). | UFG - Introduction to Software Engineering (96); Ethics, Norms and Professional Posture (64). UNB - Software Product Engineering (60); Engineering and Environment (60); Humanity and Citizenship (60). |
| Digital Business Models; Economics         | Engineering economics for software (8); Requirements fundamentals (6); Types of models (12); | UFG - Software Requirements (64); Software Economic Engineering (64). UNB - Software Requirements (60); Economic Engineering (60). |

| Related ACM/IEEE SEEK units (hours) | Related disciplines of top 2 BR SE Programs (hours) |
|-------------------------------------|---------------------------------------------------|
| Modeling foundations (8); Design strategies (6); Detailed design (14); | UFG - Concurrent Software Development (64); Networks and Distributed Systems (64); Operating Systems (64). UNB - Programming for Parallel and Distributed Systems (60); Computer Network Fundamentals (60); Operating Systems Fundamentals (60). |
| Construction technologies (20); Architectural design (12); Detailed design (14); | UFG - Introduction to Programming (64); Algorithms Fundamentals and Data Structures (64); Software Development for Web (64). UNB - Data Structures II (60); Analysis of Algorithms (60); Techniques of Programming in Emerging Platforms (60). |
| Computer science foundations (120); Problem analysis and reporting (5); Analysis fundamentals (8). | UFG - Computer Architecture (64); Software Architecture (64). UNB - Embedded Systems Fundamentals (60); Theory of Digital Electronics I (60); Computer Architecture Fundamentals (60). |
| Construction technologies (20); Construction tools (12); Architectural design (12); Engineering foundations for software (22). | UFG - Software Architecture (64). Integration of Applications (64); Software Development for Devices (64). UNB - Software Architecture (60); Embedded Systems Fundamentals (60). |
| Construction technologies (20); Architectural design (12); Detailed design (14); Computer and network security (8); Introduction to Computer Systems (60). | UFG - Secure (64); Networks and Distributed Systems (64). UNB - Computer Network Fundamentals (60); Operating Systems Fundamentals (60). |
| Eliciting requirements (10); Types of models (12); Process concepts (3); Design strategies (6). | UFG - Software Requirements (64); Human-computer Interaction (64); Software Engineering Methods (64). UNB - Software Requirements (60); Human-computer Interaction (60); Software Development Methods (60). |
| Software quality concepts and culture (2); Group dynamics and psychology (8); Security fundamentals (4); Professionalism (6). | UFG - Introduction to Software Engineering (96); Ethics, Norms and Professional Posture (64). UNB - Software Product Engineering (60); Engineering and Environment (60); Humanity and Citizenship (60). |
| Engineering economics for software (8); Requirements fundamentals (6); Types of models (12); | UFG - Software Requirements (64); Software Economic Engineering (64). UNB - Software Requirements (60); Economic Engineering (60). |
