A SURVEY ABOUT INTERNET OF THINGS (IoT): WHAT DOES IoT MEAN TO SENIOR-LEVEL INDUSTRIAL DESIGN STUDENTS

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Abstract

The concept of the Internet of Things (IoT) is not new. The first "traceable" practical application of the IoT technology was a vending machine, which reports the condition of the beverages inside, developed by Carnegie Mellon University in 1982 [1]. It was a simple system with simple sensors, compared to today's extremely sophisticated IoT applications. Since its first conception, IoT came a long way in consumer products and industrial applications. Numerous research projects have been conducted; and, countless research papers have been published.

IoT gained momentum in recent years and became one of the hottest topics in the Industrial Design (ID) discipline. IoT transformed the way once acceptable design methodologies into obsolete. New design disciplines started to emerge to solve complex information architecture problems. The consumer market is experiencing a growth of products that work by networking "things" with sensors. House appliances with sophisticated sensors help owners by carrying out house chores. Autonomous homes control indoor climate while the owners are not present. Smart devices even feed pets and play with them while their owners are at work or out of town.

As the demand for skilled designers is increasing in the industry, it is not a surprise that the IoT-related courses started to emerge in the ID curriculums. The interconnectivity of products is becoming a standard in the product development process rather than an option; consequently, companies look for designers who can conceptualize such products.

This paper asks the vital question, perhaps as a self-criticizing way: "Are we ready to address the demand when potential employers ask for a new breed of designers who are capable of designing interconnected products?"

The authors of this paper investigated this question by conducting mixed methodology research with ID students on all levels. Their focus was to understand whether the ID students were aware of the technology, its implications, and future impacts on the ID discipline.

68 ID students from Syracuse University participated in this research by answering a questionnaire, which is being presented in the *Appendices* of this paper. Findings are presented in the *Results* section; and, future recommendations are presented in the *Discussions* section of this paper.

Introduction

The Internet of Things (IoT) term is ubiquitous nowadays; it surrounds us by various devices and applications from different industries. In our daily routine, we are interacting with IoT products without questioning, or sometimes not even knowing - brewing our morning coffees, changing the environment's temperature from our mobile devices, passing from a turnstile on our commutes to work, even making payments for groceries. All connected nowadays.

A brief description of (IoT) is "The concept of basically connecting any device with an on and off switch to the Internet (and/or to each other). This includes everything from cellphones, coffee makers, washing machines, headphones, lamps, wearable devices, and almost anything else you can think of. This also applies to components of machines, for example, a jet engine of an airplane or the drill of an oilrig. If it has an on and off switch, then chances are it can be a part of the IoT." [2]

The term IoT believed to be first pronounced in 1999 by Kevin Ashton, a supply chain optimization specialist at Procter & Gamble, during his presentation to impress his senior executives [3]. However, the first recorded application of this sort of device made almost two decades ago from Mr. Ashton's presentation. In 1982, students of Carnegie Mellon University invented ARPANET-connected beverage vending-machine [1]. This is the first recorded IoT application "that could report its contents through a network. Though it was primitive by today's standards, it holds a unique distinction: it was, as far as anyone knows, the world's first IoT device." [4]

Necessity, as always, was the mother of invention. One day in the early 1980s, David Nichols, a graduate student at Carnegie Mellon University's computer science department, was in his office on campus at Wean Hall, craving a soda. But his office was "a relatively long way" from the building's beverage machine, and considering his fellow students' substantial caffeine habits, Nichols knew there was a good chance it would be empty—or that, if the machine had recently been refilled, the sodas inside would be tragically warm. Nichols wrote a few friends about his idea to track the machine's contents remotely and put an end to unsatisfying soda runs once and for all. Soon, two other students—Mike Kazar and Ivor Durham—and a research engineer at the university, John Zsarnay, began working alongside him to make it happen. [4]

Initial IoT applications used a different technology than today. They are still connected, yet in a leaner way. "The fact that Ashton's idea of IoT focused on using radio frequency identification (RFID) technology to connect devices. That was similar to but significantly different from today's IoT, which relies primarily on IP networking to let devices exchange a broad range of information. RFID tagging allows much more limited functionality" [5].

These exponential signs of progress in technology are leading us to transition to Industry 4.0, which can also be called the Industrial Internet of Things (IIoT). "The term Industry 4.0 that is strongly pushed by the German government is as limited as the industrial internet in reach as it only focuses on industrial environments. However, it has the largest scope of all the concepts. Industry 4.0 describes a set of concepts to drive the next industrial revolution. It includes all kinds of connectivity concepts but also goes further to include real changes to the physical world

around us, such as 3D-printing technologies, new augmented reality hardware, robotics, and advanced materials." [3]

Just a comparison of IoT to Industry 4.0; IoT device can be a personal wearable measuring one's daily steps, and Industry 4.0 device can be hardware that controls the inventory of a warehouse preventing it from over or understock.

The following chapters will further investigate the perception of these terms by Industrial Design students and question the necessity of IoT & Industry 4.0 related courses shall be a part of the ID curriculum or not.

Materials and Methods

As a Tier-1 research institution, Syracuse University is well-known for its diverse population of students, who are from many different countries. This quality makes Syracuse University a perfect candidate for conducting an opinion-based research study, thanks to a wide range of student background, qualifications, and interest in the subject matter. Therefore, the authors hoped that the study discussed in this paper represents the current student opinion in the ID discipline towards IoT.

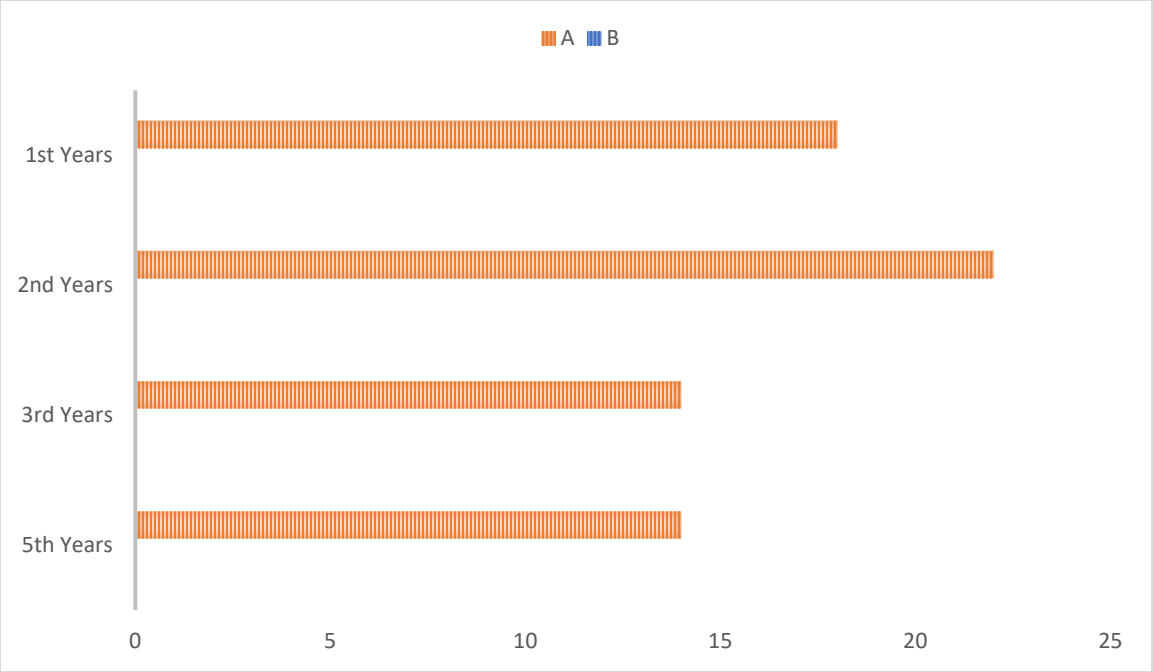
During the Spring 2020 semester, students who are majoring in ID were invited to answer questions of an anonymous survey. It was a 12-question, anonymous, and mixed-methodology type survey that aimed to understand the general knowledge and awareness of the ever-growing IoT trend in ID. The survey was a paper-based and administered in totally voluntary environment. No identification and/or markings were used to determine student identity.

A total of 68 students ranging from first-year students to senior-level have responded to the survey. The sample population consists of mixed-gender students without categorizing the race, age group, knowledge-level, or any other quantifiable factors. The only criteria for participating in the study were to be 18 years of age or older and majoring in ID at the time of the survey.

Results

The results of this study are presented as a "question-by-question style" in this paper. Results were interpreted independently based on the frequency of answers. Also, comments were included in this paper to understand general student opinions.

Although each question is presented with its interpretation, comparing results with each other or previous knowledge may lead to a deeper understanding of the subject. Since this study acts as the first of many, the authors decided to present survey results and discuss future studies in the Discussions section below.

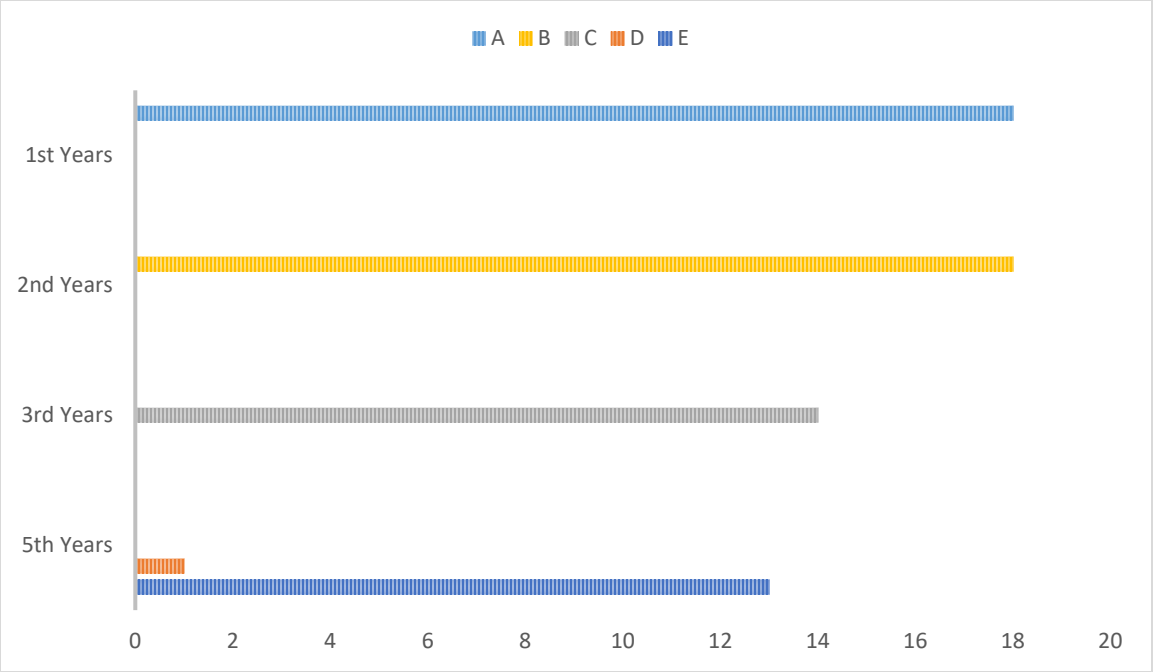


1. Are you majoring in ID? (Select one)

a. Yes
b. No

There were several students, who are not majoring in the ID program, participated in the study, and filled out the survey. Although instructions were to stop at this point, they filled out the rest of the survey. These responses were discarded to keep the data on the target. A total of 68 responses analyzed for this study.

This question was designed to keep the sample population homogeneous by preventing accidental participation from other majors. Due to the multi-major classroom settings, this question was necessary to keep data on the target. Any participation with the answer "b" was discarded, even the participant had filled out the rest of the survey. It was basically to test eligibility for the study.

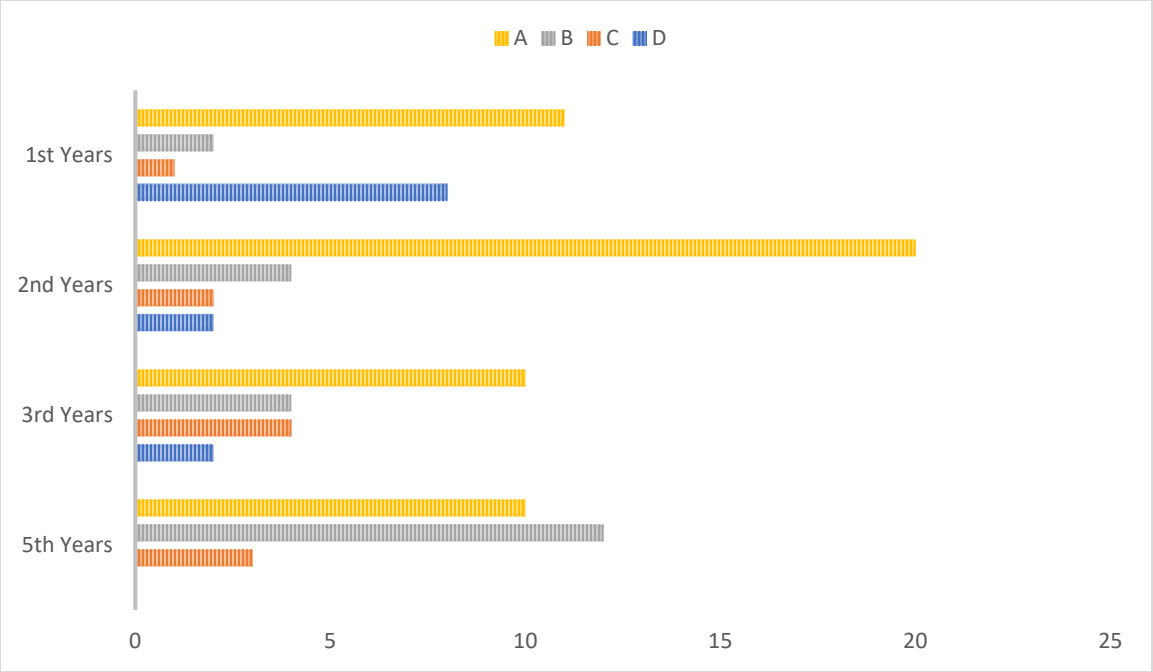


2. What level are you in? (Select one)

a. First Year
b. Second Year
c. Third Year
d. Fourth Year
e. Fifth Year or Graduate

Among the total, 18 students were freshmen, 21 students were sophomore, 15 students were junior, and 14 students were seniors. The participant quantity and quality were adequate for this study; however, more students from other institutions can provide a more thorough answer. Notice that there were no fourth-year responses to this study, due to the study abroad program. Majority of the fourth-year students were not available when this survey was conducted.

The second question was to quantify student levels, which is used as a determiner for comparison. The data that was gathered with this question helped authors to compare the seniority level to other data, such as awareness of the IoT, current trends, and/or courses taken.

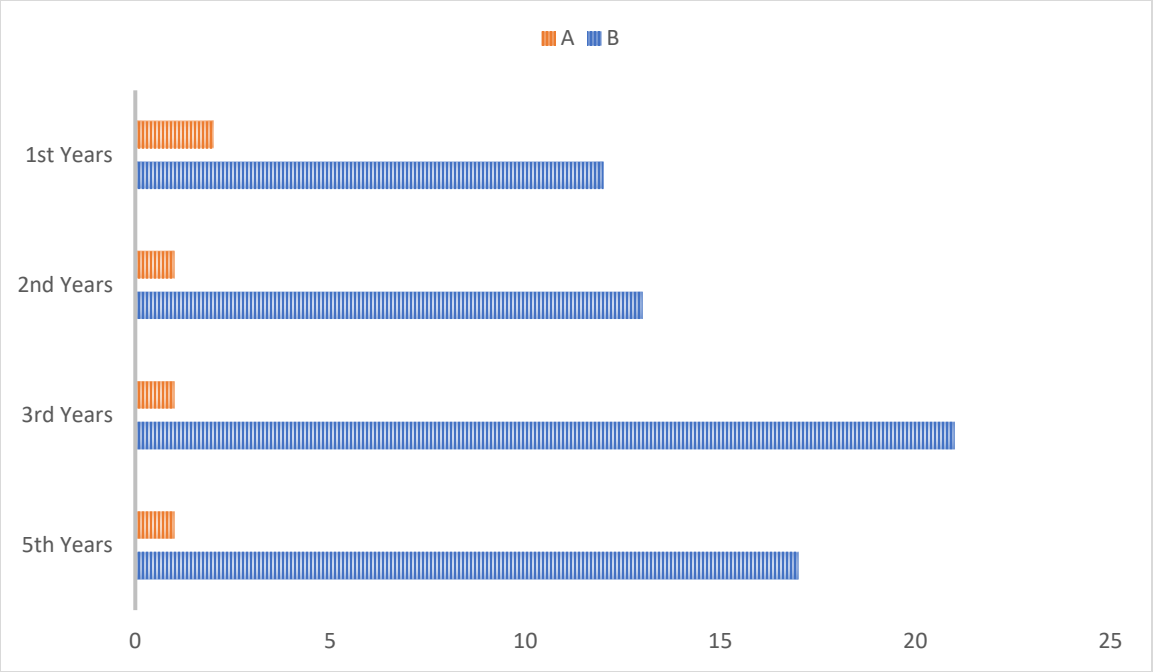


3. Do you follow trends in ID? (Select all that apply)

a. Yes – Random Internet Sources (videos, blogs, forums, etc.)
b. Yes – Curated Internet Sources (Core77, IDSA Website, etc.)
c. Yes – Printed Media (Make, Wired, etc.)
d. No – I do not follow ID trends

The majority of all students indicated that they are following random internet resources, such as videos, blogs, forums, and similar ID-related websites. However, this ratio shifts towards more related resources with seniority, such as curated ID-related websites like Core77, IDSA, and similar. Although a total of 8 freshmen students indicated that they are not following any ID trends at all, this number gradually drops to 0 towards seniors.

The third question aimed to define how students keep themselves informed in current ID trends. The idea behind this question was to understand the correlation between trends followed and the awareness of the IoT.



4. Do you know the concept called Industry 4.0? (Select one)

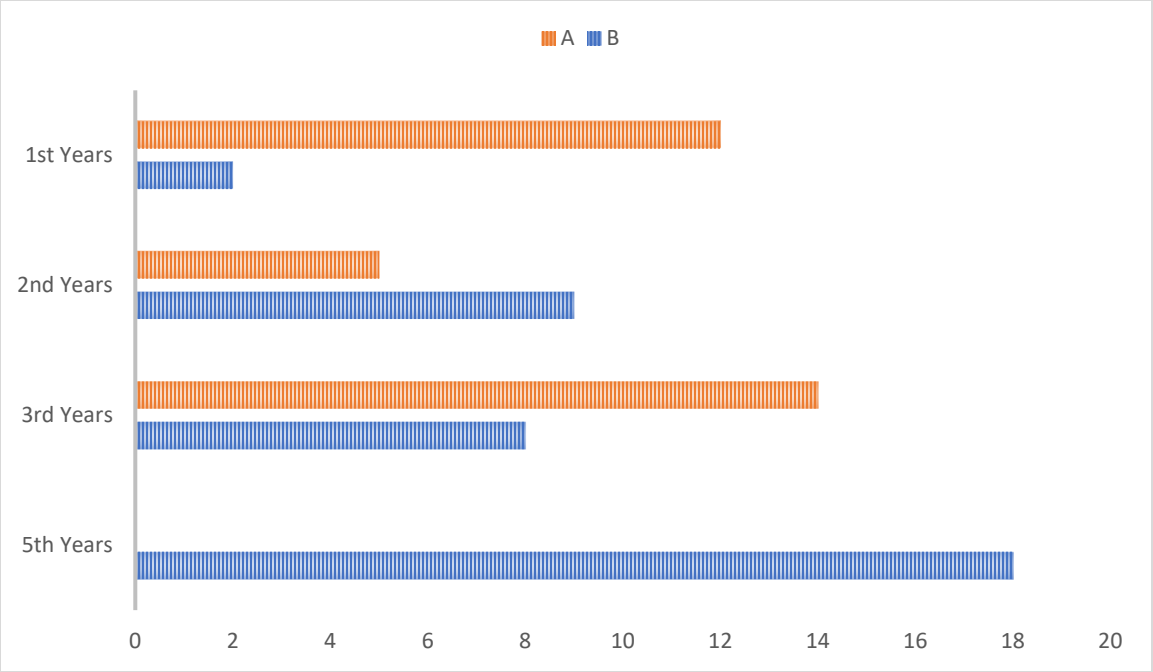
a. Yes – Please briefly explain the concept to the best of your ability
b. No – I do not know

The response to this question is consistent throughout the seniority levels. More than 90% of the students answered "No" to this question. Even though "Yes" answer invites participants to explain the concept to the best of their ability, no satisfactory answers were obtained.

The fourth and fifth questions were to test whether the students know the concepts of Industry 4.0 and IoT. These questions were straight forward and down to the point. The open-ended "Yes" option allowed participants to describe what they know about the concepts. It was necessary to recall their knowledge rather than a simple "Yes" answer; so, the quality of their understanding towards Industry 4.0 and IoT could be measured.

Student comments:

- Industrial Design from mechanical to electricity. Auto, machine… – 1st
- Artificial Intelligence – No human production – 2nd
- It's like a manufacturing revolution. Everthing is digital, AI based – 3rd
- Sorta… Has to do with a new industry. – 4th



5. Do you know the concept called the Internet of Things (IoT)? (Select one)

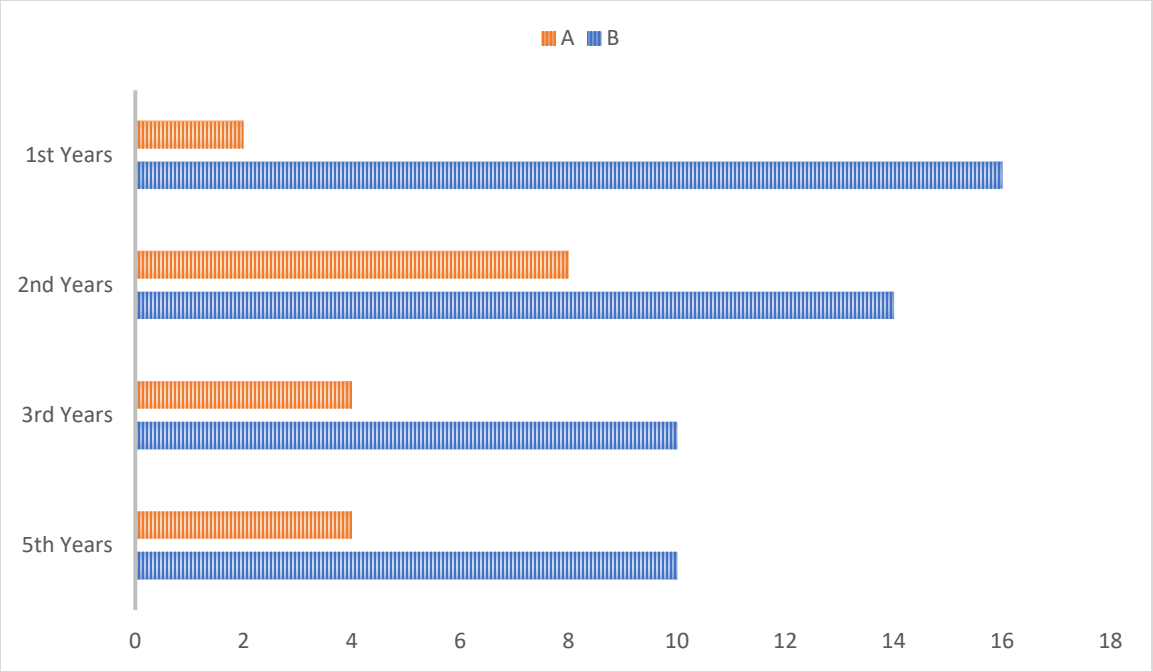
a. Yes – Plese briefly explain the concept to the best of your ability
b. No – I do not know

The results obtained from this question were as expected. While the entire freshmen responded "No" to the question, the balance gradually changes in the opposite direction towards the senior-level. Almost all seniors responded positively to the question. Written responses gradually get informed and correct, rather than mostly "heard of it" type. This clearly shows that the awareness of such specialized concepts increases with seniority.

Student comments:

- It is/are internet connected objects that are every day objects made smart by sensors inside and connection to the internet – 2nd
- I know that I've heard of the concept, but I don't remember exactly what it is" – 2nd
- Don't exactly know, but it's there – 2nd
- I have heard of it, but I'm not sure how to explain it – 2nd
- It is basically making "dumb" things smart, so for example, the trend of taking a refrigerator, which could be thought as a "dumb" object and making it smart. Companies such as LG – 2nd
- Everyday and household items can be given sensors and connections in order to create "smart" products – 2nd
- Making daily life objects "smart" and connected through the internet – 2nd
- The concept of where everyone and everything is connected by the internet – 2nd
- A system or network where many things communicate. For example, household electronics – 3rd
- Everything is connected and operated through the internet – 3rd
- Everything is linked to Internet – 3rd
- The connection of information from system to system – 3rd

- IoT means multiple devices interacting with eachother and the user through data – 5th
- I've heard of Internet of Things, but I'm not extremely familiar – 5th
- I've heard of it, but I don't know enough to explain it – 5th
- Started with military, term describes info or things that exist online – 5th
- Accessing data, information from the web from anywhere at anytime – 5th
- AI systems that connect to each other – 5th
- Connected household products via smart technology – 5th
- Wifi enabled devices that can be used without or with human interaction – 5th
- It's a digital library – 5th

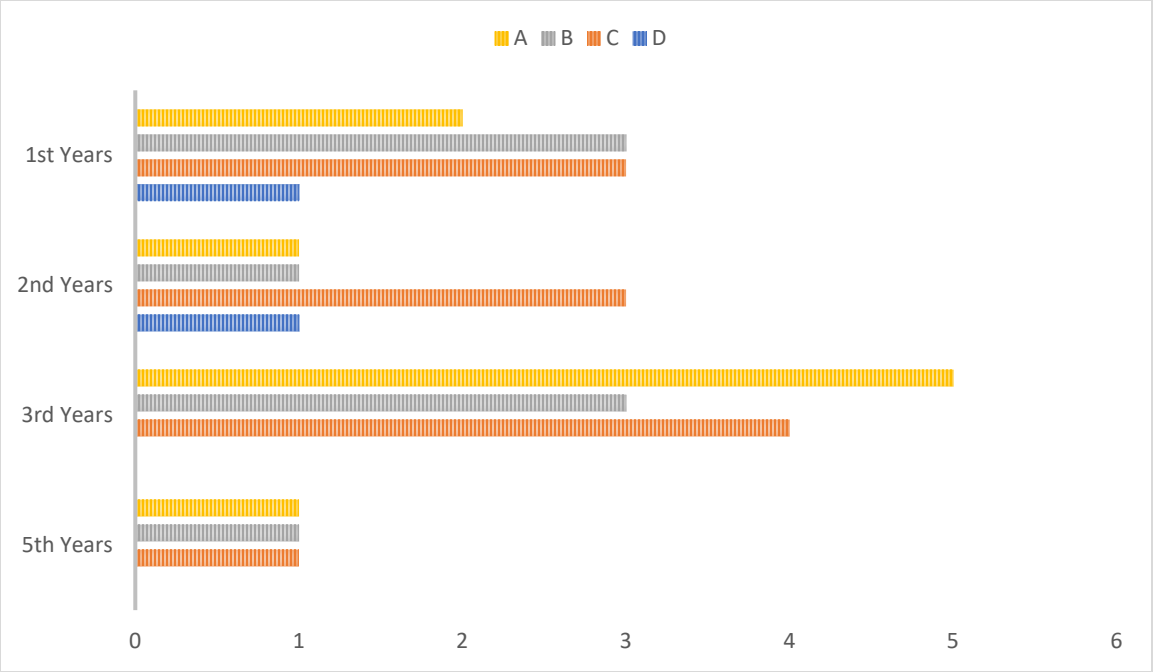


6. Have you ever taken any technology-centered ID course, such as Robotics, Smart Product Design, or Prototyping? (Select one)

a. Yes (please answer questions 7, 8)
b. No (please answer question 9)

The response to this question can be generalized as a 1 to 4 ratio. More than half of the entire participants did not take such courses in the past. Several students indicated that they took similar courses during high-school; however, they also indicated that those courses were not in-depth or not directly related to ID discipline.

The sixth question was all about learning more about previous experiences, specifically to determine whether participants have taken technology-centered courses or not. If a participant answered "Yes" to this question, the seventh and eighth questions were presented to understand more about the nature of the courses taken. If a participant answered "No" to the question, he/she skipped to the ninth question, which aims to understand the reasons why he/she did not take any technology-centered courses.



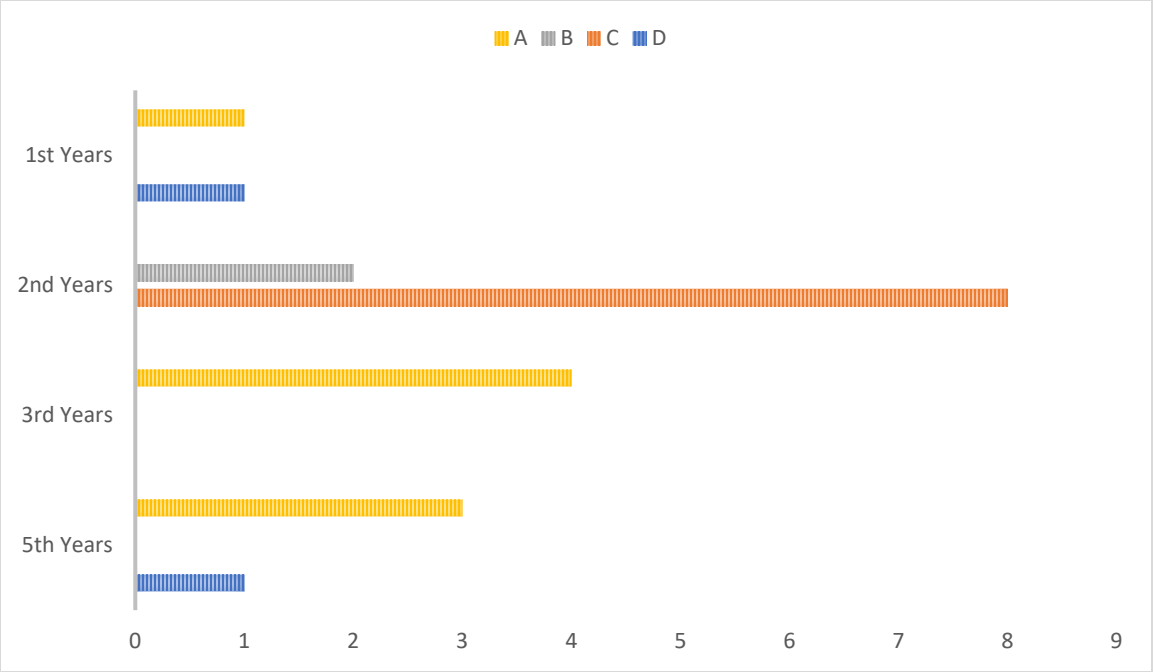
7. YES – Could you please describe the content of the course? (Select all that apply)

a. Robotics (programming and mechatronics)
b. Smart Product Design (programming and connectivity)/
c. Prototyping (circuit design and interactivity)
d. Other – Please briefly explain

This question was available to those who have taken technology-centered courses before. Even though the "Prototyping" answer had the lead followed by the "Robotics" and "Smart Product Design" among the students who took such courses, responses were too close to conclude.

Student comments:

- Smart clothing – 3rd
- Haven't taken one - very interested! – 5th
- Not very in depth in courses – 5th



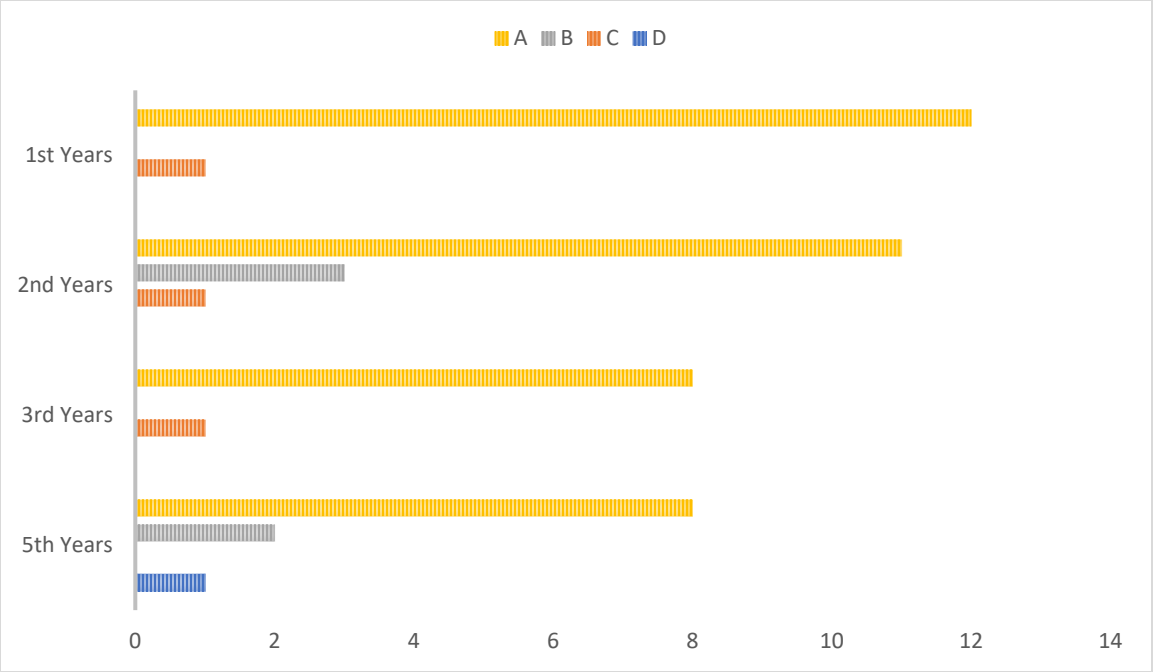
8. Yes – Where did you take the course?

a. My home department / program
b. Different department / program in my university
c. Different university
d. Online / non-credit course

The students who answered "Yes" to question 6 and 7 responded to this question. The data shows with clear distinction that the students bring their outside knowledge to their ID education. Since Syracuse University's ID program does not offer an in-depth technology-centered course, students fill the void by taking such courses elsewhere. However, when the seniority-level is compared with the answer choices, it is observed that younger level students bring their prior knowledge to the ID program. This indicates that younger students expose more STE(A)M related courses during their high-school years than senior-level students.

Student comments:

- Highschool – Mechatronics – 5th



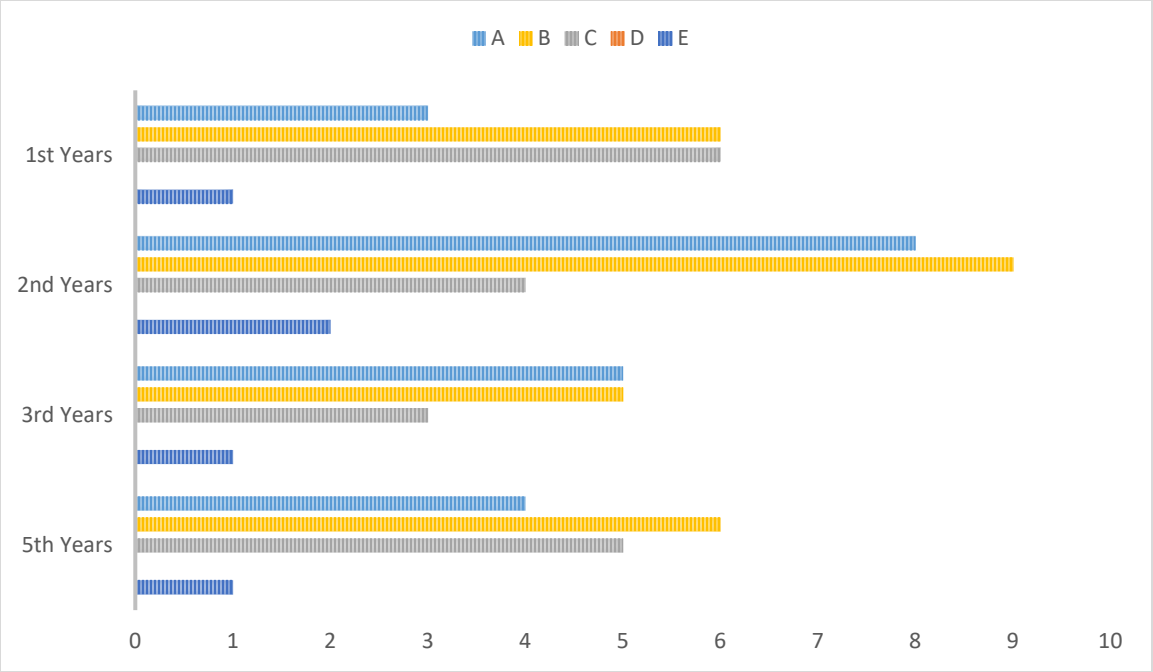
9. No – Could you please describe your reasons? (Select all that apply)

a. No such course was offered in my department / program
b. They are too scary / challenging for me
c. I do not have any interest in such subjects
d. I do not think it is necessary for ID

The students who answered "No" to the question 6 was asked to provide a reason. The majority of the students responded as "No such course was offered in my department/program." Coupled with the "They are too scary/challenging for me" answer, it can safely be said that Syracuse University's ID program can benefit tailored technology-centered course, rather than picking an elective from engineering-oriented courses elsewhere.

Student comments:

- I do it in my free time – 5th
- I'm often intimidated because I know very little, but have always been interested! – 5th



10. If your department/program offers technology-centered courses, it should be… (Select one)

a. Mandatory course, because it is important for ID
b. Mandatory course, because it can compliment what is already in the curriculum
c. Optional course, because it not for all ID students
d. Optional course, because it is not related to ID at all
e. Other – Please briefly explain

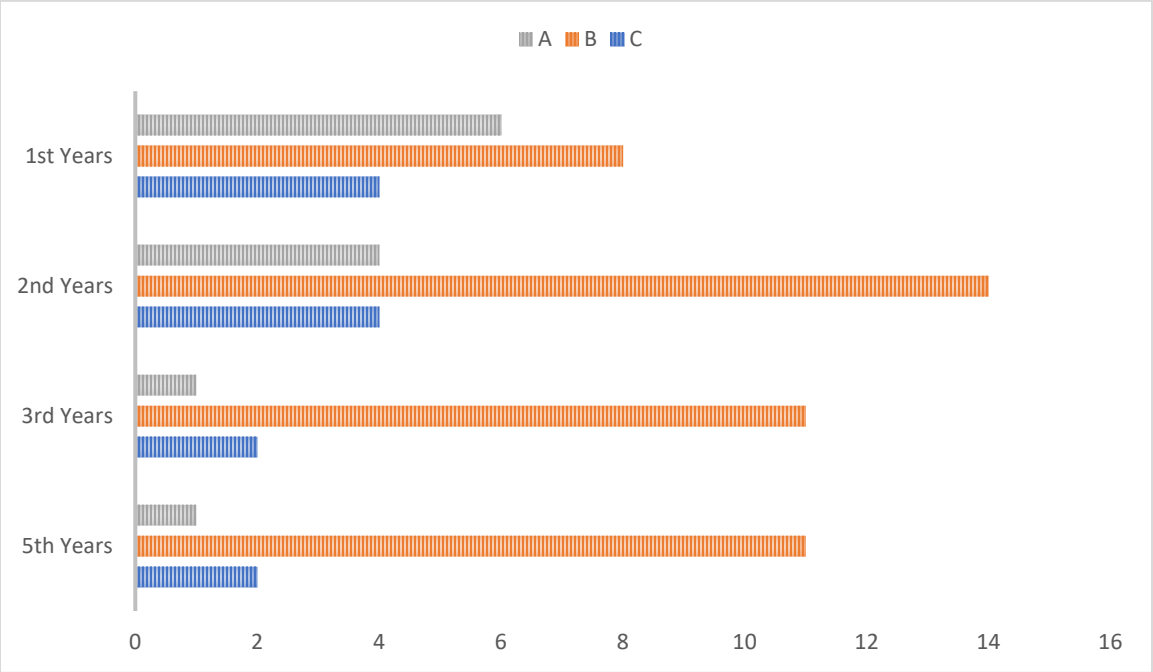
It is reassuring to confirm that all the students think that technology-centered courses are fundamental since none of them selected "d. Optional course, because it is not related to ID at all" answer choice for this question. However, it was interesting to discover that most students think that such a course should be mandatory and complementary in nature. Confirming the conclusion from question 9, technology-centered courses are a growing demand among today's ID students.

The tenth, eleventh, and twelfth questions were designed to gather student opinion about technology-centered courses, consequently IoT at the core. As a crucial part of the IoT, students were asked if they think an ID professional needs to know any programming knowledge for a successful career. Also, students were asked their preference in learning style, if they were to take any technology-centered course as a part of the ID curriculum.

Student comments:

- Other, because each student should be cable to develop skills from their own motivation – 1st
- Optional - Students should decide if it will benefit them and work towards success in their own way – 2nd
- Optional - based on what fits in schedule – 2nd

- Mandatory intro class to do basics and see if one likes it, the optional after that – 3rd
- Optional, some ID applies; however not all have the mind for it / isn't necessary for some industry – 5th
- If offered 2nd year, should be mandatory. Otherwise, it should be optional if offered any later – 5th
- Mandatory - 1000% - 5th



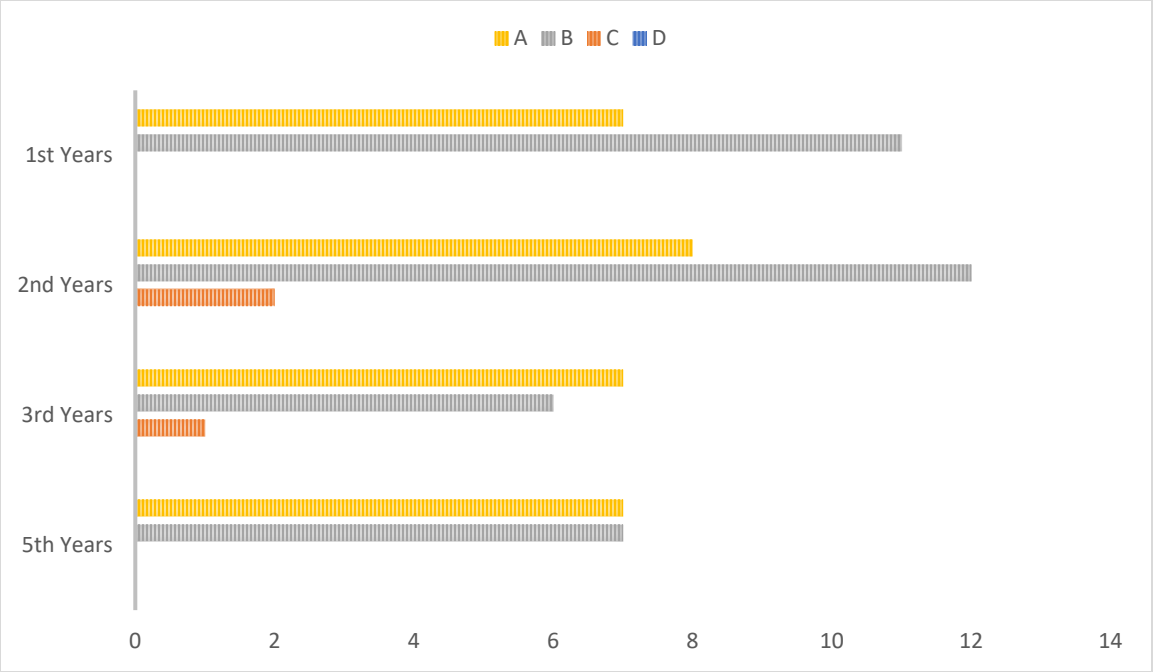
11. Do you think today's industrial designers must know any programming language, such as Phyton, C++, or Java? (Select one)

a. Yes, at least one in expert level
b. Yes, at least one in working knowledge
c. No

The majority of ID students think that today's industrial designers must know at least one programming language in working knowledge. While the ratio is comparable with the "No" answer among freshmen and sophomores, the importance of the programming skills for industrial designers significantly increases during junior year. This may be due to the existing curriculum; which, students expose to UI/UX courses during junior year.

Student comments:

- Unless they are interested in



12. What would be the ideal method for you to learn technology-centered subjects?

a. Face-to-face (in-classroom) settings
b. Hybrid (half in-clasroom and half online) settings
c. Online settings
d. Other – Please briefly explain

ID students do not favor online classes, according to their responses. Almost all the participants selected an option with a face-to-face option.

Student comments:

- Hybrid – Most of ID works this way anyway – 5th

Discussions

This study was to understand what today's students think about the IoT and its impact on the ID in general. Based on the survey results and informal interviews, it is safe to say that the awareness of IoT in ID changes with seniority. This can be the result of exposing more and more ID related content throughout the existing curriculum, even though there is no direct technology-centered course in Syracuse University's ID curriculum.

IoT is everywhere now and rapidly replacing traditional "stand-alone" product design trends. Without a doubt, students adapt to this exciting concept in their personal lives and use it in their product design assignments, even if they do not have a deeper understanding of it. The survey results demonstrate that today's technology-savvy students pay more attention to such concepts; consequently, it requires ID programs to include classes to answer the growing demand.

Hopefully, the reality of IoT makes this study worthwhile, as it may benefit other ID programs to use it as a leverage for creating more technology-centered courses. Statista predicted that IoT technology surpassed 100 billion dollars in 2017 and predicted to be 1.6 trillion by 2025. [6] The number of IoT connected devices is predicted to be 75.5 billion worldwide by 2025, which translates as a fivefold increase since 2015. [7] In other words, Industrial Designers will be busier than ever to answer growing IoT demands in the next decade.

Authors of this paper will continue researching this topic, perhaps a more in-depth and concentrated way of integrating the demands of IoT to existing university (more specifically ID) curriculums. Future findings will be shared with the IoT community.

Acknowledgments

We want to thank all Syracuse University ID students for their time and support for this study. Without them, this study would not be possible.

This study was conducted with IRB authorization number 20-032 at Syracuse University. The authorization letter is on file and available upon request.

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