Design Thinking Approach in Teaching Information Security

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ABSTRACT: *The phrase "Design Thinking (DT) is increasingly used to mean the human-centered "open" problem solving procedure, it can be described as a discipline that uses the designer's receptivity and methods to balance people's needs with what is technologically feasible and what a viable business strategy can convert into customer value and market opportunity. It has been used wildly in the industry and business in particular Systems, Applications, and Products in Data Processing (SAP), to satisfy customer needs.Design thinking's largerused in describing a particular style of creative thinking-in-action. Design Thinkinghas an increasing influence on twenty-first century education across disciplines. In this paper a new model to introduce information security Curriculum using design thinking methodology; based on: Understanding, Observe, Define, Ideate, Prototype, Test and Feedback. The model has been implemented in build a secure program as a way to understand information security and achieve the course objective and outcomes. The assessment of this course shows high level of student engagements, collaboration, research, and presenting ideas and thoughts.*

Keywords: Information Security, Teaching Information Security, Information Security Program, Design Thinking

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1. Introduction

There are many methods to introduce information security knowledge to students, such as traditional lecture approach, tutorial approach, project approach, scribe approach, research/teaching synergy approach, and attack/defend isolated laboratory approach (Yurcik & Doss, 2001).

The Seven Learning Styles (learning-styles-online.com, 2013)

- **Visual (spatial):** Using pictures, images, and spatial understanding.
- **Aural (auditory-musical):** Using sound and music.
- **Verbal (linguistic):** Using words, both in speech and writing.
- **Physical (kinesthetic):** Using your body, hands and sense of touch.
- **Logical (mathematical):** Using logic, reasoning and systems.
- **Social (interpersonal):** Learn in groups or with other people.

• **Solitary (intrapersonal):** Work alone and use self-study.

All the above method does not focus on integrating Critical Thinking (CT) approach clearly (some has embedded this approach within its activities, such logic approach). Design thinking (DT) (A way of looking at problems or situations from a fresh perspective that suggests unorthodox solutions), can be stimulated both by an unstructured process such as brainstorming, and by a structured process such as lateral thinking (businessdictionary.com, 2013). Broader use in describing a specific style of creative thinking-in-action has increasing influence on twenty-first century education across disciplines. Design thinking stands for design-specific cognitive activities that designers apply during the process of designing. It is an inventive process of thinking backwards from people (end user, customer), that leads to design a product, a service, or is based on the conclusions of the knowledge gathered in the process (click4it.org, 2014). Design thinking is to ask students to become and convert into investigators in their world, attempt to solve problems, bridge and overpass the gaps of knowledge independently, collaboratively, and resourcefully. These are skills that are highly relevant in today's job market. (designthinkingforeducators.com, 2013) Design thinking is used in a limited context in education, especially for K12 and for project development and design. In this paper a new developed model based on design thinking is used to teach information security. The evaluation shows that the students get great experience based on a hands-on developmental security program, carry limited risk assessment, build contingency plan and in select the appropriate access control method. The student collaboration, brainstorm and discussion show great impact on understanding the concept of a topic.

2. Design Thinking

The notion of design as a "*way of thinking*" can be found in the sciences to Herbert A. Simon's 1969 book The Sciences of the Artificial, (Simon,, 1969) and more specifically in design engineering to Robert McKim's 1973 book Practices in Visual Thinking. (McKim, 1973) Rolf Faste expanded McKim's work in the 80s and 90s in his teaching at Stanford, (Fast, Roth, & Wilde, 1993; Faste, 1994) defining and popularizing the idea of "*design thinking*" (Patnaik, 2009.) as a way of creative action that was adapted for business purposes by IDEO through David M. Kelley. The phrase "*design thinking*" was explained by Rowe (Rowe, 1991) to denote to the ways in which designers approach design problems, while design researchers have been studying the process for decades (Schon, 1983) and (Simon, 1969). In present-day use, the term refers to both predictable design domains as well as in different contexts such as business (Brown, 2009) and computing (Brooks, 2010). Design thinking can be seen as a grounding framework for multidisciplinary groups to communicate and to coordinate activity (Lindberg, Noweski, & Meinel, 2010).

The design thinking model presented by (Kembel, 2009) is remarkably different for its explicit treatment of empathy. "*His is a five-step cyclic model consisting of empathy, problem definition, ideation, prototyping, and testing. Empathy arises from a deep understanding of the stakeholders and their needs. It goes beyond merely involving users in a design process and considering their articulated wants and needs: in this model, empathy requires an anthropological approach to understanding users and their environments*" (Gestwicki & McNely, 2012)

Design Thinking is an inventive process of thinking backwards from people (end user, customer) (Curedale , Design Thinking: process and methods manual, February 1, 2013), that leads to design a product, a service, or else, based on the conclusions of the knowledge gathered in the process. Design thinking is to ask students to become and convert into investigators in their world, attempt to solve problems, bridge and overpass the gaps of knowledge independently, collaboratively, and resourcefully. These are skills that are highly relevant in today's job market (Gray, 2013).

Modern education depends on a diversity of different sources of information for discovery and picture conclusions. Between these sources are miscellaneous media such as videos, podcasts or text. Experts in the community can also be sought to convey information to students. In DT, students learn more about the problem they are trying to solve. They do this by going on field trips or by visiting an expert in a lab, workshop, or studio.

There are many steps in design thinking, such as (McKendrick, 2013):

• **Understand your customers:** "*For example, in a service to support decision making, it is essential to know the indicators and where data are, and understand the process, the dynamics and frequency that are required in a process of decision making*".

• **Draw the service:** Visualization is important. Apply visual drawings, diagrams and storytelling to vividly illustrate what the

service will deliver.

• **Prototype the service:** Show how the service will flow through wireframes, videos and diagrams.

• **Design the project:** Map out all the elements that the service will support, including processes, people and technology.

• **Deploy the service:** Other (Simon H., 1969)suggest Define, Research, Ideation, Prototype, Choose, Implement and Learn.Or (Jakes, 2013)

• **Empathy**: We see how others feel towards a specific item. Interviews are used to gain insight to human nature.

• **Define**: In this step, we use the information gathered from interviews to find the user's real problem.

• **Ideate**: The third step in design thinking is where the group discovers solutions to the problem.

• **Prototype**: Once an idea is decided upon, groups work together using arbitrary materials to construct examples of their product and explain how their product works.

• **Testing:** This is the final step. Groups rebuild their prototypes and create a working product. Once built, testing begins. Testing identifies problems with the item, so the product can be modified to better suit the user.
These could be expressed as in Figure 1.

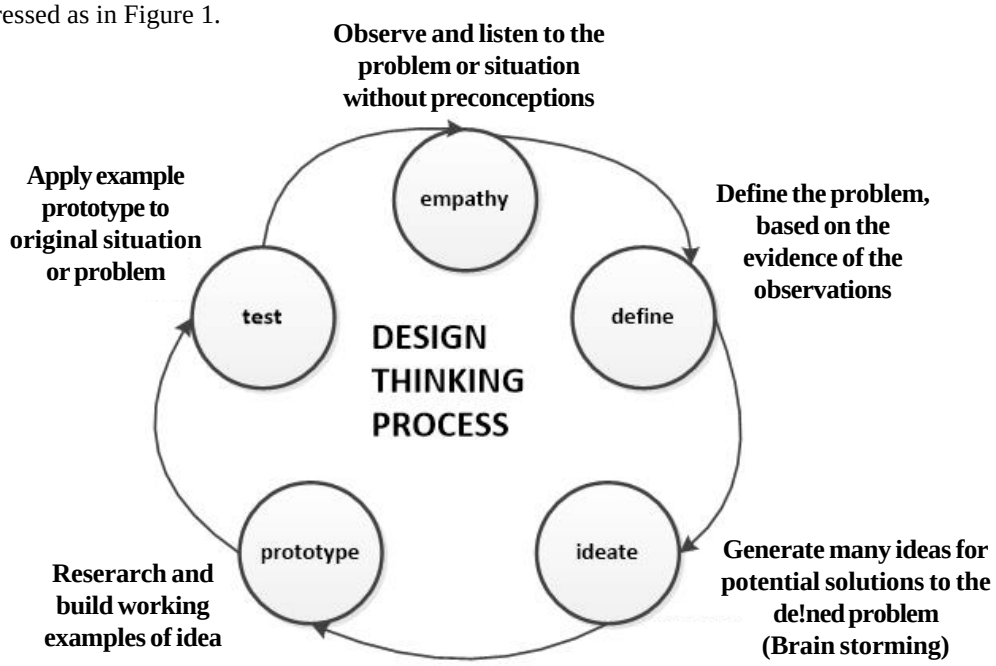

Figure 1. Design Thinking Process

In this paper we will use the design thinking to present information security, and will use the following phases (hdschool.stanford.edu, 2013).

• **Understanding:** During this part, students engage in learning. They talk to experts and conduct research. The goal is to develop background knowledge through these experiences. They use their developing understandings as a springboard as they begin to address design challenges.

• **Observe:** Students become powerful people viewers in the observation phase of the design thinking process. They watch how people behave and cooperate and they observe physical spaces and places. They talk to people around what they are doing, ask questions and reflect on what they see. The understanding and observation stages of design thinking help students develop a sense of empathy.

• **Define**: In this phase students focus to define the problem, based on the evidence of the observations

• **Ideate:** This is a critical component; the student discovers solutions to the problem. In this phase, quantity is encouraged.

Students may be asked to generate a hundred ideas in a single session

• **Prototype:** This is an irregular and speedy portion of the design process. A prototype can be a model, sketch, or a cardboard box. Student work together using arbitrary materials to construct examples of their product and explain how their product works.

• **Test:** This is part of an iterative process that provides feedback. The resolution of testing is to learn what works and what doesn't, and then repeat. This means going back to your prototype and adapting it based on feedback. It ensures that students learn what works and what doesn't work for their users.

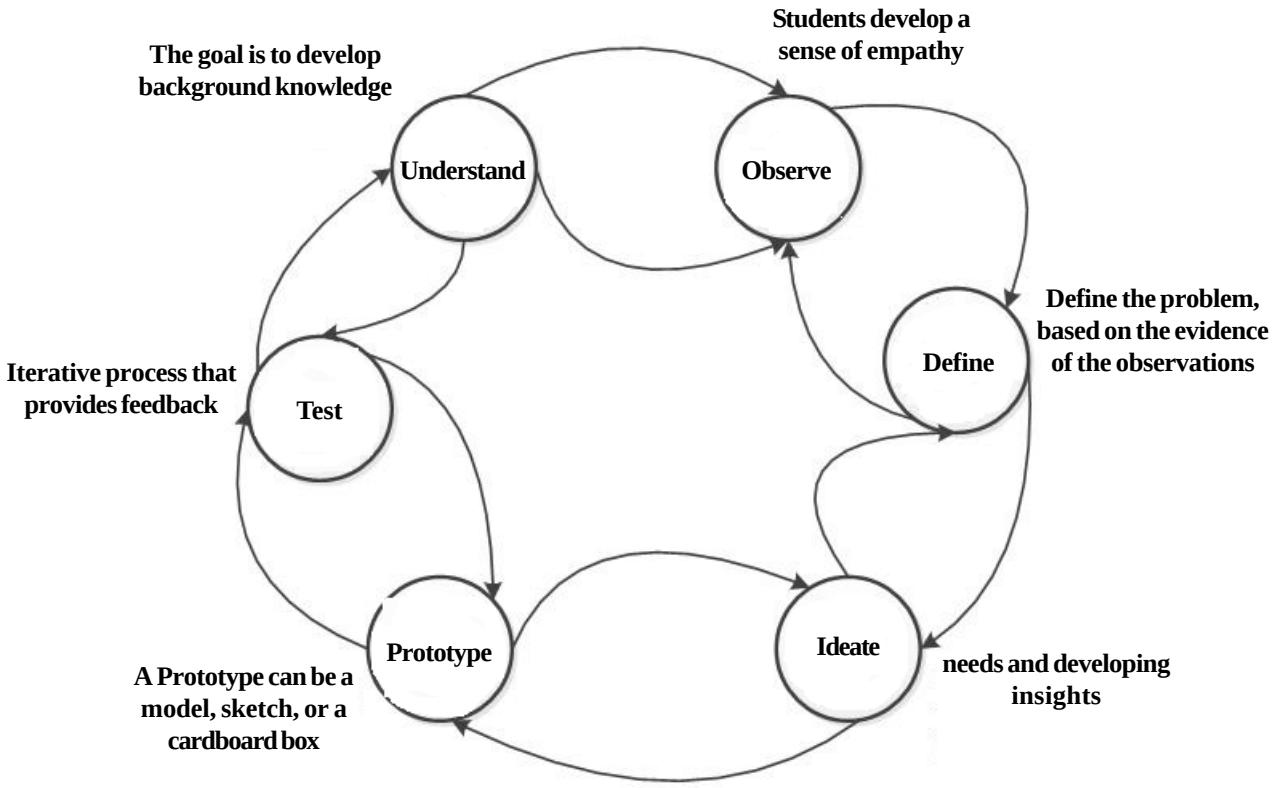

Figure 2. Design thinking process

There are many applications for design thinking in business innovation with small and enterprise groups, and in addition it is used for improving digital strategies. The application in education environment is limited to K12 and in particular for projects (designthinkingforeducators.com, 2013).

3. Information Security Design Thinking Model

A normal course in information security possibly covers the following topics

• Introduction to Information Security

• Information Security Management

• Legal, Ethical, and Professional Issues in Information Security

• Risk Management

• Planning for Security

• **Technical Security:** Firewalls, VPNs, and Wireless

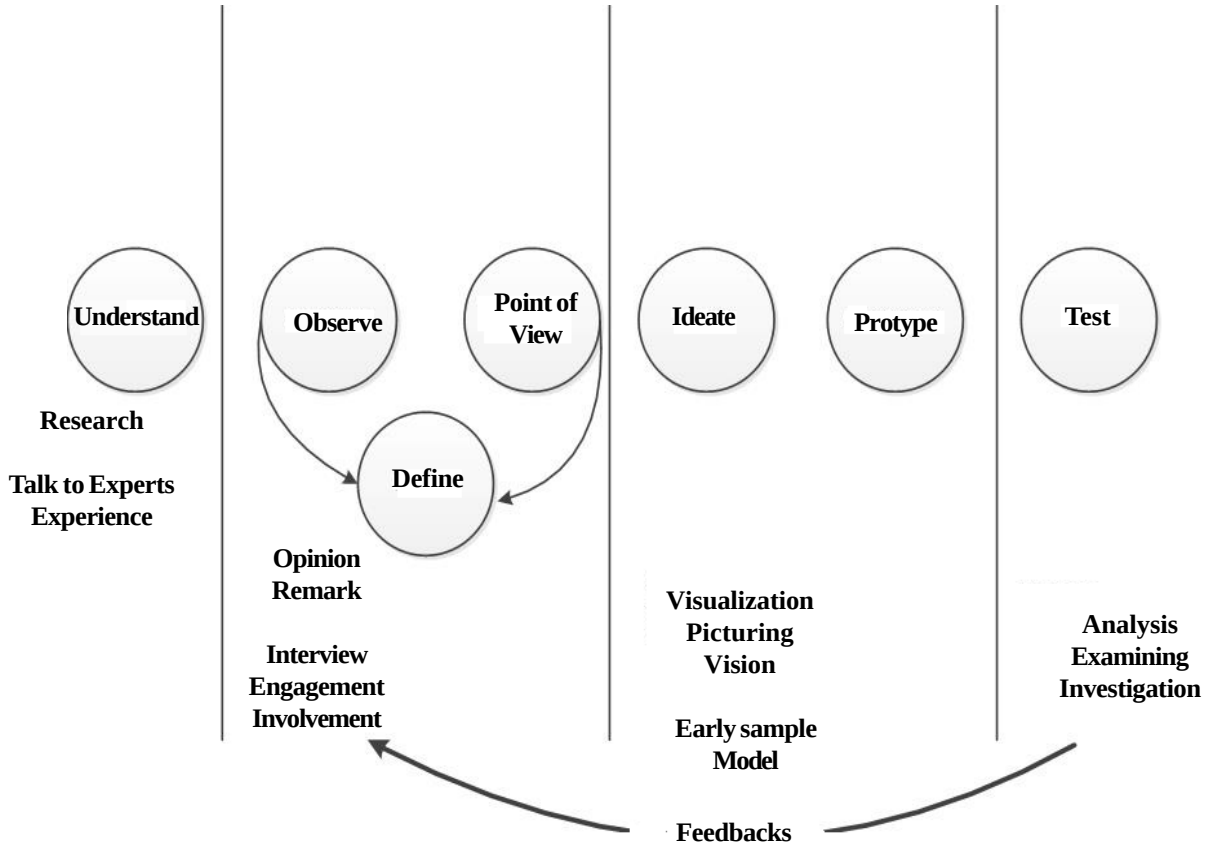

Figure 3. Details Design thinking process

- **Technical Security:** Intrusion Detection and Prevention Systems and Other Security Tools
- Cryptography
- Physical Security
- Implementing Information Security
- Security and Personnel
- Information Security Maintenance

Another module is (testout.com, 2013)

- Introduction
- Access Control and Identity Management
- Cryptography
- Policies, Procedures, and Awareness
- Physical Security
- Perimeter Defenses
- Network Defenses
- Host Defenses
- Application Defenses
- Data Defenses
- Assessments and Audits

Whatever the model to be presented, all syllabi have to cover major three elements:

- Management issues
- Technical and operational
- Physical issues

In the design thinking model, we will take the subject "*information security*" as one major project, and then will break it down in to subprojects. The project is "*Create Information Security Program*". The final overall project objectives are:

- Students write a model of information security program
- Students exchange ideas on each topic
- Students work as one team
- Students divide task according to project timesheet
- Students research, present and deliver ideas and prototypes

In additions to above challenges, there are other challenges, which are

- Grading
- Exams
- Evaluations

Phase 1: Understand

Instructor side:

- **Define a Challenge**: A KSU campus has no information security program, you need to build a complete information security program
- **Create a Project Plan:**

  Understanding: 2 weeks
  Observe: 3 weeks
  Define: 2 weeks
  Ideate: 2 weeks
  Prototype: 4 weeks
  Testing and feedback: 1 week

Student side:

- **Understand the Challenge**: Students specify what are the objectives of the challenge (Students sketch their objectives for a complete information security plan to protect personal information, medical, research, financial information, registration information, all campus networks, fax and printers)
- **Prepare Research:** Instructors guide students to start research and research methodologies.
- **Gather Inspiration:** Instructors guide students to interviews (students line up who to interview, what type of questions, and when)

All findings are documented and then presented to all groups.

Phase 2: Observe

Students gather their findings through interviews, research, discussions and visits. Student starts to document their observations and findings. At this stage a student documents the followings:

- No end user policies
- No real securities for student records, financial records, personal, medical, research and campus network
- The only security is passwords (with no limited time) and limited physical security

• Personal security are unknown
• Physical security are limited

Phase 3: Define
The problem based on the evidence of the observations. At this stage students generate a documented approach that addresses how an organization will implement security measures.

Phase 4: Ideate
At this stage students have to put all their ideas, thoughts, research and findings into a general sketch. This has to include:

- Common Control (CC)
    - o Program managements
- Management control (MC)
    - o Certification, Accreditations and Security assessment (CA)
    - o Planning (PL)
    - o Risk Assessment (RA)
    - o System & Service Acquisition (SA)
    - o Compliance & Legal (CL)
- Operation Controls (OC)
    - o Awareness &Training (AT)
    - o Configuration Managements (CM)
    - o Contingency Planning (CP)
    - o Incident Response (IS)
    - o Maintenance (MT)
    - o Media Protection (MP)
    - o Personnel Security (PS)
    - o Physical & Environmental Protection (PE)
    - o System & Information Integrity (SI)
- Technical controls (TC)
    - o Cryptography(CR)
    - o Access Control (AC)
    - o Audit & Accountability (AU)
    - o Identification and Authentication (IA)
    - o System Communication Protection (SC)
- Private Control (PC)
    - o Authority & Authority purpose (AP)
    - o Accountability ,Audit and Risk Managements (AR)
    - o Data Quality & Integrity (DI)
    - o Data Minimization and Retention (DM)

The above list was generated after two weeks of substantial meetings and discussions. At this stage, the instructor has to adjust the student findings and research to cover all required topics. It is a high possibility that student findings differ from the above. The main issue at this stage is to adjust student findings to fit with the original objectives.

Phase 5 Prototype
This stage is most critical to put all student findings together, and it is the most time consuming because student has to develop the security plan with an example why they chose a certain solution. The instructor will play major role in adjustments and will correct their prototype according to the baseline of knowledge required for the course. Quite often this stage in working together with the next stage, Testing, and feedback is because the instructor will play as the customer and needs to give the student feedback to fit his needs.

Phase 6 Testing and Feedback
In this phase students get the feedback from two sources: first from the administrator which they interviewed during early phases; and from the instructor, in addition to the other members of the group.

4. Discovery

There are some findings we came across when we started to deliver this curriculum:

• There is no clear line between these the 6 phases and there always overlapping items. Figure 4 shows these:

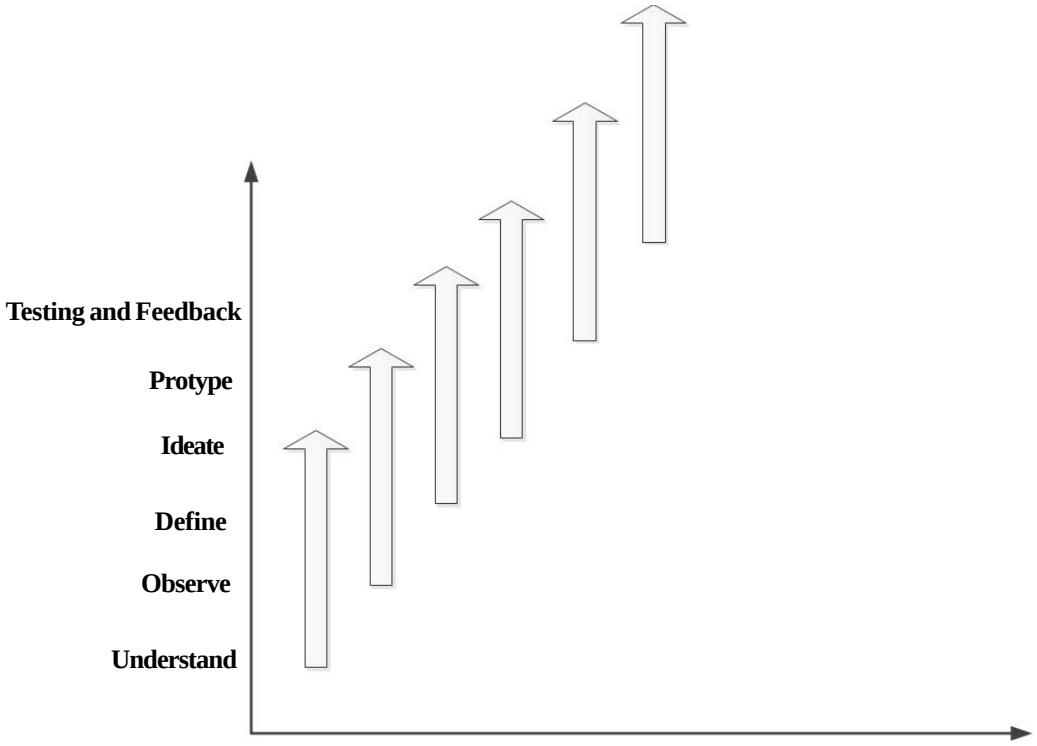

Figure 4. Critical thinking overlapping

• The transfer of this course into design thinking method requires that the instructor be in touch with the student on daily basis to discuss ideas, finding guide their research and all students should share these. For all these reasons, the instructor and the student create a course blog where all users can post their questions, findings and all been on the same page.

• In addition to normal class hours, the instructor and the student meets 1.30 houses per week, for 30 minutes a session to discuss whatever they need. The instructor used Adobe connector for online meetings (or any other media).

• For student evaluation the instructor uses their engagement in the discus, finding, and writing the report.

• The process of the course evaluation is based on the creation list of questions that have never been discussed in the class, or any phase such as base line security, buffer overflow, and the answers for these 30 questions show that the students has had come across these definitions in their work to build and putting together the prototype, the evaluation.

• At this stage of adopting design thinking as an innovation teaching and learning method, the implementation was for a graduate program.

• Further study is needed to reflect on this method at the undergraduate learning process.

• Students have shown they have to be at the edge of technology to achieve their objective.

5. Conclusion

Design thinking is usually measured by the ability to merge empathy for the context of a problem, inspiration in the generation

of insights and solutions, and consistency to analyze and fit solutions to the context. Design thinking has become part business and management and lexicon of engineering practices. This method is a particular style of creative thinking-in-action has influence on education across disciplines. In this paper an information security course has been presented using design thinking, where students face the problem to build security program from no background. The outcome of this experiment shows that the students gain great experience indifferent topics in information security and they get this knowledge from: interviews, research, discussion, gathering ideas together and feedback. The work shows there are another approach to execute DT which is divides the course in many different projects. Overall result of this criticalthinking approach shows: the need for more courses to test it efficiency and effectiveness

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