Improving Software Engineering Students' Creative Thinking and Motivation Using Practical Prototyping and Innovation Techniques

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Abstract **– Traditionally university students lack motivation in subjects that are more focused on documentation and theory. This problem only deepens with each new generation. A practical workshop approach has been implemented in the subject "Analysing system requirements and specifications". Its place in the curriculum is explained. A technique for developing innovation and prototypes, used by Google for motivation is described. The method of its' implementation is thoroughly documented. A brief experiment in the form of a workshop is described and the gathered data is analysed. A survey on student feedback is conducted and the results are discussed. Influence on student soft skills improvement is evaluated. An observation on using the methodology as an introductory workshop to break the ice with engineering students is made. The conclusions made based on the feedback data and discussions with students show that the methodology is successful and student motivation and attendance is increased.**

Keywords **– Software engineering, business analyst training, higher education, soft skill improvement, practical application, prototyping and interview methodology.**

DOI: 10.18421/TEM131-67
https://doi.org/10.18421/TEM131-67

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Received: 15 October 2023.
Revised: 29 January 2024.
Accepted: 16 February 2024.
Published: 27 February 2024.

1. Introduction

The curriculum for software engineering students at the University of Ruse includes a wide variety of subjects, which reflect the requirements the profession has. They are mostly related to programming, algorithms, and web design. Some are oriented towards improving the students' basic understanding of existing complicated neural networks and artificial intelligence, others let them experience working with actively used existing software and hardware infrastructure. The subject "Analyzing system requirements and specifications" aims to improve their understanding on how a company starts, works on, and completes a project. The business analyst role is used as a cornerstone to describe the process. The students must create their own specification and are encouraged to come up with their own creative ideas for a course project, as that motivates them to fully complete their project, as writing and analyzing documentation is not the most attractive of activities to them. In order to "break the ice" in the beginning, as well as give them an accurate idea on how and why prototyping and brainstorming is used in companies, a workshop taught by the Google Innovation center is considered.

The methods used by Google Innovation aim to improve the students' soft skills - teamwork, communication, and empathy, as well as heighten their creative sense and brainstorming skills. It is intended to break the ice and ignite interest and motivation in students. The improvement in communication and breaking the ice is achieved through the interview process where they exercise their imagination in pretending to be someone else in a different position (role-playing in education [1]).

Introducing the basic aspect of pretending activates the zones in the brain responsible for social cognition [2] and stimulates the learners to be more acceptable to new activities, teamwork and collaboration, and any other forms of communication. More such activities, workshops, and exercises should be included in higher education [3] computer science degrees, where students are often encouraged to spend enormous amounts honing programming skills. Many students and professors often forget that while being better at solving complicated problems is important, finding the correct problem to solve using communication skills is also obligatory for the success of a project.

Considering the necessity of forming a core of experiences in students, which will help them become valuable members of the industry, the use of practical manual operations combined with visualization and communication process are required. To cover the needs for communication it was decided to use an approach that includes an interview process. For the visualization requirement the method of fast prototyping and designing was chosen. The inclusion of a manual operation to the process (students working / creating an object using their hand-to-eye coordination skills) improves the physical neuroergonomics [4]. The field of software engineering has few ways in which a student can be given an opportunity to "touch" a product they have created, thus detaching them from reality, leading to disappointment and unhappiness with their results, as well as dissatisfaction with their work in general. Providing them with an activity that jump-starts their manual creativity and innovation is imperative for keeping their interest in a subject with very abstract base. The Google innovation workshop activity that has been chosen satisfies all the above requirements. The experiment has been conducted for two consecutive years with software engineering students in their third course. The method chosen was to include a workshop during the starting week of their work on the subject.

2. Layout

The workshop has been separated into several stages, each of them fulfilling a part of the requirements we had previously formed. Every stage is timed using a countdown on a watch by the professor.

3. Theoretical Preparation

The students are walked through a presentation that explains why it is necessary to understand the clients' needs and the problem itself when creating a prototyping solution.

They are shown several ways to direct and expand on their interview questions to get more relevant information from their client. Examples of good business analyst practices are discussed and demonstrated in study [5]. It is stressed that empathy, paying attention to non-verbal communication, and body language are all important parts of the successful communication process. An overview of the entire workshop is given, but details for the practical manual work are intentionally kept secret to surprise them and produce a positive impact.

3.1. Team Task Delegation

Students are then separated into groups of two (if there is an odd number of participants, the professor takes an active role in the discussions and pairs with a student). They are asked to conduct an interview with their partners, describing in turn their needs for a new home or office chair. There is a rotation between their two roles - an interviewer from a company that must build a chair, and a person that needs that chair. The role of a person in need of a product can be taking any job, interesting examples include - astronaut, writer, miner, dentist etc. As the needs of each profession vary depending on their specific duties, their life experience, age and their personal quirks; the discussions are healthy for the creative processes and the role-playing experience. The students are required to write down the questions they have asked and the interviewees' answers, starting the basic process of generating a draft of the documentation on a project and warming them up for the following stages. After the allocated time has passed (usually 10 minutes are delegated for the interview stage), the students are urged to proceed to the next step.

3.2. Creative Stimulation

Each participant is given a sheet of paper and is asked to separate it into eight sections, where they will draw. Most of the creative process improvement happens here, as they are given the task to design eight different versions of the chair that they have collected requirements for. They are instructed to try and consult these requirements as much as possible, but as time is of the essence, usually few students have the time to even look at them. Each section of their paper should contain their uniquely designed version of the chair – they all should be meaningfully different from the previous sections. The students are on a timer - they have only one minute per design, which helps introduce a bit of the urgency during an actual software engineering project, and from our experiences so far this stage has been effective with achieving that.

The first few designs are usually very close to existing standard versions of chairs – four legs, sometimes five, wheels, backrest, and handrests. When the time comes to design a chair in the last four sections though, the time for real creativity starts, as students are encouraged to do flying chairs, chairs with different abstract designs, physically impossible models, bent shaped figures and more. Different, unusual shapes are used, and the imagination of the participants is flaring. The time constraint helps the participant power through their anxieties, as everyone has to finish their design fast and move on.

3.3. Choice and Evaluation

Upon finishing their eight designs and the time is up, the students must show their creations to their partner and each client decides on the prototype they like the most. Usually, the clients like one of the first designs and choose them, but that does not diminish the role of the 'whacky' elements of the later creations – as the clients often comment on the strange designs and communicate emotionally about them. This generation of ideas helps feed the imagination of the participants further, as they boost their possibility for creativity by witnessing their partners' designs, thus receiving ideas for their own future inspiration.

3.4. Product Creation

This stage has the most significant impact on students. The prototyping itself is memorable and having a finished product at the end of the process is highly satisfying to the participants. The students are prompted to position themselves in a way that gives them enough space for working with their hands. Aluminum foil sheets are distributed to everyone. They are instructed to create the prototype their client has chosen using the foil and take their time doing it. Students are often surprised that they must physically prototype their designs, but they immediately get to working with their hands. At this stage the artistic capabilities of some students shine through, the perseverance of others is notable, as well as the ingenious ideas of some – using pens and keyboards to prop their prototypes, using origami as structural support, making flat designs and more.

Seeing their scribbles and designs go through their own hands into their muscle memory and becoming physical objects that shape their thoughts is a memorable experience. Photos of students' creations can be seen in Figures 1, 2, and 3.

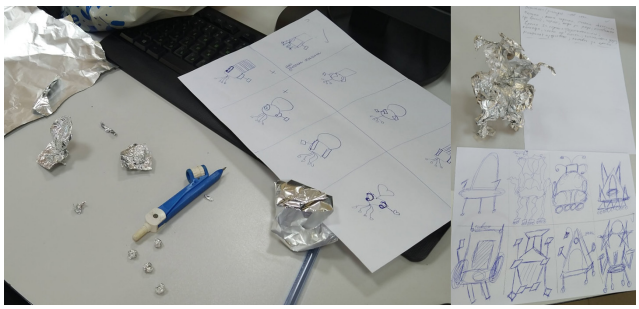

Figure 1. Student creative output using the innovation method for prototyping

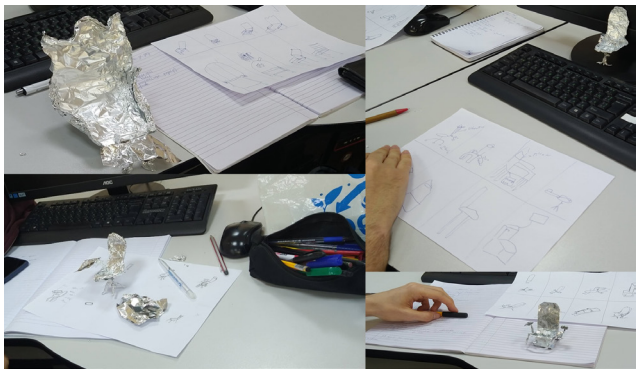

Figure 2. Student creative output using the innovation method for prototyping

Figure 3. Student creative output using the innovation method for prototyping

As an optional final step, if there is an opportunity for establishing a healthy competition between colleagues and time allows for it, a contest is be held to choose the best-looking chair.

4. Results and Feedback

A diverse set of questions has been created in order to measure the effect the workshop had on students' consciousness and their desire to learn. The possibility for improving the existing methodology is considered when analysing the responses.

The overall results are positive, as the trend of the answers tends to be going up, which indicate higher impact. Student feedback is measured using the created Likert scale shown on Figure 4. There is a notably positive reaction from students when this method for breaking the ice is used, especially for a subject that is strictly related to formal documentation in a discipline often removed from the real world and closer to computers themselves. Heightening the motivation of students is imperative if we want to achieve positive results in making them capable software engineers and improving their attendance in class, as well as their soft skills.

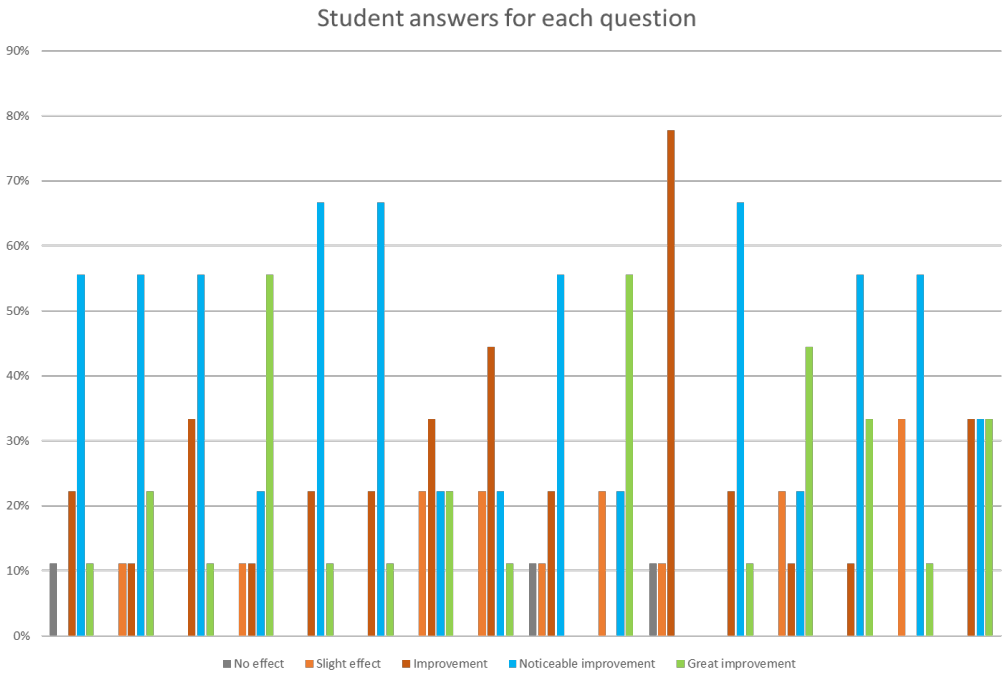

Figure 4. Measured student feedback using a Likert scale

The results in percentage for each question are shown in Figure 5, the answers range from one to five, and each number corresponds to "No effect", "Slight effect", "Improvement", "Noticeable improvement", "Great improvement" respectively.

Questions	1	2	3	4	5
Did the google innovation exercise improve your interest in the subject?	11%	0%	22%	56%	11%
How much did you like the overall experience?	0%	11%	11%	56%	22%
How useful did you find the workhop?	0%	0%	33%	56%	11%
How satisfying did you find the workshop organisation and the time it took?	0%	11%	11%	22%	56%
How useful do you think it would be for your future/present ideas?	0%	0%	22%	67%	11%
Did you learn something new?	0%	0%	22%	67%	11%
How likely are you to apply what you have learned in practice ?	0%	22%	33%	22%	22%
Do you think the activities you were involved with gave you new perspective or ideas?	0%	22%	44%	22%	11%
Did you use any skills you learnt as a student?	11%	11%	22%	56%	0%
Do you think more workshops like this would be useful?	0%	22%	0%	22%	56%
How difficult did you find the workshop?	11%	11%	78%	0%	0%
How well were the workshop goals defined?	0%	0%	22%	67%	11%
Did you like the team interactions?	0%	22%	11%	22%	44%
Were you engaged during the entire workshop?	0%	0%	11%	56%	33%
How likely do you think you are to share what you have learned to others?	0%	33%	0%	56%	11%
Did everyone take part equally?	0%	0%	33%	33%	33%

Figure 5. Student responses for each question on the survey on a positivity scale of one to five

During the course of teaching the subject, the results of this ice-breaker workshop are directly witnessed in two to three of the following workshops and classes, in the form of unprompted positive discussions on the topic, and questions about whether similar exercises will be performed during the student curriculum and in other subjects. As is expected, student interest is relative to the level of their engagement during the workshop – the more emotions and incentive they displayed, the more interested they were in talking about it.

The synthesized methodology can be seen in Figure 6. All the necessary steps for conducting the workshop can be summarized in the statements that can be seen in the elements of the figure.

Figure 6. Synthesized methodology for teaching the method

Active research is continuously being published on how the gamification of subjects is beneficial to developing student potential [6]. Role-playing is a sufficiently advanced social construct that can be classified as " social gaming" [7]. We have applied similar approaches to subjects for our computer engineers, software engineers and we are planning to do the same for our computer science students as well.

The time constraint during the designing phase is especially useful to stress on the effect real life projects can have if the project governed by tight schedule. Teaching this to students is imperative to helping them understand why the planning phase of creating a software project and the distribution of time on tasks is so important to avoid such situations. Short brainstorming sessions with time limits also benefit the students' creativity greatly, as this practice has been used in writing extensively [8]. Including a small amount of manual labour to the process helps the development of their other skills [9]. A symbiosis between visual activities and communication with other developers is imperative to achieving great results and staying productive [10].

5. Conclusion

The experience from teaching this subject throughout the years helps with evaluating the inclusion of this workshop to the study plan. It can be said with certainty that the workshop is a successful icebreaker, that improves students' opinions and attitude towards the following lections and workshops. The opinions of students are shown in the survey, as well as their reactions during and after the workshop confirm this conclusion.

It is suggested that such workshops are spread evenly between more traditional workshops, as they keep the student's attention, engagement, and desire to participate in activities high. This workshop has been useful in getting students to know each other better. The activities provide an opportunity for them to showcase their non-technical skills and abilities. Another notable situation that perhaps warrants further study and investigation is the positive effect the workshop had on students with obvious communication issues and/or a light form of autism spectrum disorder. Due to the low prevalence of the condition, our sample size was insufficient to achieve representative results. One of the achievements that should also be mentioned is the positive comments we have received from students, in both years we have implemented the workshop, leading to improving their outlook on the future of their education, as well as building a sense of belonging to a thriving community of creative and open to communication colleagues and professors. Our observations on the current trends in education, generational differences, software engineering, computer science and computer engineering, both in the private sector, as well as in the universities, show the need for more improvement of soft skills, communication skills, and the need for at least a small amount of manual labor or practical mechanical application of skills included. It is a growing concern especially with pure software developers that have no access to hardware, or any physical product born of their work. This leads to work dissatisfaction, lack of motivation, and often leads to hobbies which try to compensate for this void. It is the author's belief that more practical activities must be included not only in the curriculum as different subjects, but also strongly integrated into the core of each subject, dedicated to a specific field of software, to ensure long term success and mental health, as well as happiness of the participants in the process.

Acknowledgements

This research is supported by the Bulgarian Ministry of Education and Science under the National Program "Young scientists and Postdoctoral Students – 2.

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