

# Joint Creative Classroom as a Response to Industry 4.0 Demands

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**Abstract.** *This paper presents an analysis of the results collected from the eight Joint Creative Classrooms (JCC), a new approach to learning and teaching in computer science and related courses, which was piloted within a European project among five different universities. Factors that affect student satisfaction and engagement, as well as gains in their skills were studied. In total, 96 responses related to student reactions before and after the JCC sessions, as well as 110 responses related to learning outcomes, were analysed. The results indicate that the students would recommend their JCC to others, suggesting that the overall satisfaction with JCC is quite high. Research results indicate various benefits to learning within JCC. According to the results, student engagement and peer collaboration are positively related to student satisfaction.*

**Keywords.** Industry 4.0, Joint Creative Classroom, Higher Education

## 1 Introduction

Industry 4.0 brings changes in how people work and create value in contemporary society. Increasing automation, robotization, and digitalisation of business processes are transforming the demands of the labour market (Guadalupe et al., 2023) requiring new knowledge and skills from the workforce, thus placing new tasks in front of the educational system. To answer the challenges of higher specialisation of the labour market, higher education must provide students with the knowledge and skills necessary to adapt to the rapid changes in the industry and face the challenges of digital transformation (Baygin et al., 2007). New jobs are being created due to the need to implement the concept of Industry 4.0, which means that employers will demand new technologies, particularly digital skills of their employees (Grenčíková et al., 2021). Higher education institutions are essential drivers of these changes and must embrace new teaching techniques based on technologies such as the Internet of Things (IoT), Cloud computing, Virtual and

Augmented reality, simulations, Artificial intelligence (AI), Data analytics, and others. In addition, there is significant pressure on governments to recognise the requirements of such education.

One of the main advantages of Industry 4.0-influenced technology in higher education is improved accessibility to education (Mian et al., 2020). Many talents are lost due to the unavailability of quality motivation or comprehensive materials. Additionally, greater efficiency is achieved using interactive content and simulations (Chen et al., 2020). Better collaboration and deeper learning approaches can foster greater adoption of educational materials, the formation of learning communities, the development of new curriculum programmes by faculties, and the collaboration between teachers and students (Adams Becker et al., 2017).

The teaching process that is influenced by Industry 4.0-influenced technology has multiple advantages over traditional teaching methods. These benefits will have a positive impact on students and the institutions they represent through their work (Baygin et al., 2016; Sudibjo et al., 2019; Goh & Abduh-Wehab, 2020).

To be successful in teaching, higher education must focus on student satisfaction as one of the factors contributing to its quality. Since satisfaction is a complex construct, higher education institutions should focus on relevant factors that will contribute to the defined goal (Alves & Raposo, 2009; Hang & Tam, 2018). Thus, this paper focusses on the satisfaction and skills change of students after participating in Joint Creative Classrooms (JCC) that were designed as part of the project "Accelerating the transition towards Edu 4.0 in HEIs" (Teach4Edu4) conducted from 2020 to 2023 (Rienties et al., 2023). JCCs are computer science courses developed in collaboration with two or more partner universities using the learning design approach aligned with Education 4.0 with a total workload of 2-3 ECTS. They can be seen as a unique student-centred environment that enables students from different partner institutions to join the same classroom and, in addition to domain knowledge, to gain mobility from home experience and transferable skills (e.g., Communication, Reliability, Teamwork, Organisation, etc.). At the same time, at least two teachers from

different universities are also working collaboratively to design such courses, create the content, and run them in different settings. Some JCCs were run completely online, while others were run in blended mode.

The purpose of this paper is to explore the factors that influence student satisfaction and how individual skills have changed after JCC sessions. For that approach, we used the Kirkpatrick's model, a globally recognised method of evaluating the results of online learning programmes (Gandomkar, 2018). The Model allows programme designers and researchers to assess formal and informal training methods and to rate them against four levels of criteria: reaction, learning, behaviour, and results. In this paper we will focus on learners' reaction, and their learning gains which are the first two levels in the Kirkpatrick's Model.

## 2 Research goals

Since Kirkpatrick's model describes four fundamental levels of evaluation without suggesting any relationships within the constructs, the research objectives of this paper are as follows:

- RO1: To identify factors that affect students' satisfaction with the Joint Creative Classrooms;
- RO2: To determine how individual students' skills have changed after completing the Joint Creative Classrooms;
- RO3: To investigate how student engagement in learning and peer collaboration influences their satisfaction.

## 3 Methods

In this section we will describe the participants (sample), data collection procedure and measurement instrument creation.

### 3.1 Participants and data collection procedure

The Teach4Edu4 project started its activities in November 2020. A total of 21 teachers and 162 students from 5 different universities in Europe participated in the Teach4Edu4 project. In total, 8 JCCs were held on different topics within the computer science field. In this paper, we focus on the student's satisfaction through the analysis of 92 responses from JCC participants and 110 responses related to learning. The difference in the number of students arises because not all students decided to participate in the surveys at the end of the JCC, nor did all of them complete the JCC. The sample profile is presented in Table 1.

## 3.2 Instrument

The first questionnaire was designed to measure student reactions (the first level of the Kirkpatrick model) and consisted of three constructs: satisfaction (7 items), engagement (3 items) and peer work (2 items). For each item, students had to indicate their agreement or disagreement on a Likert scale ranging from 1 - "strongly disagree" to 4 - "strongly agree". The final set of items is presented in Table 4 after validation of the measurement instrument. There are numerous examples that describe satisfaction, but we focused on a set of measures proposed by Ashby et al. (2011) and Li et al. (2016) that are most suitable for our research. Literary sources by Dixon (2015) and Handelsman et al. (2005) were used for the construct of engagement.

**Table 1.** Sample profile

	Gender	Reaction aspects group (n=92)	Learning aspects group (n=110)
Gender	Male	65 (71%)	78 (70,9%)
	Female	24 (26%)	29 (26,4%)
	Prefer not to say	3 (3%)	3 (3%)
Average age	Male	23,8	23,9
	Female	24,6	24,9
	Prefer not to say	25,3	25,6
Standard deviation	Male	2,65	2,99
	Female	2,66	2,98
	Prefer not to say	1,38	1,32

The second questionnaire was related to the learning aspect of JCCs (the second level of the Kirkpatrick's model) and consisted of 10 items related to skills and 2 items related to attitudes. The instrument was administered to students at the beginning and at the end of each JCC to measure the gains in specific skills and expectations from the JCC. Examples of questions before JCC started and after it ended are presented in Table 2. The main difference between the two columns presented in Table 2 is that the first column shows the outcomes that students want to learn before the JCC started while the second column refers to fulfilment of the outcomes.

**Table 2. Items related to learning**

Before JCC	After JCC
I would like to learn where and when I choose.	I could learn where and when I chose.
It would be great if the course was personalized to my learning.	Learning was personalised to my needs.
I would like to be able to study how I like to study (rather than following a predetermined structure by the teacher).	I could study the way I like to study.
I would like to work on projects with other students.	I worked on projects with other students.
I would like to gain hands-on, authentic experiences and real-world skills.	I gained hands-on, authentic experiences, and real-world skills.
I would like to learn how to interpret and reason with data.	I learnt how to interpret and reason with data.
I would like the assessments to be innovative.	I participated in new ways of assessment.
I would like to contribute to the design and implementation of the JCC.	My voice and input were used to (re)design, implement, and/or improve the JCC.
I would like to be more independent.	I have become more independent in my study.
I would like to study an approach to learning and teaching that emphasises the development of skills and competencies necessary in a modern workplace using up-to-date technology.	I would like to study an approach to learning and teaching that emphasises the development of skills and competencies necessary in a modern workplace using up-to-date technology.
I would like to develop my soft skills (such as teamwork and creativity).	I was able to strengthen my soft skills (such as teamwork and creativity).
I would like to develop my skills to work effectively in a modern workplace.	I was able to strengthen my skills to work effectively in a modern workplace.

## 4 Results

Before we could interpret the results with confidence, the validity and reliability of the instrument needed to be confirmed for the first level of the Kirkpatrick

model. Table 3 shows the results of the instrument validity and reliability with the sample of 92 students. As seen in Table 3, the instrument showed good validity and reliability. Confirmatory factor analysis was also conducted and items below the 0.6 threshold were eliminated to achieve the satisfactory validity of the instrument scales. To assess the reliability of the responses within the measuring instrument, Cronbach alpha (CA) was calculated with a values above 0.7, which is considered acceptable according to Pallant J. (2007). Average Variance Extracted (AVE) is used to asses the convergent validity of a construct. Considering that all the latent variables have an AVE value of more than 0.5, therefore, convergent validity has been achieved (Pallant J., 2007). Construct Reliability (CR) which measure of internal consistency in scale items is very high because all the values are above 0.85 (Pallant J., 2007). The final list of items for further analysis is presented in Table 4.

**Table 3. Construct reliability and validity**

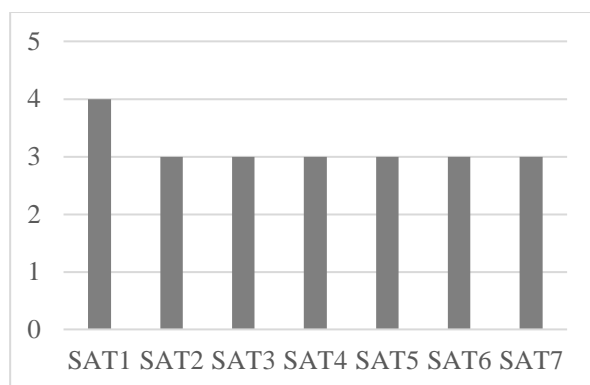
	CA	AVE	CR
Engagement	0,75	0,655	0,850
Peer Collaboration	0,86	0,877	0,935
Satisfaction	0,88	0,589	0,908

**Table 4. Instrument items in three (sub) constructs for the first level of Kirkpatrick’s model**

Satisfaction
SAT1 Overall, I would recommend this JCC to other colleagues. (Li et al., 2016)
SAT2 Overall, this JCC met my expectations. (Li et al., 2016)
SAT3 Overall, I enjoyed studying this JCC. (Li et al., 2016)
SAT4 Overall, I was satisfied with the JCC materials provided. (Li et al., 2016)
SAT5 Overall, I was satisfied with the method of delivering different JCC materials and learning activities. (Li et al., 2016)
SAT6 Overall, I was satisfied with the assessment during this JCC. (Li et al., 2016)
SAT7 I was satisfied with the support provided by my facilitator. (Li et al., 2016)
ENGAGEMENT
ENG 1 I carefully read the JCC materials. (Dixon, 2015)
ENG 2 I applied the JCC materials to my life. (Dixon, 2015; Handelsman et al., 2005)
ENG 3 I was very motivated to learn the JCC content. (Dixon, 2015; Handelsman et al., 2005)
PEER WORK
PW1 I enjoyed working with students from the partner JCC institution.

PW2 I have learnt a lot working with students from the partner JCC institution.

To address the first research objective (RO1), the results were interpreted based on the mode function within each category because not all categories had an identical number of items (questions). Mode presents a value which appears most often in the data set. Survey responses were based on a 1-4 Likert scale and are presented in Figure 1. Overall, the highest satisfaction was expressed with the highest possible rating of four in the Overall JCC (SAT1) category, where students indicated that they would recommend this JCC to others, suggesting that the overall satisfaction is quite high. In all other satisfaction categories, the most common rating is three which points to a positive agreement with the statements presented in Table 4 (SAT 2-7). The observed satisfaction categories are Materials (SAT 4-5), Assessment (SAT 6), and Tutor/guidance (SAT 7).



**Figure 1.** Results of the first research objective (Mode values)

Based on the results of the T test shown in Table 5 which shows whether there was a statistically significant difference between two groups of answers (Pallant J., 2007) or the responses before and after the implementation of the JCC, the second research objective (RO2) significantly demonstrated that the students were able to learn where and when they wanted and in the way they desired, to a greater extent than expected as shown in Table 2. The reasons that can be inferred are the flexibility of the instruction itself, as some teachers recorded lectures and provided interactive video materials, enabling students to adjust their own schedules. Additionally, the students truly worked on projects with other students through collaborative learning environments, which allowed them to improve skills such as communication, teamwork, organisation, problem solving, stress management, and more. However, students believe that the approach to learning and teaching did not emphasise the development of skills and competencies needed in the modern work environment using contemporary technology. The students also learnt to a lesser extent than expected how to interpret and think

about data. The students also feel that the JCCs did not lead them to develop learning strategies and they believe that they were able to strengthen their skills for effective work in a modern work environment to a significantly lower extent than expected. A possible reason for such a result could be high student expectations, but this needs to be further researched.

**Table 5.** T-test values

Question	Df value	T Stat value	P value
1.	267	-3,781	0,001
3.	267	-5,649	0,001
4.	267	-4,121	0,001
6.	198	1,707	0,05
9.	197	3,123	0,001
10.	267	2,482	0,05
12.	193	3,954	0,001

To address the third objective of this research (RO3), the Spearman correlation was calculated. Correlation analysis is used to describe the strength and direction of the linear relationship between two variables, while Spearman rank order correlation is designed for use with ordinal level or ranked data and is useful when your data does not meet the criteria for Pearson's correlation (Pallant J., 2007). A total of 92 student responses were analysed and the literary source used in interpreting the results was Pallant J. (2007). The answers were analysed to the questions shown in Table 4 and the results are shown in Table 6.

**Table 6.** Correlations between main constructs

	Engagement	Peer collaboration	Satisfaction
Engagement	1,000		
Peer collaboration	0,074**	1,000	
Satisfaction	0,73*	0,51*	1,000

\* $p < 0,001$ , \*\* $p > 0,5$

The first correlation conducted compared the responses between student engagement and satisfaction, resulting in a value of 0,73. This value indicates a relatively high positive correlation between these variables. Since in most cases, more engaged students are more active and dedicated to learning, they usually achieve better results, which fulfils them and makes them more satisfied. The second correlation conducted compared the responses regarding peer collaboration and satisfaction, resulting in a value of 0,51. This value suggests a highly positive correlation between these variables, closer to the lower limit. On the basis of the responses, it can be concluded that the students provided support to each other, which can

positively impact their satisfaction. However, it should be noted that if there is poor team organisation, the responses of all students are not relevant because students who are more burdened will certainly feel less satisfaction if they must work more than other students. The third correlation between engagement and peer collaboration results in a value of 0,074, suggesting a minimal correlation between these two variables. Such a value can be observed because not every student who collaborates in peer work have identical engagement motivation, and not all the students are equally burdened.

## 5 Conclusions

Industry 4.0 has a significant impact on higher education, requiring adaptation of curricula, integration of new technologies, and collaboration with industry. This research analysed JCCs as a new concept of learning and teaching in line with the requirements of Industry 4.0. The research results showed that the students strongly agree that they would recommend this JCC to other colleagues, which means that overall JCC satisfaction is quite high. In other satisfaction categories like materials, assessment or tutor/guidance, satisfaction is evaluated with the most common rating of 3 out of 4. Furthermore, the implementation of JCC has positively influenced the development of certain student skills, such as flexible learning and teamwork, but did not emphasise the development of skills needed in the modern environment. The possible reason for such a result could be high student expectations or lack of attention to the mentioned skills, but this needs to be further researched. According to Williams (2003), it is essential for coaches and administrators to underscore the significance of teamwork and collaborative skills in the realm of policymaking and staff/faculty development initiatives, placing particular emphasis on the role of teamwork in the development of courses and the implementation of technology. Student engagement and peer collaboration have a positive correlation with student satisfaction, which is consistent with previous research studies conducted by the authors Grey and DiLoreto (2016). JCCs are an innovative approach to higher education that promotes the development of key skills and knowledge for the contemporary job market. Future research can focus on differences between traditional teaching methods and adapted JCC, key skills that influence student outcomes, perception of modern approaches in higher education, and possible improvements in the application of modern technologies in JCC among gender groups. It is important to embrace new learning trends while critically considering their implementation, and to develop skills and leverage satisfaction in their application as motivation for further learning and improvement.

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