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A research on the use of learning by developing action model in computing studies in Finland and the UK HEIs.

LINTILÄ, T. and ZARB, M.

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A RESEARCH ON THE USE OF LEARNING BY DEVELOPING ACTION MODEL IN COMPUTING STUDIES IN FINLAND AND THE UK HEIS

Taina Lintilä[1]

[1]*School of Computing, Robert Gordon University (UNITED KINGDOM) / Haaga-Helia University of Applied Sciences (FINLAND)*
[2]*School of Computing, Robert Gordon University (UNITED KINGDOM)*

Abstract

This article describes a study in which the Learning by Developing (LbD) action model has been used as a teaching and learning method for computing students in Finland and the United Kingdom. The study has been carried out as action research, and the subjects of the study have been Laurea University of Applied Sciences (Laurea) and Haaga-Helia University of Applied Science (Haaga-Helia) from Finland and Robert Gordon University (RGU) from the UK. The research aims to get information about how computing students' competence in different competence areas develops during the study module chosen for the research and how well the students think it fits into computing studies. The research results are also utilised in developing the LbD action model.

Keywords: Learning, teaching, Learning by Developing, computing studies, learning outcomes.

1 INTRODUCTION

The research aims to discover the development of computer science students' competence with study modules that apply the principles of Learning by Developing (LbD) action model, which includes customer projects, in Finland and the UK. The study aims to determine whether the LbD action model is a suitable learning and teaching method for computer science students' study modules, including genuine customer projects. In this article, research results from the studies conducted at all three higher education institutions have been compiled and compared. Research cycles are related to research at three higher education institutions, Laurea and Haaga-Helia in Finland and RGU in the UK. In the computer science students survey, the students self-evaluated the development of their skills during the study module. The first research cycle was carried out at Laurea in the fall of 2019. Subsequent cycles have been done at RGU in the fall of 2020 and 2021 and Haaga-Helia in the spring of 2022. In addition, the survey wanted to find out the student's learning experiences of using the LbD action model in teaching and learning.

The research data obtained from the study is also used in the development of the LbD model. The LbD action model was initially developed at Laurea University of Applied Sciences to support teaching and learning [1]. The LbD action model has been used at Laurea since 2006 and has been perceived as a successful way to teach new skills needed in working life in higher education [2]. In the LbD action model, competence development comprises research, authenticity, partnership, experience, and creativity [3]. Authenticity means a genuine working life context, which is helpful to students during their studies and helps them develop the skills needed. One part of LbD pedagogy is the importance and value of lifelong learning. [4].

2 METHODOLOGY

Action research has been chosen as the research strategy of this study. Action research is well suited to a development-oriented approach, where the researcher has acted as an active actor as part of the developed organisation. The researcher's participation in acquiring information is characteristic of action research. The researcher's goal is also to change practices in the future based on the information obtained [5]. In this study, the researcher has been personally involved in the role of a lecturer in the first research cycle and, at the same time, systematically and carefully examined her teaching practices using research methods. In the following research cycles, the researcher has been involved in the role

of an external observer and information seeker, identifying the teaching practices of the participating lecturers. [6]. Action research is well suited to educational study, and only one teacher, a group of teachers, or the entire school faculty with a common problem can participate [7].

Action research progresses in cycles, where new information about the observed case is always obtained from the situation under study based on the analysis of the research material of each cycle. Based on the data to be analysed, the researcher first maps a picture of the current state, based on which the researcher plans the target state. Typically, the researcher participates in the development process, developing it further by reflecting on the situation of other participants. [8]. The first research data collection cycle was implemented at Laurea in the fall of 2019. The following two research data collection cycles were implemented at RGU in the fall of 2020 and 2021. The latest research data collection cycle was implemented at Haaga-Helia in the spring of 2022. Method triangulation is used as the primary research method, i.e., in this study; several data collection methods were used to acquire research material. [9].

Narrative analysis has been used as the analysis method in the students' free-form questions. To be explored in these are the meanings of people's actions and phenomena, which are built into different stories. Narrative, which means story, can be used in research conducted through interviews and free-form written responses. The narrative research strategy is interested in what kind of narrative is told in the culture or society of the research target and what stories are told about the research project in general. Language and seeing the use of language in creating meanings is the basis of the narrative strategy. A narrative perspective helps to understand entities and individual meanings based on personal and collective interpretations [10].

In studies where the object of the study changes in one way or another, narrative analysis is suitable for analysing the survey. In narrative research, background information can be essential, and often, the researcher relates the narrative to its contexts and the texts to their narrators. In this study, narrators play a significant role as storytellers and backgrounders because each research subject had a slightly different background. [11].

Mean and standard deviation is commonly used in quantitative research. The average value is used to compare estimates, but the mean value does not tell the mean frequency of observations. In addition to the mean value, the standard deviation is also used in quantitative research because it is well-suited for expressing the frequency of observations on the mean. The standard deviation is very helpful if the observations follow a normal distribution. If the mean and standard deviation of the set of observations is known, valuable information can be obtained using a simple arithmetic method. [12]. In this study, the quantitative answers to the student survey have been analysed with the help of mean values and standard deviation. The differences between all three institutions have been studied in the comparison, mirroring these results. The quantitative results of the different institutions are not entirely uniform, but they can be seen as indicative results.

3 RESULTS

This study collected research data from Laurea, Haaga-Helia, and RGU computer science project-based study modules. In all three higher education institutions, the research subjects were computer science students who participated in study modules that included a representative or representatives of working life and a customer project or projects. During the study module, the students participated in a development project related to working life in cooperation with a client. Students communicate with customers both independently and under the guidance of the lecturer.

The LbD action model was used as the teaching and learning method in these study modules. The LbD model has been successfully used as a pedagogical method at Laurea in the project-based studies of students in several different fields. This study aimed to get information about its suitability for the project-based studies of computer science students.

At the beginning of all study modules, the researcher introduced the LbD model to students and explained why this pedagogical method is used so that everyone understands the principles of LbD. The researcher informs students about the survey related to the study, which will be carried out at the end of the study module.

The study's goal for students was to obtain information about how the students' skills develop during the study module and what kind of learning experiences they have from implementing a study module according to the LbD action model. The goal in all these research cycles was to get information on how

well the LbD approach fits the project-based studies of computer science students at higher education institutions and whether they think it is a good and functional method.

This study compares the research results of these three institutions. In all study modules, the customer's IT projects were implemented, but the topics of the projects were all slightly different. The research material was collected from student surveys. The student surveys were conducted in 2019-2022. The student survey had questions classified according to the Likert scale and free-form questions. There were 31 Laurea students in the study module, of which 29 answered the survey. Two research cycles were conducted at RGU, the first in autumn 2020 and the second in autumn 2021. In the fall of 2020, there were twelve students, but only one answered the survey.

For this reason, a new research cycle was carried out at RGU in the fall of 2021. At that time, all participants in the study module answered the survey, but there were only five students. RGU's study modules in 2020 and 2021 were almost identical and had the same lecturer and the same client in both years. Therefore the results have been combined, and their results can be viewed as a single entity. Haaga-Helia's research cycle was implemented in the spring of 2022, partly because the desired number of student responses to the research conducted at RGU was not received. Another reason for implementing the research cycle in Haaga-Helia was that the background factors of Haaga-Helia and Laurea are more similar, which gives a better possibility of comparing the research results.

The background of the research is the general working life skills related to the development of the competence of higher education students. Laurea's 2030 strategy [13] has defined and identified not only the general skills of the degree but also the competence needs of working life, which are still perceived as essential skills for all graduates of a university of applied sciences. The common and general working life skills defined for degrees in Laurea's 2030 strategy consist of six competencies: self-management and entrepreneurial attitude, critical thinking and problem-solving skills, foresight and innovation skills, communication and interaction skills, global skills, and responsibility skills.

In the survey, the students self-assessed their competence development concerning these six areas. Four competence areas contained three detailed questions, and two competence areas had four questions. Concerning these 20 detailed questions, the students evaluate their level of competence before the study module and at the end. Here are just a few examples of these results. When interpreting the answers, it must be taken into account that it is the student's self-assessment, and it has been taken into account as a limitation of the reliability of the results.

3.1 Laurea students; surveys results in classified questions

Thirty-one students participated in Laurea's study module, of which 29 answered the survey. Seven of Laurea's students were foreign exchange students, and 24 Finnish students. The teaching language of the study module and the working language of the groups was English because each group also included foreign exchange students. All students were second or third-year students. Figure 1 shows the students' answers to the questionnaire, where they self-assessed their competence level at the beginning of the study module (blue bar) and the end of the study module (brown bar). For this article, Self-management and an entrepreneurial attitude have been selected from the answers of the students in the competence area question Own skills and skills for continuous learning. Students rate their skills (in figure 1 Level of knowledge) on a scale from 1 ("no skills") to 5 ("expert"). Figure 1 shows the results of Laurea students for the question Own skills and continuous learning skills. At the beginning of the study module, the student's competence average was 3.07, and the standard deviation was 0.78. At the end of the study period, the student's competence average had risen to 3.76, and the standard deviation was 0.73, so the variance had decreased at the end of the study period.

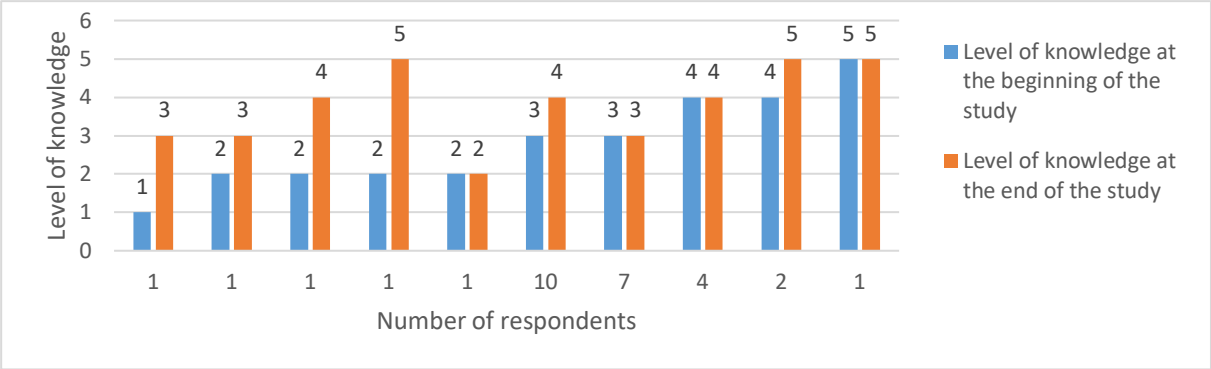

Figure 1. Laurea students' survey results for Own skills and continuous learning skills.

In Figure 1, the x-axis shows how the students' competencies have developed in their opinion during the study module. One student estimated his competence level was at level one at the beginning of the study module. This student estimated his competence level rose to level three during the study module. Seventeen students answered that their competence level was at level three at the beginning of the study module. According to their assessment, ten of these students' competence levels rose to four.

3.2 Haaga-Helia students; surveys results in classified questions

A total of 24 students participated in Haaga-Helia's study module, of which 13 answered the survey. The study module also included students in Haaga-Helia English-degree education, so English was the language of instruction in joint meetings. Still, only one group used English as the working language in group work. The students in the other groups were Finnish and used Finnish to work with the client on the projects.

The corresponding results of Haaga-Helia's students are shown in Figure 2. The average was 2.69 at the beginning of the study module and 3.69 at the end. The standard deviation was 0.99 at the beginning of the study module and 0.46 at the end. The variance also decreased in Haaga-Helia's students' results.

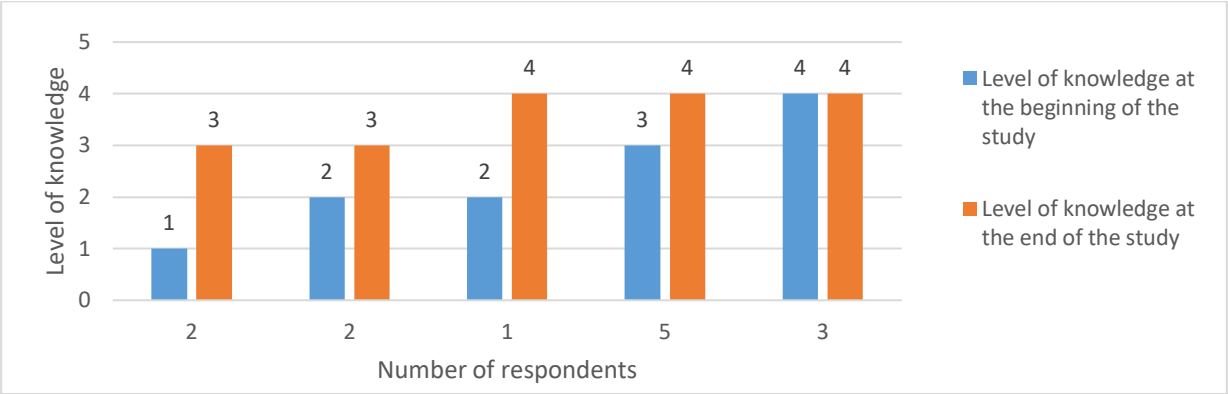

Figure 2. Haaga-Helia students' survey results for Own skills and continuous learning skills.

Figure 2 shows that ten students estimate that their level of competence has increased in this area of competence during the study module. Only three students estimated that their competence level remained the same at the end of the study module. Still, they estimated that their competence level was already level four at the beginning of the study module.

3.3 RGU students; surveys results in classified questions

At RGU, the student survey was carried out twice in the fall of 2020 and 2021. The results of both surveys have been combined and analysed together. In autumn 2020, 12 students participated in RGU's study module, of which only one answered the survey. In autumn 2021, five students participated in the study module, and all answered the survey. The nationality of all the students was British, which certainly impacted some of the study's results.

A total of 17 students participated in these two study modules, but only six of RGU's students answered the survey. Figure 3 shows that three students, i.e., half of the respondents, assessed that their level of Own skills and continuous learning skills had increased, and three students answered that their level of skills remained the same. At the beginning of the study module, the average was 3.00, and the standard deviation was 0.58. At the end of the study module, the average was 3.67, and the standard deviation was 0.47, so the variance also decreased among RGU students.

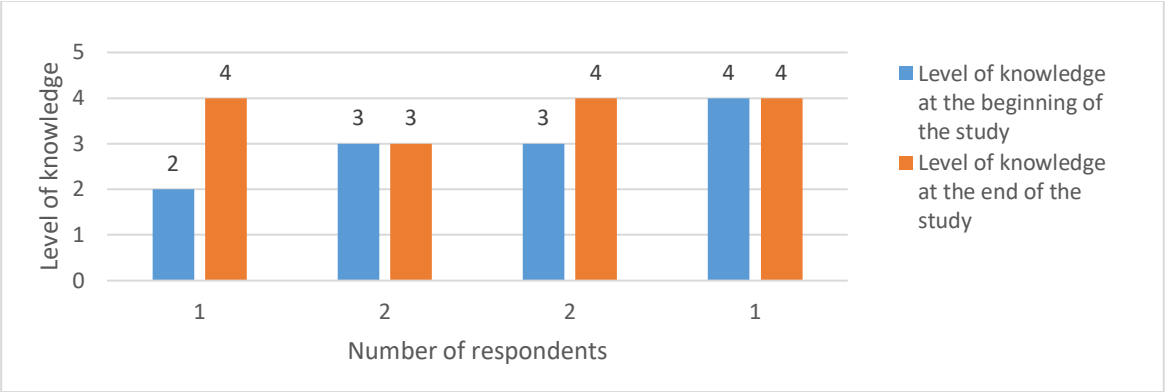

Figure 3. RGU students survey results for Own skills and continuous learning skills.

It can be seen from Figure 3 that three students estimated that their level of competence increased during the study module, and three assessed that their level of competence did not increase at all. At the end of the study module, according to their self-assessment, the competence level of two students was level three, and according to four students, it was four, of which three students had risen to level four.

3.4 Summary of surveys results in classified questions

An interesting observation in all these Own skills and continuous learning skills results is that in all these three institutions, according to the student's self-assessment, students' skills increased relatively much, in Laurea by 0.69 units, in Haaga-Helia by one unit and in RGU by 0.67 units. Out of Laurea's 29 students, 16 students rated their level of competence increased during the study module, of which one student ranked their competence increased from level 2 to level 5 (figure 1). Ten of the 13 students at Haaga-Helia (figure 2) and a half (three) at RGU students (figure 3) estimate their competence level has increased. Based on self-assessment, the competence level of Haaga-Helia and RGU students was at least level three after the study module.

Table 1 shows the mean and standard deviation of the student's self-assessment results for all three higher education institutions for the competence area of Foresight and innovation skills, which was the third competence area. It can be seen from table 1 that for the third question of this competence area, i.e. Technology and digital competence, the students in all three institutions estimate their average competence level before the study module to have been more than three, and after the study module in Laurea 4, in Haaga-Helia 3.92 and RGU 4.5 percent. After the study module, the competence level of all students was three or higher based on self-assessment.

Table 1. Students research results for Foresight and innovation skills competence areas

	3. Foresight and innovation skills				
		Mean at the beginning	Mean at the end	Standard deviation at the beginning	Standard deviation at the end
a. Creativity and initiative	Laurea	3,34	3,97	0,80	0,67
	Haaga-Helia	2,92	3,38	0,83	0,84
	RGU	3,17	3,83	0,69	0,37
b. Co-development and service design skills	Laurea	2,97	3,93	0,85	0,52
	Haaga-Helia	2,38	3,62	1,00	0,62
	RGU	2,83	3,83	0,37	0,69
c. Technology and digital competence	Laurea	3,69	4,00	0,75	0,54
	Haaga-Helia	3,08	3,92	0,92	0,47
	RGU	3,83	4,50	0,90	0,50
d. The ability to change	Laurea	3,45	3,79	0,77	0,48
	Haaga-Helia	3,23	3,77	0,97	1,12
	RGU	3,17	3,67	0,69	0,47

Table 1 also shows that Co-development and service design skills were estimated to be below three on average in all three institutions. Still, according to the self-assessment, this skill level increased the most during the study modules. In Laurea, the level had risen by 0.96 units, Haaga-Helia by 1.24 units, and RGU by one unit.

Students' self-evaluation fifth competence area in the survey was Global expertise. From the research results, table 2 shows that the competence level of both International capacities and Understanding cultural meanings was the lowest for RGU students of all three institutions. This result is probably explained by the fact that RGU's students were all British citizens, and no international students participated in their study module. At Laurea, exchange students from several countries participated in the study module and were involved in all project groups. In Haaga-Helia, international degree students participated in the study module but not in all project groups.

Table 2. Students research results for Global expertise competence areas

	5. Global expertise				
		Mean at the beginning	Mean at the end	Standard deviation at the beginning	Standard deviation at the end
a. International capacities	Laurea	3,17	3,62	0,65	0,55
	Haaga-Helia	2,54	3,00	1,08	1,11
	RGU	2,00	2,33	0,82	1,11
b. Understanding cultural meanings	Laurea	3,14	3,48	0,73	0,68
	Haaga-Helia	2,85	3,08	0,95	1,14
	RGU	2,33	2,83	0,75	1,07
c. Ethical engagement in a global media and technology environment	Laurea	3,21	3,38	0,66	0,76
	Haaga-Helia	2,77	2,85	0,89	0,86
	RGU	2,50	3,17	0,96	0,69

Only a tiny part of the research results is reported here. A more extensive analysis of the research results is still in the works. The studies' results at all three higher education institutions are gathered together and analysed in more detail. The analysis of the results also aims to make comparisons, especially between two Finnish universities of applied sciences. Regarding the research done at RGU, the point of view is slightly different because the starting points and backgrounds are different.

A few research results related to the development of students' skills during the study module have been included in this article. A more extensive analysis of the research results is still in progress. When interpreting the research results, many background factors must be considered, which affect the

reliability of the research and the interpretation of the results. In the student survey, the students evaluated their skills using self-assessment, which affects the results reliability. In all three higher education institutions, the target group was the computer science students' project-oriented study module, in which an IT project was implemented for the customer. However, the projects differed, so skills development varies a lot from project to project. The number of students and the situations was also slightly different in all three places, making the comparison challenging. Laurea's and Haaga-Helia's background factors are pretty similar, and they both collaborate a lot with companies, and the study modules often include real customer projects. RGU also has project-oriented study modules, but their business cooperation is not as common as in Laurea and Haaga-Helia. These background factors greatly influence the use of the pedagogical method according to LbD as the study module's teaching and learning method. In addition to these, research cycles have been implemented in different years. RGU's research cycles were implemented when, due to restrictions due to COVID-19, the study modules were considered online implementations. The research cycle at Laurea was carried out in 2019 before COVID-19, and the teaching took place on campus. Haaga-Helia's research cycle was implemented in the spring of 2022 when the COVID-19 restrictions had already been lifted, and teaching mainly took place on campus as well.

3.5 Students survey answers for free-form questions

Students were also asked in writing what new things or skills they learned during the course. The first question was: What new things and/or skills did you learn during the study module?

The students of all three institutions answered that they had learned various new technical skills or deepened their knowledge during the study module. The students said they learned new technologies, different development methods, software development, configurations of different technologies, better coding skills, and a better understanding of Scrum. In addition to technical skills, the students said they learned many other skills. Here is a list of some examples of those skills: being more proactive, leading and project management, understanding customer needs, international co-working, ethnic perspectives in designing, teamwork skills, communication skills, trust more in own opinions and solutions, planning skills, presentation skills, working with a real company, multitasking and managing time efficiently.

The students were also asked if they understood what LbD means in practice. The scale was 1 ("no understanding") to 5 ("very good understanding"). Figure 4 shows that all of Laurea's students estimate they understand what LbD means in practice. Only two rated the level of understanding as two, and the rest rated the level of knowledge as at least 3. The majority thought the level of knowledge was four, and six students thought they understood the meaning of LbD very well. Most RGU students also estimate (Figure 5) that they understand what LbD means in practice (levels 3 and 4). Only one student assessed that he did not understand LbD at all. Eight of Haaga-Helia's students (Figure 6) estimate their understanding at level three or four. Two students rated their level of knowledge as two, and three students rated that they did not understand what LbD practically meant.

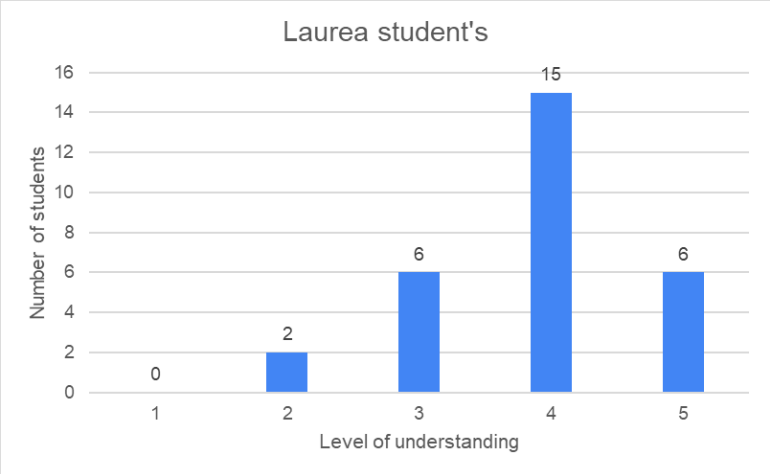

Figure 4. Laurea students' own opinion of understanding the LbD approach in practice.

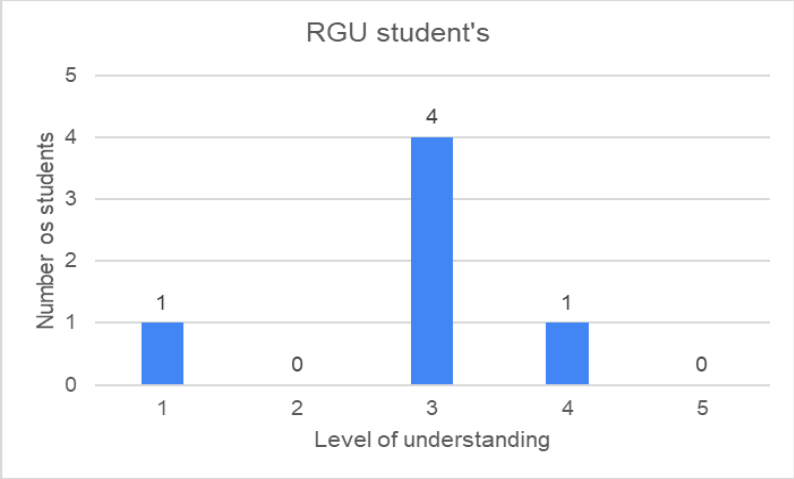

Figure 5. RGU students' own opinion of understanding the LbD approach in practice.

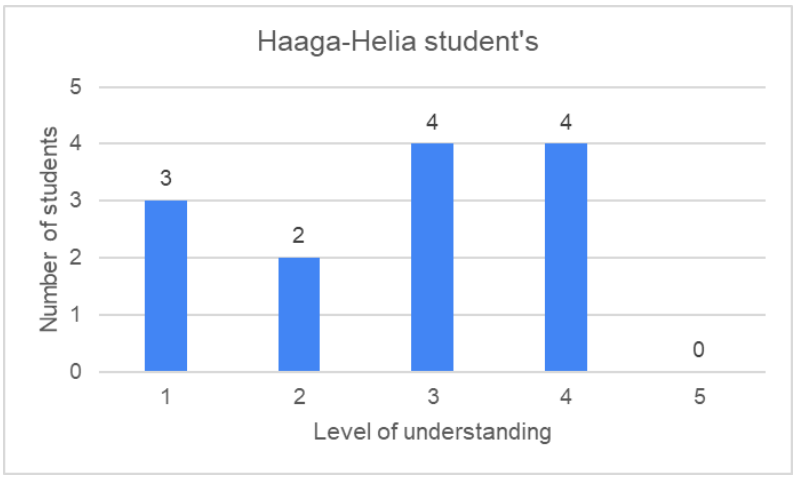

Figure 6. Haaga-Helia students' own opinion of understanding the LbD approach in practice.

Students were also asked to verbally describe what they believe the LbD approach means in practice. The answers to the numerical self-assessments are primarily in line with the verbal descriptions. Students who had chosen a scale value of 1 ("no understanding at all") could not explain in writing what LbD means. Those who chose three or four on the scale could relatively well describe what LbD means in practice. However, a few students wrote that it is learning by doing.

The students were also asked if they think LbD suits computer science studies. One Haaga-Helia student thinks it is unsuitable for computer science studies. One Laurea student and one RGU student have chosen level two for this question. All the remaining students have chosen level three or more. None of the RGU students chose level five. In the opinion of most students, LbD is well suited to computer science studies because the contents learned in it are already applied in practice during the study module instead of studying things only through theory.

According to most students, LbD suits well in computing studies because, in addition to theory, students also learn things in practice and gain experience in real working-life projects. According to the students, LbD supports the learning of skills, and the only way to learn to code is by coding. In the students' comments, it can be seen in many answers that LbD is well suited for this purpose, and someone even answered that LbD should be the primary teaching and learning method. A student who thinks LbD is unsuitable for computer science studies answered, "I literally have no clue what is going on." One student believes that LbD is suitable for computer science studies, but the challenge is that it requires commitment from the participants and the final results depend on their skill level.

Based on the student's answers, it can be concluded that most students felt that the LbD approach is suitable for computer science studies, especially for study modules where client project work is also done. The students thought they learned and absorbed many things better because they could apply what they learned in practice.

CONCLUSIONS

In summary, it can be stated that most students who participated in the survey felt that the LbD approach was suitable for project-based computer science study modules. In the students' opinion, the software development project implemented in cooperation with customers was good for developing their skills. In customer projects, students could apply what they had learned in practice and, at the same time, gain experience in projects related to customers' working life environments. Several students thought that the LbD approach, which combines things learned through theory and their application in practice, is a method that deepens competence.

The students' experiences of the LbD approach were positive, with a few exceptions. The students felt their skills developed in several areas during the study module. In addition to substantive competence, the students' competencies developed in teamwork, customer understanding, communication, and other soft skills. This result strengthens the idea that LbD is also well suited as a teaching and learning method for computer science students, especially when the study module is project-oriented. The survey conducted for students is based on the competencies needed in the working life of higher education students derived from Laurea's 2030 strategy. These competencies are wide-ranging, and many are not directly related to the goals of computer science students' study modules. Even though these general competence goals are not mentioned in the study module's objectives, several students' competence is also developed in these areas.

Based on the research results, creating a new kind of practical guide for the needs of lecturers, students and customers has already been identified as a development target. The creation of a new practical guide has already begun to be outlined, and a project is being planned to produce it, in which three Finnish universities of applied sciences would participate in the first phase. Binkley & al. [14] model has been used as the background frame in the preliminary outline. The new guide is intended to include instructions and tips for all three parties who participate in work-oriented learning projects. The form or implementation method of the new guide has not been thought about yet. However, the idea is that the guide would be both a physical and digital tool implemented during the project.

REFERENCES

[1] K. Raij. Learning by Developing. Vantaa, Laurea, 2007.

[2] K. Raij. Summarising the basis of LbD for further development – review. Laurealaisella väylällä. 2012.

[3] K. Raij. (eds.) (2014). Learning by Developing Action Model. Espoo: Grano Oy. 2014.

[4] K. Ojasalo. Introduction - Learning by Developing in the open networked, digital world in Learning by Developing 2.0 - Case studies in theory and practice. (S. Juvonen, P. Marjanen & T. Meristö eds.), pp. 6 - 13, Helsinki, PunaMusta Oy, 2019.

[5] E. Ferrance. Action Research. Themes in Education. Northeast and Islands Regional Educational Laboratory, Brown University, 2000.

[6] K.S.Taber. Action Research and the Academy: seeking to legitimise a 'different' form of research Teacher Development, 17(2), pp. 288 - 300, 2013.

[7] R. Sagor. Guiding School Improvement with Action Research. Association for Supervision and Curriculum Development. Alexandria, USA, 2000.

[8] J. Whitehead & J. McNiff. Action Research Living Theory. Los Angeles, London, New Delhi, Singapore, Washington DC, Sage Publications. 2006.

[9] J. Eskola & J. Suoranta. Johdatus laadulliseen tutkimukseen. 7. painos. Tampere, Vastapaino, 2005.

[10] N. Frost. Qualitative Research Methods in Psychology. Combining Core Approaches. Open University Press. 2011.

[11] C. Dauite & C. Lightfoot. (Eds.). Narrative Analysis. Studying the Development of Individuals in Society. Thousand Oaks, Sage Publications. 2004.

[12] J. Collins. "The Purpose of Statistical Analysis: Mean & Standard Deviation" sciencing.com. 2002. Accessed 15 April 2022. Retrieved from: https://sciencing.com/info-8515547-purpose-analysis-mean-standard-deviation.html.

[13] Strategy 2030 of Laurea University of Applied Sciences. Accessed 20 September 2020. Retrieved from https://intra.laurea.fi/en/laurea/organisation/strategy/Documents/Laurea%20strategy2030.pdf

[14] M. Binkley, O. Erstad, J. Herman, S. Raizen, M. Ripley, M. Miller-Ricci & M. Rumble. "*Defining twentyfirst century skills" i*n *assessment and teaching of 21st-century skills*. P. Griffin, B. McGaw. & E.Care (eds.), pp 17-66., Dordrecht: Springer, 2012.