Evaluation of an Educational Microcontroller and Workshop from the Perspective of K-12 Teachers

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***Abstract*—Background: With the advancement of technology and its' potential as a tool in educational activities, the transformation of the ways teachers organize and teach in modern classrooms was imposed. Yet, learning new technologies and developing pedagogical activities that incorporate such tools could be a challenge for teachers. Because of the different background knowledge of the participants in this study and also their students, the traditional ex-cathedra approach might not be suitable to promote quality progression, facilitate experimentation and interestingness with the platform, and maintain interest**

Objective: This innovative practice full paper presents a user experience and usability study targeting teachers. The first aim of the study was to investigate the personal experience of teachers and reveal issues associated with the utilization of the platform and materials. On the other hand, the second objective was related to the practical applicability of such in their everyday teaching. Teachers' feedback and recommendations are important for the improvement of the materials to fit the needs of the classroom and to make use of the full potential a platform offers.

Methods: Data collection was conducted during the workshop utilizing an emerging developing microcontroller, VIDI X. VIDI X is a new educational tool that can have ample uses in technology education as a multifunctional microcontroller, a developing board, or as a cluster hub with multiple sensors. The workshop aimed to familiarize teachers with the new learning tool and propose content and pedagogy that could be adapted to the classroom environment. They constituted a basic introduction to electronic components and programming in Arduino IDE. The instructional methodology for the workshop was based on instructional scaffolding. The workbook was organized into lessons with gradually increasing task difficulty. The educators provided instructions when needed to each participant individually. To evaluate the content of the workshop and the microcontroller, a questionnaire was administered immediately after the workshop. The questionnaire comprised: 1) participants' background information, 2) content of the workshop, and 3) VIDI X. User Experience Questionnaire (UEQ) that covers attractiveness, pragmatic, and hedonic quality was utilized to appraise VIDI X.

Results: The analysis of the workshop questionnaire showed that the teachers' liked the workshop and the workbook. Furthermore, the microcontroller and the workbook are suitable for high school students. The analysis of the UEQ showed that the VIDI X was perceived positively on all items, and scales compared to the UEQ benchmark.

Conclusion: As today's students have different prior knowledge in the field of programming, electronics and robotics, the proposed workshop where everyone is progressing at their own pace accompanied with the support of educators, seems to be a good approach to educating in the future.

Keywords—*Computer science education, educational technology, educational innovation, human–computer interaction (HCI), ICT platform, microcontroller, STEM, teacher training, technology-assisted learning, user experience, VIDI X.*

I. Introduction

Recent advances in education have been grounded in the digitalization of education, and the introduction and integration of technology in learning. These advances have yielded a plethora of new educational tools, especially in the field of computer science and electrical engineering education. Because of this, teachers face multiple challenges and pressures to learn and implement technology in their classrooms, which demands ongoing professional development. [1] examines the external and internal challenges that teachers meet when new technology is introduced. Lack of access to technologies, insufficient training, and inadequate support are external factors that influence teachers' ability to introduce new technology in their lesson plans. The internal factors are subjective and vary from teacher to teacher. Still, the pressures and challenges to teaching with technology in the twenty-first century are not limited to these external and internal factors. [2] discuss the difficulties of facilitating creativity through technology in teachers' capabilities. Teachers also face challenges in conforming to modern students' needs. The current students expect a classroom where interaction is similar to the virtual world they have grown up with, requiring faster information rates and visual learning [3]. All these challenges point to a need for adequate teacher training for utilizing emerging educational tools, not only to tackle the complexities of implementing these tools but also the activity design (methodology and content).

One such tool is the microcontroller VIDI X, which entered the market in 2021. Yet, it has already been implemented in several schools in Croatia and many more plan to introduce it in due course. Considering that it was developed as an educational tool, the platform comes with a manual and the additional support available on the project's

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website [4]. The website accommodates users of diverse backgrounds with introductory instructional materials, advanced projects, ideas, and challenges, accompanied by code available on the open-source GitHub repository.

In the scope of this study, teachers were trained to use VIDI X. The methodology of the training was in a form of an instructional scaffolding workshop that was based on utilizing respective introductory instructional materials [5] available on the website. The used materials were created by the third author of this paper. As both the platform and the materials are new, the goal of this exploratory study was to evaluate the teachers' experience with the workshop design (methodology), and the used materials (instructional materials and VIDI X microcontroller). On that note, not only is the user experience a matter of a subjective impression but the factors such as the level of expertise or knowledge, previous experience with somewhat similar products, expectations and preferences can influence the evaluation [6]. Still, this evaluation will benefit developers, teachers, and instructors to better implement VIDI X in education as students also differ in background knowledge and experience.

II. Literature review

Development of open-source microcontrollers and corresponding development kits has become increasingly common in education [7]. Introducing microcontrollers and electronics in K-12 influences university education, but is also dependent on curriculum reforms, availability of tools and teacher training [8]. According to [9], one problem in designing a microcontroller course for university level education is the difference in students' previous exposure to a microcontroller platform. Furthermore, microcontrollers in higher education have been included in different STEM fields, not restricting it to computer science and electrical engineering [10]. Therefore, developing and improving the platform that has been obtained by a significant number of schools in Croatia would benefit microcontroller education from K-12 through university level.

The market for educational microcontrollers is considerable. Furthermore considering that the complexity of microcontrollers increases with the advancement of transistors, rising their speed and flexibility while reducing power consumption and cost they have become more available. Consequentially, [11] propose the following criteria for teachers to choose the right microcontrollers for their students: popularity, availability, pricing, architecture and features, ease of learning, and educational support and tools. While all the above are important, with the introduction of VIDI X to the market and schools in Croatia this part of the problem has been circumvented, still as it is a new product on the market a usability study is needed. Subsequently, Croatian teachers in K-12 mostly face challenges when designing educational materials.

Innovative instructional strategies and educational materials lead when designing lessons that address coding and electrical engineering education [12]. Consequently, studies have observed approaches for restructuring and improving microcontroller courses [8], [10], [12]–[15]. In [8], the authors designed the educational program based on interviews with the students and teachers, as a result converging on a two part pilot educational program consisting of basic theory and expressive practice. With sensory engagement in mind in [10], Arduino learning modules were developed. To take advantage of the students' curiosity the modules taught microcontroller coding by using sensory feedback (LED, loudspeaker). Also in [12] a 10 day extensive, hands-on learning course was designed to encourage students to self-construct their knowledge. While in [10] the modules were developed for a biology students and in [12] for a STEM camp both studies, had similar concepts in their tasks, using sensors to appeal to the students curiosity while gradually guiding them to more complex tasks. Similarly as in [10], the authors of [13] designed a new approach to teaching microcontroller courses that would benefit not only electrical engineering students, but also students from other engineering branches. The motivation behind their proposed approach was to offer a more interesting and versatile course that would not only attract students from the electrical and electronic systems area at their university, but also from the other branches and so would equalize the level of knowledge in embedded systems in higher years. In Malaysia, to complement the traditional approach of direct instruction and lecture, a two day hands-on course was designed [15]. The participants in the study found that even a two day hands-on course helped them gain a much better understanding than direct instruction. The course in [14] was designed to take into account the financial, educational and motivational impact on the students, resulting in a low-level course that introduces students with microcontrollers, hardware and assembler programming.

The literature mentioned in the paragraph above converges toward similar problems when designing educational materials and courses for microcontroller education. The common denominator in these studies is the need to engage and motivate students by designing more interesting and less daunting educational materials and courses. Particularly because microcontrollers are perceived as complex and it can be detrimental to attracting students to STEM fields, especially electrical engineering. Accordingly, our motivation regarding the research questions in this paper was to discover if the designed lessons and novel microcontroller would interest and not further intimidate the students.

III. Methodology

A. Participants

A total of 42 participants were involved in this exploratory study. The participants attended one of the workshops held at three different locations in Croatia. Locations were determined according to the interest of educators to make the workshop more accessible to the audience of interest. All the participants were beginners in terms of working with the VIDI X microcontroller.

Among the participants, 30 work in high schools, 9 work in elementary schools, 1 works in higher education, and two did not answer.

B. Materials

VIDI X microcontroller (Fig. 1) is specially developed for education in schools [4]. It is based on low power dual-core 32-bit ESP32, has an 8 MB flash memory, and 4 MB PSRAM. Its advantage over similar platforms lies in many built-in inputs and outputs (TFT touchscreen, 10 buttons, 3 LEDs, speaker, temperature sensor, IR transmitter and receiver), connectivity support (Wi-Fi and Bluetooth) and storage (SD card). Also, the platform offers the possibility of adding extra sensors and actuators with its 28-pin expansion header. Considering it uses 3,3V logics, it is compatible with available sensors and actuators.

Fig. 1. VIDI X microcontroller.

C. *Workshop*

The workshop was intended for elementary and secondary school teachers and educators from clubs. Since the educators' experience with similar platforms was diverse, the workshop design provided participants with the opportunity to progress through lessons at their own pace over a period of 8 hours which was the duration of this one-day workshop.

The workshop started with a short verbal introduction and explanation of VIDI X hardware, functionalities, and its versatility. Afterwards, the participants were instructed to progress through the instructional materials at their own pace. To make it possible for students to progress independently, instructional materials were in a form of a workbook. The included lessons with short descriptions are given in TABLE I.

Each lesson began with a brief introduction and a solved example that used new commands or new electronic parts. Participants had to rewrite the example on their computers and discover what the program does. Tasks in the workbook are designed to build knowledge gradually, with each subsequent task expanding the previous. At the end of each lesson, teachers were given a project proposal that could be utilized in class with the students to stimulate creativity and further use of the knowledge gained through the lesson.

The workshop was led by three or four facilitators, whose task was to provide technical support and help participants with troubleshooting, examine the correctness of the teachers' solutions and motivate the participants to experiment with additional creative projects that were not assigned in the workbook. Besides, the facilitators provided the participants with guidelines on how to conduct workshops in their schools using VIDI X and similar platforms. Considering the differences in participants' prior knowledge of programming and robotics, which is also true for their students, this problem of today's teaching was approached by encouraging progress at their own pace. By applying this approach, the participants were not stressed by the timeline and were able to gain maximum understanding of the lessons they've solved which facilitated experimenting and thus extended the scope of the workbook.

In general, participants who had more experience with similar platforms solved a few introductory tasks to comprehend the differences between VIDI X and platforms they were familiar with and spent the majority of time on their own ideas, experiments, and projects. In contrast, the beginners solved more tasks from each lesson and thus often went through fewer lessons in total. The percentage of lesson completion is given in TABLE I, and a more detailed analysis is discussed later in the text.

TABLE I. LESSONS IN A WORKBOOK, THEIR DESCRIPTIONS AND COMPLETION RATES.

Label	Lesson name	Description	Completion rate
A	Installation	what to install on the computer and how to test it	100%
B	Traffic light	introduction of programming language, LED programming and how to add additional LED using an expansion header	100%
C	Morse code	if-else conditions and how to use buttons as input elements	100%
D	Piano	usage of pulse width modulation and speaker	94%
E	Temperature	usage of temperature sensor, value range conversion, usage of a serial monitor for monitoring results and debugging	100%
F	Text printing	installation and usage of TFT screen for printing texts	100%
G	Images	usage of TFT screen for printing images	100%
H	Drawing device	usage of TFT screen as a touch device	92%
I	Catch the circle	make a game using the knowledge about the TFT screen	78%
J	IR transmitter and receiver	how to catch an IR signal from a remote control and use it to control the VIDI X	72%
K	Light music	connection and programming of a photoresistor	69%

D. *Research questions*

The following research questions outline the areas of interest for this study:

RQ1: Is there a difference in assessing the difficulty and interestingness level of the workshop for teachers and their assessments for their students based on their own previous experience?

RQ2: Will the professors who found the workshop easier and more interesting assume the same about their students?

RQ3: What is the relationship between difficulty and interestingness level for individual lessons?

RQ4: What do the participants think of a workshop where everyone progresses at their own pace?

RQ5: Based on experience, what do participants think about the educational placement of VIDI X?

RQ6: Based on teachers' user experience evaluation what are the possible areas of improvement for VIDI X?

E. *Research instruments*

Two separate questionnaires were used at the end of the workshop. One referred to the workshop experience, and the other to the platform user experience.

1) *Workshop questionnaire*

The workshop questionnaire consisted of several different sections regarding background information of the participants, lessons, and general questions about the workshop and the workbook. The questions varied between close-ended multiple-choice, Likert items, Likert scales and open-ended questions.

The background information questions were related to the educational level at which participants teach and about their previous interaction with a microcontroller and a microcomputer. The second was assessed with the following questions: *'Do you have a personal experience with Arduino?', 'Do you have an experience with teaching Arduino?', 'Do you have a personal experience with Raspberry Pi?', 'Do you have an experience with teaching Raspberry Pi?'.*

The second part of the questionnaire acquired participants' opinions about each lesson of the workshop. This was accessed by using 5-point Likert items for each lesson, summarized into four Likert scales (TABLE I). The scales referred to the *personal difficulty level*, *perceived difficulty level for students*, *personal interestingness level*, and *perceived interestingness level for students*. The scales regarding difficulty level ranged from 1 (easy) to 5 (hard), and regarding interestingness level from 1 (not engaging) to 5 (very engaging).

The third part of the questionnaire collected the general opinion about the workshop and the workbook. This comprised self-reflection of gained knowledge, opinions about the instructional methodology of the workshop, the workload of the workbook, and VIDI X's placement in education.

2) UEQ questionnaire

To assess the platform (VIDI X) participants were asked to complete a user experience questionnaire (UEQ). Rating occurred immediately after the workshop. This questionnaire consists of 26 items that form six scales. The attractiveness scale is formed with six items, while the perspicuity, efficiency, and dependability scale, considered pragmatic (task-related) quality aspects are based on four items. Also, the stimulation and novelty scale, i.e. hedonic (non-task related) quality aspects, are based on four items [16].

Each of the items in the questionnaire is formed by using opposed semantic dimensions (anchoring attributes) and seven points denoting a continuum of options on a Likert scale. The middle point stands for a neutral impression, while the points toward the ends gradually imply more negative or positive opinions regarding the platform. Amidst the items of the questionnaire, positive and negative attributes are randomly but in an equal proportion positioned on the left and right side of the scale, to minimize answer tendencies [17]. Items formulated with negative attributes on the right side are marked with an asterisk (*) in Fig. 5. Still, to provide a uniform overview of the participants' answer distribution (negative to positive), negative attributes are positioned on the left side and positive attributes on the right side for all the items in Fig. 5.

Although the questionnaire is translated into more than 30 languages among which is the Croatian language, the authors of this paper felt that the original version was not written in the spirit of the language/adequate. Therefore, the English version was used as a reference and the original Croatian version served for additional synchronization to yield a new translation. The procedure somewhat followed the steps proposed by the authors of the questionnaire [18]. At first, the English source version was translated to Croatian by one of the authors. Additionally, after the first step, this author used the original Croatian version for fine adjustments if she considered the original version a better fit. This was followed by a backward translation of this version to English, performed by another author to rule out bias. Deviations between the original English and backward translated English versions were then discussed among all three authors of this paper to reach a consensus and tackle the reliability of the translation.

F. Data analysis

To obtain answers to the research questions, the following analyses were conducted on the collected data.

The data from the workshop questionnaire were summarized with descriptive statistics for RQ1 and RQ2. Additionally, the Likert scales were tested for reliability with Cronbach's alpha. Further, for RQ2 and RQ3 the data were analyzed using Spearman's correlation. A qualitative analysis was used on the open-ended questions to obtain information about the participants' input about the workshop and VIDI X (RQ4, RQ5).

Participants who did not finish all the lessons, could not give their full assessments and the data was interpreted as missing at random. The completion of a lesson was defined as having at least a partial success in solving the specific lesson. The completion rate of the individual lessons is given in TABLE I. Although data missing not at random can be ascribed, no information seemed to be gained, so both where data was missing not at random and at random it was dealt with omission. Taking into consideration missing data, the sample for RQ1, RQ2 and RQ3 was 32 participants.

Regarding UEQ related dataset (RQ6), 6 participants were excluded from further analysis for having three or more inconsistent answers. Inconsistent answers are drawn in relation to random and not serious answers, response errors and misunderstanding of an item. Besides, 1 participant was excluded due to missing data. Therefore, related analysis was conducted on a sample of 35 participants. For the analysis, the UEQ data analysis tool was used. Data was observed in terms of descriptive and interferential statistics.

IV. Results and Discussion

A. Workshop

The first step in analyzing the data for RQ1, RQ2 and RQ3 was to determine the reliability of the Likert scales. Considering that the Likert items in each of the scales were constructed from the lessons, Cronbach's alpha (α) coefficient was calculated for each of the four scales [19]. For *personal difficulty level* Cronbach's alpha (α) coefficient was 0.89, regarding *perceived difficulty level for students* it was 0.88, for *personal interestingness level* it was 0.88, and for *perceived interestingness level for students* it was 0.9. For this reliability test, coefficients with values greater than 0.7 reflect acceptability of internal consistency for Likert scales.

Next, to determine if there is a difference between the perceptions of the groups of participants who had previous experience with Arduino and/or Raspberry Pi (Fig. 2), and those who did not have any previous experience means for the different Likert scales was calculated (TABLE II). Lower means for difficulty level indicate that the workshop was not difficult and well adapted to diverse background knowledge, while higher means for interestingness level might reflect motivation. The results showed that the difference between difficulty level means for participants with different background experiences is negligible. Still, there is a slight difference between interestingness levels (RQ1). This can be a result of the use of Arduino IDE for programming the platform, because the participants with previous experience were already acquainted with the programming in Arduino IDE and the only novelty for them was the microcontroller.

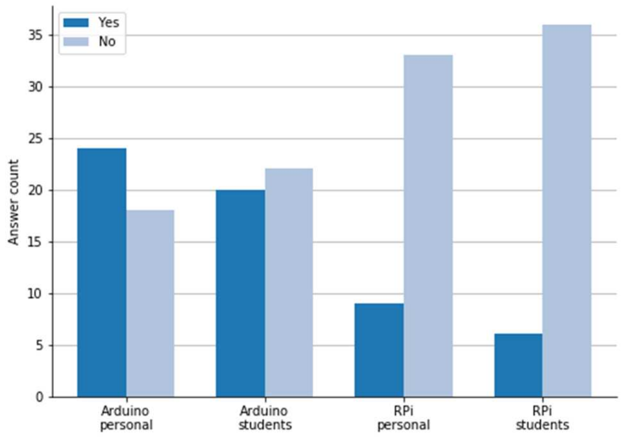

Fig. 2. Distribution of the participants' answers about their previous interactions with Arduino and Raspberry Pi.

TABLE II. LIKERT SCALES MEANS OF DIFFICULTY AND INTERESTINGNESS LEVEL IN RELATION TO BACKGROUND EXPERIENCE (FIG. 2)

Scale	With previous experience	Without previous experience
personal difficulty level	2.113	2.150
perceived difficulty level for students	2.917	2.875
personal interestingness level	4.339	4.750
perceived interestingness level for students	4.256	4.975

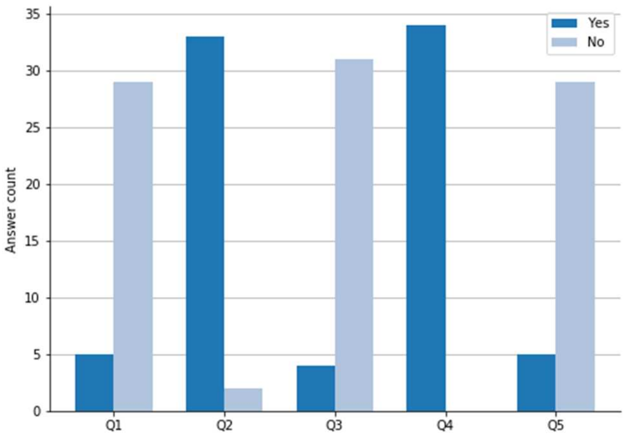

Fig. 3. Distribution of participants' answers to the questions from Table III.

TABLE III. QUESTIONS ABOUT THE INSTRUCTIONAL METHODOLOGY OF THE WORKSHOP WITH RESULTS DEPICTED IN FIG. 3.

Q1	'The workshop would have been better if it had been guided by a presentation using a projector.'
Q2	'I like that the workshop was done without a projector and with the help of workbooks so that everyone could progress at their own pace.'
Q3	'I would have learned more if the lecturers had been with me more often with explanations.'
Q4	'The lecturers came to my aid just enough times.'
Q5	'I expected a workshop that is more guided'

Furthermore, to ascertain the relationship between difficulty and interestingness level in the aspects of personal and perceived, pairwise Spearman's correlation was conducted on the separate Likert items (RQ2, RQ3). The correlation coefficients are calculated for each lesson separately denoted with the labels given in TABLE I. The resulting correlation matrices are given in Fig. 4 with a corresponding legend denoting the coloring of the positive and negative correlation values. Correlation coefficients values can vary between -1 (strong negative relationship) and +1 (strong positive relationship), while values that are close to 0 suggest a weak or no relationship. The correlation matrices show the relationship between difficulty and interestingness for all lessons since a pairwise correlation was conducted, but our research focuses only on the findings about the same lessons in the different aspects. The correlation coefficients between *personal difficulty level* and *perceived difficulty level*, and *personal interestingness level* and *perceived interestingness level* vary between 0.2 and 0.79. Thus, it can be summarized that there is positive correlation between these assessments, indicating that teachers emulate their views about themselves to their interpretations about the students. The strongest positive correlation (0.79) was for interestingness level of lesson G (Images). Therefore, we can assume that the teachers found the interestingness level for themselves and their students to be on the same level. Subsequently, the correlation coefficients between *personal difficulty level* and *personal interestingness level*, and between *perceived difficulty level* and *perceived interestingness level for students* vary between -0.46 to 0.07. Hence, there is no distinguishable relationship indicated between these assessments.

Concerning the input about the general opinion of the participants about the instructional methodology of the workshop (RQ4), the questions given in TABLE III. were analyzed and the results are given in Fig. 3. From the results, we can see that the participants liked the design of the workshop. These results coincide with the results of the participants' overall experience with the workshop. The ratings of the Likert items were 1-5, with 1 as the lowest rating and 5 as the highest rating. Namely, when asked to rate the workshop, 92% used the best rating option (5), followed by the remaining 8% who used the second-best (4). Additionally, when asked to evaluate their gained knowledge 5% answered 3, 34% answered 4 and 61% answered 5.

Regarding the educational placement of the platform, an open-ended question analysis showed that 64% of participants considered VIDI X suitable for high school education, 23% for elementary school, and 13% for both. On the other hand, when it comes to the corresponding close-ended question specifically about the suitability of VIDI X for elementary school, the answers were almost evenly distributed. Namely, 41% of educators answered positively while 59% answered negatively. Lastly, through a multiple-choice question, participants expressed that VIDI X can be used both in informal (94%) and formal (82%) education, indicating versatility in situational context (RQ5).

When it comes to the workbooks' load 91% of participants found the number of lessons appropriate; only 6% answered that there were too many, while the remaining 3% found the coursework insufficient (RQ4). Interestingly, most of the inputs to the item '*List one thing that needs to be fixed in this* *type of workshop*' were that the workshop lasted too long. These results could be related to the duration of the workshop where a potential solution would be to split the workload into multiple sessions. Considering that the workshops require the facilitators to travel across Croatia, in our case it was not possible to extend the timeline of the workshops.

B. VIDI X

Before further analysis, the consistency of the UEQ scales was observed using Cronbach's alpha (α) coefficient and Lambda2 (λ2) (TABLE IV). Low Cronbach's alpha coefficients (e.g., 0.73 for dependability) might be reasoned by a misinterpretation of some items or the irrelevance of the scale to a product. Items forming the dependability scale are 8 (unpredictable - predictable), 11 (obstructive - supportive), 17 (secure - not secure) and 9 (meets expectations - does not meet expectations) (Fig. 5). An example for misinterpretation was specifically acknowledged regarding the item 17 (secure - not secure). Namely, the expected connotation is controllable or not by the user, and not security in terms of e.g., data on social networks [20]. According to the obtained results, the reliability of the used Croatian version of the questionnaire is sufficiently high (α>0.7) for all scales. Still, due to the lowest α coefficient regarding the dependability scale, Pearson inter-item correlations were inspected. Although positively correlated, very weak correlation (<0.2) was noted between items 8 (unpredictable - predictable) and 11 (obstructive - supportive), 8 and 17 (secure - not secure), and 8 and 19 (meets expectations - does not meet expectations). Also, the mean value regarding item 8 was low, namely 0.6. Furthermore, items 11 (obstructive - supportive) and 17 (secure – not secure), and 17 and 19 (meets expectations – does not meet expectations) were moderately correlated (≥0.5 and <0.7), while items 11 and 19 were highly correlated (≥0.7).

The distribution of answers (Fig. 5) showed the most divided opinions regarding the following items: 4 (difficult to learn - easy to learn) having most ratings with a first degree on a positive side of an item, 8 (unpredictable – predictable) having most of neutral ratings, 9 (slow – fast) having most of neutral ratings, followed by the most positive ratings and item 13 (complicated – easy) having most of neutral ratings. On the other hand, items 3 (dull – creative), 7 (not interesting – interesting), 12 (bad – good), 23 (cluttered – organized), 24 (unattractive – attractive), 25 (unfriendly – friendly) and 26 (conservative – innovative), were rated with the most positive options by more than 70% of respondents.

Overall, mean values showed positive evaluations regarding the majority of the items (Fig. 5). Although in a positive category (mean ≥ 0.8), two items showed disparity compared to others by having borderline values, namely item 4 (easy to learn - difficult to learn), and item 9 (fast - slow). Furthermore, a neutral evaluation (-0.8 < mean < 0.8) was obtained for items 8 (unpredictable - predictable) and 13 (complicated - easy).

Referring to the scales (groups of items), means and standard deviation (SD) with the respective width of the confidence interval (Conf, p=0.05) and reliability measures (Cronbach's alpha - α, Lambda2 - λ2) are given in TABLE IV. Regarding the confidence interval, the smaller the value, the more consistent are the answers within the sample regarding the scale constituting items.

Considering the distribution of answers (Fig. 5) related to items 4 (easy to learn - difficult to learn) and 13 (complicated - easy), it is not surprising that the confidence interval of the perspicuity scale showed the least consistent answers within the sample, which might be related to different background knowledge and previous experience of teachers. This was followed by the efficiency scale where item 9 (slow-fast) had the biggest impact on the result.

Best mean related results were obtained regarding the stimulation scale which questioned if it is exciting and motivating to use the platform. This was followed by attractiveness which denotes an overall impression of the product, i.e., did the teachers like or dislike VIDI X. Similar results were retrieved regarding the novelty scale which reflects if a product is innovative. Interestingly, novelty had the lowest SD and confidence interval.

In addition, with respect to the estimated scale means, the maximal proposed sample size for this study across the scales with the precision=0.5, err. prob. = 0.05 was 25. Therefore, the sample of this study (N=35) is enough to reflect this accuracy of measurement on all scales. Also, the sample is adequate for precision=0.5, err. prob.=0.01 regarding all scales besides the perspicuity scale for which a sample size of 39 participants was proposed.

To further evaluate obtained scale means, results were compared to the benchmark [21], a dataset devised from 468 studies (a total of 21175 participants) using UEQ to evaluate different products. In this analysis, VIDI X showed excellent results (in the range of the 10% best results) regarding the attractiveness, efficiency, dependability, stimulation, and novelty scale. On the other hand, concerning the perspicuity scale, VIDI X was rated above average (25% of results better, 50% of results worse). This scale consisted of items hence 2 (not understandable – understandable), 4 (easy to learn - difficult to learn), 13 (complicated – easy), and 21 (clear – confusing). Therefore, this dimension of quality is the most promising for future improvement, followed by dependability and efficiency (RQ6).

As a result, the scales reflecting pragmatic quality (perspicuity, efficiency, dependability) showed a cumulative mean of 1.74 and those reflecting the hedonic quality (stimulation, novelty) the mean of 2.39. Although the non-task-oriented quality was evaluated more positively, taking into consideration the unfamiliarity of teachers with such platforms and the extent of the workshop, goal-related quality results are encouraging.

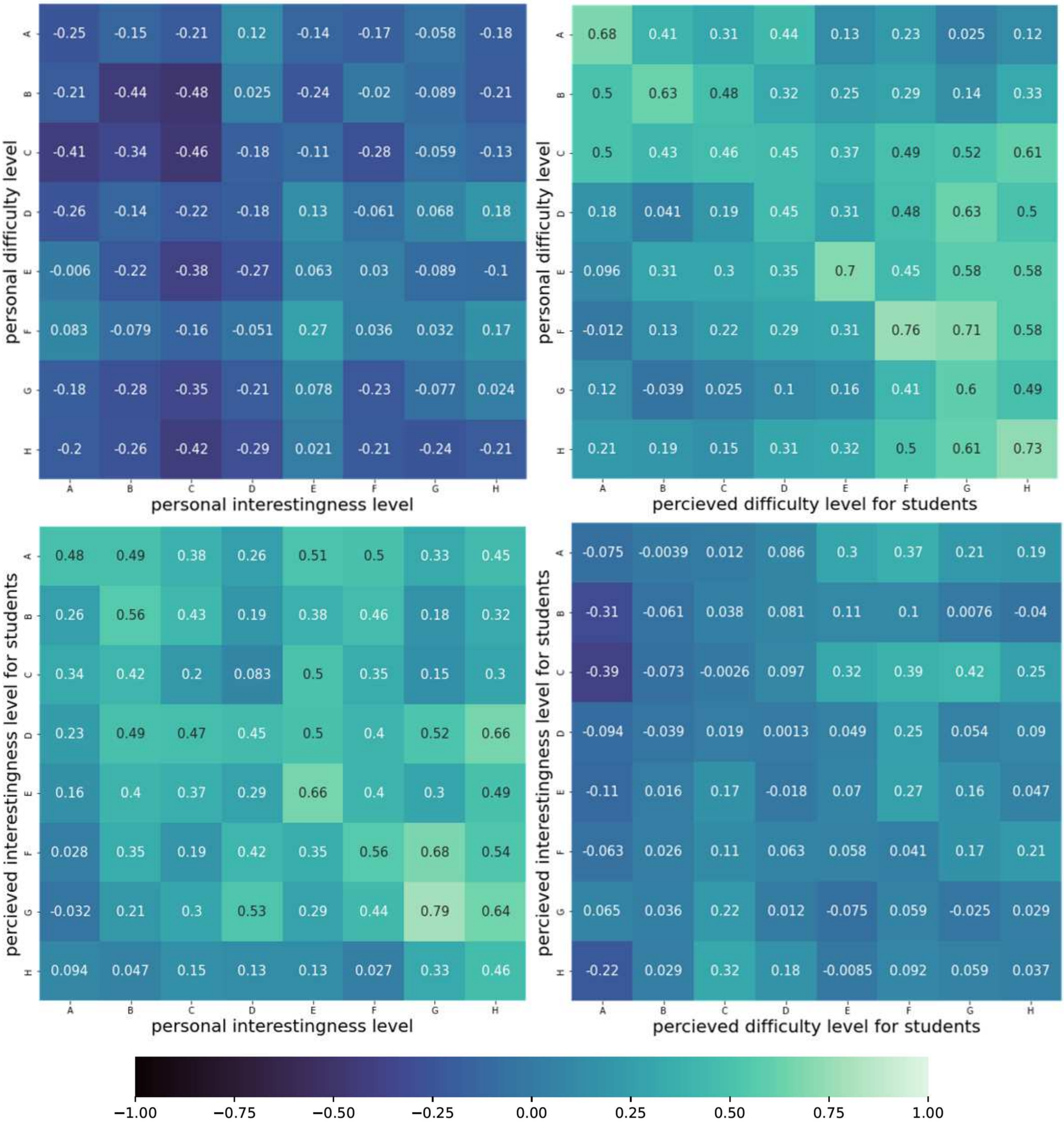

Fig. 4. Spearman's correlation matrices depicting correlation coefficients for the four Likert scales between difficulty and interestingness level. The legend shows the colors depicting the correlation coefficient values, where -1 shows strong negative correlation, +1 shows strong positive correlation, while values around 0 show weak or no relationship. The labels on x- and y- axis (letters A to H) denote observed lessons as given in TABLE I.

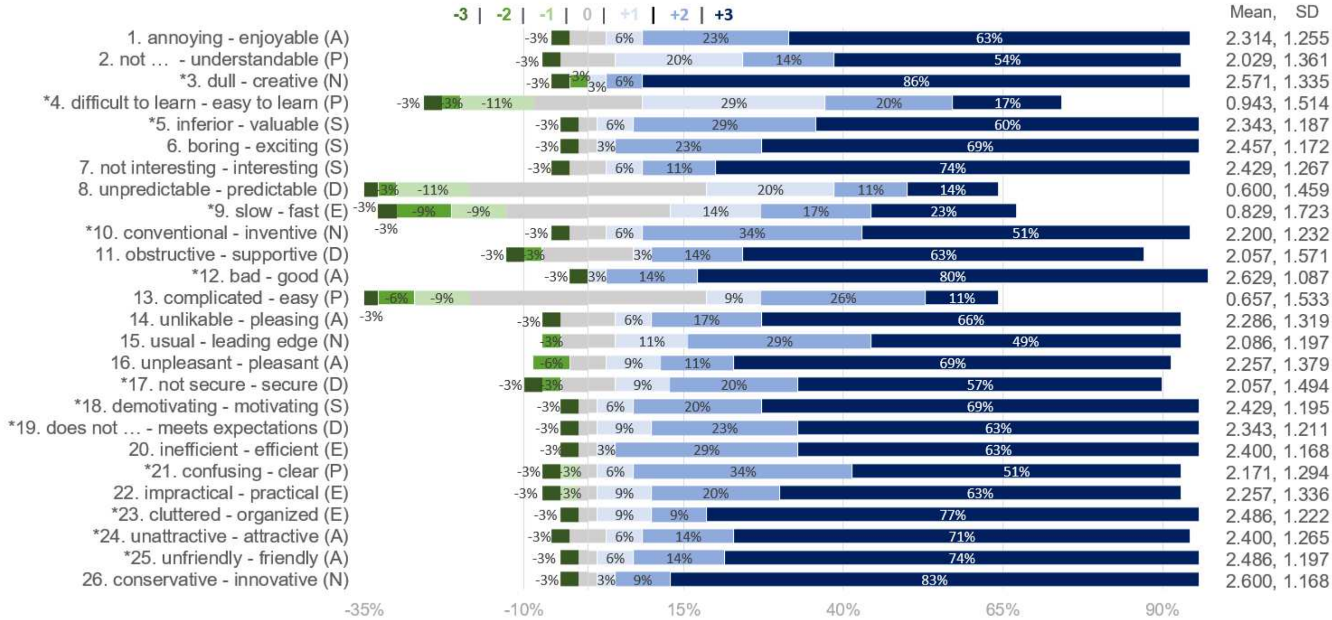

Fig. 5. Distribution of answers per item, and respective mean with standard deviation (SD).
Relation between the items and scales of the UEQ is noted within the brackets:
(A) - attractiveness scale, (P) - perspicuity, (E) - efficiency, (D) - dependability, (S) - stimulation, (N) – novelty.
* UEQ items originally formulated and used with negative attributes on the right side.

TABLE IV. UEQ RESULTS: MEAN PER SCALE WITH RESPECTIVE STANDARD DEVIATION (SD), 5% CONFIDENCE INTERVAL (CONF.) AND RELIABILITY MEASURES (A - CRONBACH'S ALPHA, Λ2- LAMBDA2)

Scale	*Mean*	*SD*	*Conf.*	*α*	*λ2*
Attractiveness (A)	2.395	1.097	0.363	0.94	0.94
Perspicuity (P)	1.450	1.217	0.403	0.88	0.88
Efficiency (E)	1.993	1.146	0.380	0.88	0.85
Dependability (D)	1.764	1.059	0.351	0.73	0.75
Stimulation (S)	2.414	1.116	0.370	0.94	0.94
Novelty (N)	2.364	1.044	0.346	0.87	0.86

V. CONCLUSION

The goal of this exploratory study was to evaluate VIDI X, as an educational microcontroller, the corresponding instructional materials and the teachers' experience with the workshop. The general opinions regarding the workshop and the workbook were positive. Even though there was a lower interestingness level score from the teachers who already have an experience with similar platforms, the overall interestingness level score was satisfactory. Indeed, teachers gained introductory knowledge which will help them in designing their course with VIDI X since most of them already have it in their schools or will have it in the near future. However, from the analysis of the data it can be seen that the workload was slightly overwhelming, not all of the teachers' managed to complete all the lessons. Also, the timeline of the workshop was tiring, as the workload was done in one day. Another insight was that the workbook was not entirely suitable for primary school. Accordingly, future improvement for the workshop would be to lessen the workload over several days, and to develop materials suitable for younger students.

Based on the mean values, the microcontroller was rated positively regarding the majority of the items. Still, the ratings of teachers were cumulatively neutral regarding the items ranging from unpredictable to predictable and complicated to easy. Furthermore, compared to the benchmark dataset, VIDI X was rated excellent on all scales besides the perspicuity scale consisting of the following items: not understandable - understandable, easy to learn - difficult to learn, complicated - easy, and clear - confusing. Therefore, this dimension of quality is the most promising for future improvement.

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