When Choice Doesn't Mean Motivation

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Abstract— **Contribution: This research-to-practice full paper describes a practical application of self-determination theory in microcontroller education and contributes to the field of motivation research on engineering and technology students with respect to microcontroller education.**

Background: Previous research indicates that developing and maintaining student interest and motivation is essential yet difficult in gateway courses that have students from various majors. According to self-determination theory, providing the students a choice in their assignments should build interest in the subject and lead to increases in motivation.

Research Question: This study examined to what extent does providing students a choice in the laboratory assignment they undertake increase intrinsic motivation in the laboratory activities associated with an introductory gateway microcontroller course?

Methodology: Students enrolled in an introductory microcontroller course are given autonomy with respect to the option to select which assignments they completed during their required laboratory activities. A single case pre/posttest methodology was utilized along with the Intrinsic Motivation Inventory (IMI) to collect data about student interest and motivation. Students complete a pretest survey based on the IMI to obtain their baseline values for: interest and enjoyment levels, perception of value and usefulness, the students' perceived competence, the students' perception on effort and importance, the students' feeling of relatedness, and the students' perception of choice and autonomy. The students are then given a choice in the laboratory assignments that they complete as part of the normal laboratory portion of the course. The pretest values were compared to the posttest scores using statistical methods to determine changes in student motivation.

Findings: The key finding of this study is that simply giving the students a choice does not necessarily increase their interest and motivation. There was no evidence of change for the students' interest in the education, their value of the education, or their perceived value and importance of the education when examining the entire class as a whole. It appears that the key factor is how the students actually perceive having choices. The link between the perception of choice by the students and their motivation within courses should be examined in greater detail in future studies.

Keywords— Intrinsic Motivation, Self-Determination Theory, Autonomy in Assignments

I. INTRODUCTION

One of the key responsibilities of instructors is to help the students learn [1]. One of the best ways to help the student learn is by supporting student motivation. Motivation is an important factor in student engagement and learning. When students are properly motivated, it has a major impact on student learning [2]. Motivation typically comes from either an intrinsic or extrinsic source [3,4]. The self-determination theory states that when students are intrinsically motivated, they will be more successful in learning [5].

Self-determination theory is based on three basic humans needs: competence, relatedness, and autonomy [4]. When these three needs are met, intrinsic motivation is built [4]. When self-determination theory is applied to the education setting, the key traits for fostering intrinsic motivation are interest in the education, valuing an education, building personal confidence, and feeling confident about one's ability [4]. Promoting these traits has been shown to increase the quality of learning within the students, leads to better conceptual understanding and personal growth [5].

In order to foster intrinsic motivation within the students and to help the students learn, the self-determination theory was applied to a gateway introduction microcontroller course.

II. BACKGROUND

The target of this study is an Introductory Microcontroller Gateway course that has students from seven different majors enrolled in the course. The students include electrical engineering technology, computer engineering technology, audio engineering technology, energy engineering technology, mechanical engineering technology, mechatronics technology, and robotics engineering technology. Previous research has indicated that it is difficult to build and maintain student motivation in Gateway courses when students from different majors are all taking the same course [6]. What one student finds interesting and/or motivating may not be motivating to other students enrolled in the course [6].

The students enrolled in the Introductory Gateway course were given autonomy to pick their laboratory activities during the last third of the microcontroller course. This selection was designed to allow the students to determine how the course information was applied to solve problems and allowed the students to tailor their education based on their own interests.

The design of the study was based on the key characteristics of self-determination theory and designed to engage the students in the learning and build intrinsic motivation within the students.

III. BRIEF LITERATURE REVIEW

Microcontrollers are taught in virtually all electrical and computer engineering curriculums [7]. Like many other subjects, student motivation can play a major role in the ultimate success of the students studying these devices. Mondragon and Becker-Gomez [8] describe the biggest challenge to teaching a basic microcontroller course is keeping the students motivated and engaged.

The motivation required to complete a task can come from within the individual, intrinsic motivation, or it can come from outside the individual, extrinsic motivation [9]. A high level of intrinsic motivation can influence an individual to invest significant amounts of effort to acquire new skills, overcome challenges, and perform at high levels [10, 11]. Low levels of intrinsic motivation may result in minimal effort being put forth by an individual resulting in minimum expectations being met, and an overall low level of performance being achieved [11]. Intrinsic motivation plays an important role in the educational process [2].

Intrinsic motivation, on the other hand, occurs when the reward for doing the activity is built into the activity itself. Deci et al. describe intrinsic motivation as doing something for the enjoyment of the activity itself, not some sort of reward for doing the chosen activity [4]. They also state that intrinsically motivated students show more enjoyment for academic work when compared to extrinsically motivated individuals [4]. Bohli et al. state that teachers should strive to encourage intrinsic motivation in the academic setting where curiosity drives the learning, and/or the challenging nature of the tasks provides the motivation, and/or the students' desire for mastery of the skills and knowledge is the driving force [12].

According to Ostrow & Heffernan, inventory scales are designed to measure a wide variety of traits and are a common tool utilized to support educational research [5]. The Intrinsic Motivation Inventory (IMI) is one such tool that was developed to support the self-determination theory and has been utilized and validated in numerous studies [5, 13]. In addition to the educational environment, Ostrow and Heffernan state that the IMI has been used for over 30 years in a wide variety of contexts including: "sports, reading, mathematics, language learning, psychiatry, medicine, puzzle completion, computer tasks, and teacher training" [5, pg. 383].

The Intrinsic Motivation Inventory (IMI) survey contains six subsets of questions to determine: 1 - the students' level of interest/enjoyment in an activity, 2 - the students' level of value/usefulness of the activity, 3 - the students' perceived competence in their abilities to do the activity, 4 - the students' level of effort and importance that they place on the activity, 5 - along with the students' level of relatedness to their peers and the instructor in the educational setting, and 6 - the students' perceived level of choice in the assignments that they undertake [5, 13]. The IMI survey instrument is designed to collect a participant's experiences related to an activity and it has been validated and used in multiple experiments designed to measure intrinsic motivation [13, 5].

IV. RESEARCH QUESTION

This paper is focused on one key research question: To what extent does providing students a choice in the laboratory assignment they undertake increase their intrinsic motivation in the laboratory activities associated with an introductory gateway microcontroller course?

V. METHODS

A. Study Design

A single-group pretest/posttest design methodology was utilized to study the impact of providing the students with a choice in assignment during the last third of an introductory microcontroller course. A single-group design was chosen as the belief was that the intervention was an important improvement in the educational environment and that all of the students in the course would benefit from having the opportunity to pick which assignment they wanted to undertake [14]. The design of the target course also did not allow for students to be randomly assigned to a control and experimental group which is somewhat common in many educational settings where intact groups must be used [15].

B. Study Context

The laboratory portion of the course was broken down into three phases. The first phase encompasses the first three weeks of the semester and is based on basic information such as how to utilize the compiler and download code into a microcontroller. The second phase spans between week four and week nine of the semester where the students learn foundational skills such as input and output operations, decision making, and interfacing with hardware. The last phase of the course runs for five weeks and is focused on small-scale practical applications and are known as the "choice labs" where the students are able to select one of six laboratory activities. The choice labs allow the students to select a project that is based on traditional microcontroller activities, one based on robotics, one based on green energy, one based on the entertainment and audio sector, or one that is targeted towards mechanical engineering technology students. The options are designed to allow the students to tailor their learning activities based on their own interest and allows the students autonomy and ownership of their education, a key trait of self-determination theory.

C. Data Sources

Data for this study was collected through the IMI (Intrinsic Motivation Inventory) survey instrument. The IMI survey contains multiple scales that are designed to determine a student's level of interest in the education, the student's value of the education, the student's perceived competence, the student's perceived level of effort and importance they place on the education, and the student's feeling of relatedness to their instructor and peers [13]. The survey itself was administered through Qualtrics where the students indicated their responses to each of the questions using a 7-point Likert scale. The students complete a pretest survey during week 9 of the semester which corelates to the last of the foundation labs and the week before the students are given a choice in which laboratory

activity they undertake. Then, the students complete a posttest survey at the end of the semester after they have completed the choice laboratory activities.

D. Data Analysis

Once the data was collected, it was analyzed for missing scores, duplicate entries, and valid responses in a process similar to that described by Ostrow and Heffernan [5]. In the event of duplicate entries, the first complete entry was taken and any other duplicate entries were deleted from the data set. Reverse scored items were then processed and student pretest and posttest scores were aligned. A total of 88 students completed the pretest survey while 89 students completed the posttest survey. However, only 78 students provided both pretest and posttest surveys. Ultimately, only the 78 matched data sets were utilized for the final analysis. Once the preprocessing was completed, the data was loaded into SPSS for processing and analysis.

The complete data sets for both the pretest and posttest values were analyzed for internal consistency by calculating Cronbach's Alpha for each data set [5,16,17]. The results for the internal consistency are shown in table 1. General guidance on Cronbach's Alpha states that values below .6 are poor, value between .6 and .7 are questionable, values between .7 and .8 are acceptable, values between .8 and .9 are considered good, and values above .9 are considered excellent [16]. The results from the study data are consistent with results from other studies based on the IMI survey and fall into acceptable, good, and excellent categories as describe by Lewis et al. [16]. The lone exception to this is the internal consistency for the pretest choice scale. At the time of the pretest survey, the students did not yet have a choice in assignment so this scale has no true meaning to the students and a low consistency value is expected.

In order to determine how the student responses changed between the pretest and posttest scores, a paired analysis was needed. In order to determine which paired test was the most appropriate, the data was analyzed for normality through a Shapiro-Wilk test, along with analysis for skewness and kurtosis using SPSS along with a visual inspection of the data.

Table 1. *Cronbach's Alpha Calculations*

IMI Subscale reliability

	Pretest (n =88)		Posttest (n=89)
Scale	# Items	α	α
Interest and Enjoyment	7	.914	.911
Value and Usefulness	7	.898	.941
Perceived Competence	6	.891	.822
Effort and Importance	5	.772	.789
Relatedness	8	.818	.889
Perceived Choice	5	.350	.814

The Shapiro-Wilk test, along with skewness and kurtosis was performed on both the pretest and posttest data, along with the difference between the pretest and posttest values for each scale since the actual analysis is conducted using the difference between the scores [14].

The results of the analysis indicated that the data for this study is not normally distributed, contains outliers, and is skewed. Since that data violates the assumptions for a parametric analysis, a non-parametric test was required. A Wilcoxon signed-ranks test was utilized to compare the pretest and posttest values for the key variables in this study. The Wilcoxon signed-ranks test does not require the data to be normally distributed and has been used in other studies where data was collected through the IMI to compare pretest and posttest values [18,19,20].

VI. Results

In order to conduct the analysis, the pretest and posttest scores for each student were aligned. Students with missing data (either missing the pretest of posttest survey) were removed from the data set leaving a total of 78 complete, matched data sets. Once the data was aligned, the pretest and posttest survey results were compared using a Wilcoxon signed-ranks test. The results of the tests are shown in table 2.

The students' pretest and posttest results were compared after the students were given a choice in their laboratory assignments. A Wilcoxon signed-rank test indicated that the difference in the Interest in Education scale were not significantly different, W = 1338, z = -1.24, p = .214, with (Mdn = 5.8571) before having a choice and (Mdn = 5.7252) after having a choice. The Wilcoxon signed-rank test also indicated that there was not a significant difference for Value of the Education W = 1101, z = -1.11, p = .265, with (Mdn = 6.2857) before and (Mdn = 6.4285) after having a choice, and that there was not a significant difference in the Perceived Effort W = 1227, z = -1.02, p = .310, with (Mdn =6.2000) before and (Mdn = 6.3000) after having a choice.

By contrast, the Wilcoxon signed-rank test indicated a significant change in the students' Perceived Competence W = 1814, z = -3.07, p = .002, with (Mdn = 5.5000) before and (Mdn = 5.6667) after having a choice, with a medium effect size of r = .35; a significant difference in the students' reported Relatedness W = 1527, z = -3.27, p = .001, with (Mdn = 5.9375) before and (Mdn = 6.0000) after having a choice, with a medium effect size of r = 0.37; and a significant difference in the students' Perception of Choice W = 2983, z = -7.53, p = <.001, with (Mdn = 4.2000) before and (Mdn = 5.8000) after having a choice, with a large effect size of r = 0.85.

Table 2. *Wilcoxon Signed-Ranks T Test*

Test Statistics based on Negative Ranks

	Z	Asymp Sig. (2-tailed)	Effect Size
Post – Pre Interest	-1.244	.214	.14
Post - Pre Value	-1.115	.265	.13
Post - Pre Competence	-3.074	.002	.35
Post - Pre Effort	-1.015	.310	.11
Post – Pre Relatedness	-3.268	.001	.37
Post – Pre Choice	-7.529	<.001	.85

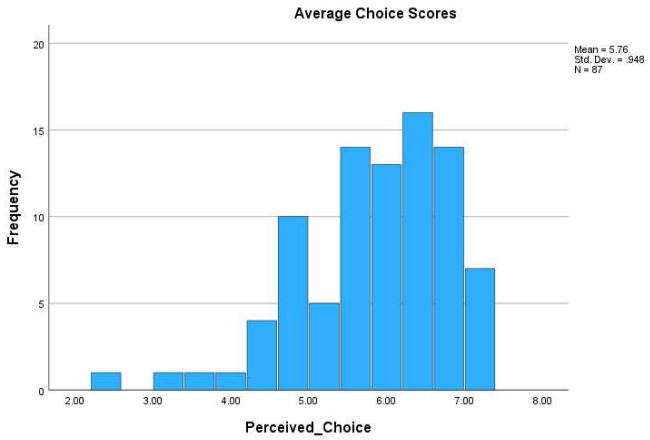

Fig 1. Average Perceived Choice Scores for the Students

VII. DISCUSSION

At a first glance, the overall results indicate that providing the students with a choice in laboratory assignment did NOT accomplish the goal of increasing the students' intrinsic motivation as described by the self-determination theory. When analyzing the entire class as a whole, there was no significant increase in the students' interest in the education, nor was there a significant increase in the students' value of the education or the students' perceived effort and importance of the education. These results are in direct contrast to the expected results as described by the self-determination theory. The results do indicate that the students' perceived competence, relatedness, and perception of choice do significantly increase between the pretest and the posttest scores.

However, it is important to note that the students' intrinsic motivation also did not drop! Many studies have reported that student interest and motivation drop during the last half or third of the semester and that was not seen in the data collected during this study. While providing the students a choice in assignment did not raise their interest and motivation compared to the middle of the semester, it appears that giving the students a choice did prevent their overall motivation from dropping, when examining the class as a whole, which is an important finding.

A closer inspection of the data also revealed that not all of the students perceived that they had a choice in the same way or at the same level. The average perceived choice scores from the posttest IMI survey are shown graphically in figure 1. This data clearly shows that some students truly felt that they had a choice while other students did not, or at least felt they had a lower level of choice.

A follow-up analysis was conducted by utilizing the students' posttest perception of choice scores to group the students into categories. Once the students were grouped into these classifications, the follow-up analysis indicated that the students that had a higher perception of choice did show significantly higher levels for interest in the education, significantly higher levels of perceived value of the education, and significantly higher levels of perceived effort and importance of the education.

A follow-up Wilcoxon signed-rank test for only the students with a high perception of choice indicated that the difference in the Interest in Education scale were significantly different, W = 268, z = -2.65, p = .008, with (Mdn = 5.9313) before having a choice and (Mdn = 6.2252) after having a choice. The Wilcoxon signed-rank test also indicated that there was a significant difference for Value of the Education W = 173, z = -3.19, p = .001, with (Mdn = 6.4203) before and (Mdn = 6.6456) after having a choice, and that there was a significant difference in the Perceived Effort W = 268, z = -2.331, p = .020, with (Mdn =6.2692) before and (Mdn = 6.4192) after having a choice.

VIII. KEY FINDINGS AND APPLICATION

When applying motivation theories, it is important to look at how the students perceive the intervention, not whether or not an intervention existed. The results of this study serve as an indicator that further research into how students perceive interventions is warranted along with more research on how students should be grouped or compared for analysis.

The overall results of this study represent a positive outcome. While student interest and intrinsic motivation did not increase during the last third of the course, it also did not decrease which is a significant finding. Furthermore, when factoring in how the students perceived choice, the students that indicated a high level of perceived choice (about 2/3 of the students in the course), did report a significant increase in their interest in the course materials and an increase in their intrinsic motivation towards the course.

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