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The Effects of Learning Styles and Perceptions on Application of Interactive Learning Guides for Web-based Courses

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BACKGROUND
As the great deal of courses provided online increases rapidly, it is crucial for instructors to identify specific learner characteristics of successful online students. An analysis of the relationship between learning styles, perception, interactive learning mode and course achievement will offer administrators with the vital information they need to prepare courses that cater to the needs of learners involved. Little research exists on how robot engineering students learn in different learning environments. Despite literature on the effectiveness of online instruction, little is known about the influence of learning styles and perceptions in online interactive learning.

PURPOSE
This research investigated the effects of learning styles on learner perceptions of the use of interactive learning guides (ILGs) for web-based courses. This research reported on a study that compared an online group of juniors mechanical engineering majors with an equivalent on-campus group to found if their individual learning styles play a role in the selection of course delivery mode and in their academic achievement.

DESIGN/METHOD
The present research was undertaken using as subjects third-year robot engineering majors, 90 of which were enrolled in the online portion while the remaining 95 were enrolled in the face-to-face portion of 'Introduction to Robot Engineering'. Meanwhile, the Kolb Learning Styles Inventory (LSI), a statistically reliable and valid questionnaire, in which respondents attempted to depict their learning style, was administered online to student groups 1 week after the start of the course. The format of the LSI is a forced-choice format that ranks an individual's relative choice preferences among the four modes of the learning cycle: concrete experience (CE), reflective observation (RO), abstract conceptualization (AC), or active experimentation (AE). Combining the scores of the four learning modes and following the formulas [AC]-[CE] and [AE]-[RO] results in two combination scores. By sketching the combination scores a grid and identifying the quadrant where the two scores intersect, one can determine a specific learning style from among the four styles.

RESULTS
The author found no significant statistical differences were detected in learning styles and learning performance between the two groups. In addition, significant main effects for both gender and learning style, and gender and the perception of utility. The relationship between learning styles and gender was statistically significant.

CONCLUSIONS
Based on the results of this research, there are several important issues indicated: (1) the online classroom, either as a sole instructional way or as a complement for on-campus learning, provides the tools to address different learning styles. Because learners in the F2F or online classroom do not differ in the way they process information, the same learning activities could be designed and utilized in both environments. (2) Instructors may want to consider providing ILGs in their campus-based courses as supplemental materials and make their use optional. These types of ILGs may also be helpful to online learners. Regardless of the learning which they are implemented, the design should be consistent and user-friendly. (3) Understanding their learning styles, students can effectively choose the tools that will add the most value to the learning experience.

KEYWORDS
Interactive learning guides, Learning styles and perceptions, Media in education.

Introduction

Interaction can either be about the classroom (and take place in a face-to-face context) or be an integral part of the online system (and take place in a virtual context). In the latter case, several multimedia tools can be used to create interactive instructional material that includes more than static text and graphics (Birch and Sankey, 2008). The use of interactive multimedia can make learning more pleasant and offers learners a chance to explore and construct their own knowledge actively. Online interactive multimedia resources can provide learners with abundant, interactive learning environments that appeal to different learning styles (Birch and Sankey, 2008).

Furthermore, the non-linear access of the different types of online digital resources allows learners to take control over the learning process, engage in social interaction and dialogue, develop multiple modes of representation, and become more self-aware (Battalio, 2009). However, the freedom and flexibility provided by the online environment have as a side effect that many learners are pursuing online learning opportunities only for the sake of convenience without any real consideration of the appropriateness of this delivery mode for their individual learning styles. The current literature does not rule out the possibility that there may be only certain types of students who can successfully learn via the online format (Meyer, 2003). Meyer stated students with a more independent learning style, greater self-regulating behavior and the belief they can learn equally well through this modality are more successful in the online environment. An analysis of the relationship between learning styles, perception, interactive learning mode and course achievement will offer administrators with the vital information they need to prepare courses that cater to the needs of learners involved. Little research exists on how robot engineering students learn in different learning environments. Despite literature on the effectiveness of online instruction, little is known about the influence of learning styles and perceptions in online interactive learning (Battalio, 2009).

Literature Review

A number of multimedia software applications can be used to incorporate visual, verbal and kinaesthetic learning into online instruction. The integration of vide-based simulations allows learners to control the sequence and step of the instructional material in a way that benefits them. Some individuals may learn better when they can handle the step of presentations. Despite many multimedia software applications have been applied in developing interactive learning guides or tutorials as online supplements, each type of multimedia application offers a unique benefit to learners. Different forms of media can influence learning based on the capability of the media and the methods they employ. The proper interface of interactive learning guides can assist in obtaining students' attention (Meyer, 2003). The application of interactive learning guides seem to have a positive effect on learning and the overall improvement on the learners' level of understanding of learning contents (Budka, Schallert, and Mader, 2011). The researchers report a significant relationship between the utility, level of understanding and non-linear navigation.

On the other hand, several learning style instruments or inventories can be used to assess individuals' learning styles. They vary in format, length and complexity, and no instrument can capture all of the richness of the phenomenon of learning styles (Santo, 2006). Grounded on experiential learning theory, Kolb's model of learning styles has survived examination and criticism over the years and is used extensively to categorize the way learners take in and process information in traditional or web-based environments. Fleming (2011) proposed the VARK inventory in 1987 was provided metrics for each of four perceptual modes – visual, aural, read/write, and kinaesthetic. An individual's preference may range from a single mode to all four modes. In addition, a number of studies have examined the association between students' learning style and the selection of course delivery format. The implementation of interactive learning guides can also provide an

alternative method of delivering instruction and can accommodate different learning styles. Terrell (2002) investigated the participants, majoring in Computing Technology in Education, using Kolb's model of learning styles during their coursework in an online learning environment and showed that learning style determines preference for online delivery format. Participants with a preference for convergers and assimilators (AC) preferred online learning and were more likely to succeed than students preferring divergers and accommodators (CE).

The aforementioned studies generate inconsistent empirical evidence that fails to demonstrate convincingly the relationship between learner learning style, perception, preference for interactive learning guides (ILGs), and learning achievement. Therefore, using data from a robot engineering course that had an online and a traditional section, the author examined the following research questions: (1) Is there a relationship between a students' learning style and the selection of course delivery format? (2) Is there a difference between the course grades of students based on their learning style? (3) What are participants' perceptions of the utility, accessibility, user interface, and learner performance of the ILGs? (4) Do learning styles and gender have any effect on the survey phases? (5) Are there any differences in participants' responses to survey questions depending on learning styles of students?

Methodology

Course content and organization

The present research was undertaken during the 2011 fall semester using as subjects 185 third-year robot engineering majors, 90 (50 males and 40 females) of which were enrolled in the online portion while the remaining 95 (65 males and 30 females) were enrolled in the face-to-face portion of 'Introduction to Robot Engineering'.

In its traditional format, the course is taught during a sixteen-week period with two 50-minute lectures and one 2-hour practice session each week. The two weekly lectures are in the traditional style with short presentations which are based upon carefully prepared examples that illustrate key concepts, and in-class manipulation exercises which provide scaffolded practice opportunities for experimentation, feedback, and reflection. In each practice session, a sample project is given to students to run and see how things work, and then they are asked to modify the parameters and extend the functionalities of the program.

The course website on Moodle LMS supplements classroom instruction by providing students with access to all lecture material, practice units, homework assignments, study guides, and discussion boards. Using the online environment students can choose to view a recorded lecture or access several ILGs (five demonstrations and three simulations) in Moodle LMS throughout the semester in order to review the lessons. The guides were embedded Flash files that had been developed and composed of screen captures with audio. The simulations prompted students to click on certain menu items and icons, and enter text in predetermined areas.

The participants in the online group were taught by the same instructor, used the same online resources and lecture contents, submitted the same homework and project assignments, and took the same exams as their on-campus counterparts. The extra facility they had in their disposal was one instructor-led online session every 2nd week via Microsoft NetMeeting, in which they could see and hear the instructor commenting on their project and answering questions. Online members could not use face-to-face office hours to access the instructor. Instead, their office hours and lab support was facilitated by Moodle through email and group blogs.

Meanwhile, they were also required to complete a Webquest assignment with the use of Microsoft Office®. Instructors used several class sessions to discuss manipulation issues,

demonstrate the assembly programs and provide students with time to work on the project during class time in a computer integrated manufacturing lab. After the Webquest assignment was submitted for grading, participants were asked to complete a paper-based questionnaire. Although both groups could participate in the classroom discussion lists and post their questions and answers, online students could not use F2F office hours to access the instructor. Instead, their office hours and lab support was facilitated by Moodle through email and group blogs.

Data collection and instrumentation

The Kolb Learning Styles Inventory (LSI), a statistically reliable and valid ten-item questionnaire, in which respondents attempted to depict their learning style, was administered online to student groups 1 week after the start of the course. The format of the LSI is a forced-choice format that ranks an individual's relative choice preferences among the four modes of the learning cycle: concrete experience (CE), reflective observation (RO), abstract conceptualization (AC), or active experimentation (AE). Each item in the LSI has four possible answers, and the respondents are asked to rank order these answers starting with a 'four' for the answer that best depicts their learning preference down to a 'one' for the answer that seems the least like the way they would learn. Combining the scores of the four learning modes and following the formulas [AC]-[CE] and [AE]-[RO] results in two combination scores. By sketching the combination scores a grid and identifying the quadrant where the two scores intersect, one can determine a specific learning style from among the four styles. Meanwhile, a correlational design was used to collect data and decide if there was a difference in learning styles of online versus on-campus participants. The learning styles of the participants were compared using a two (online or traditional instruction) × four (converger, diverger, accommodator and assimilator) chi-square test of independence with a significant level set at 0.05. In addition, a full factorial ANOVA was performed to see if a particular learning style could predict success (course grade) in the course. Course grade was derived from ten home work assignments, two group projects, midterm exam, and the final examination.

On the other hand, the participants in online group completed the online VARK learning style inventory (2011) and the student perception questionnaire developed by the author. Fleming (2011) reported that fifty-eight percent of individuals believe that VRAK profiles match their perception, thirty-eight percent do not know and four percent indicate that the profile does not match. Several studies also have utilized the instrument (Wehrwein, Lujan, and DiCarlo, 2007; Zapalska & Dabb, 2002). The student perception questionnaire was composed of twenty Likert-scale items. The rating scale of the survey ranged from strongly disagree, 1, to strongly agree, 5. The questions were generated based on existing literature regarding students' perceptions of the use of multimedia instruction (Burke and Karen, 2008). The survey was composed of four phases: utility, accessibility, user interface, and learner performance. The questionnaire was review by a psychometric expert. In order to determine the reliability of the instrument, the internal reliability coefficient was calculated (α=0.86).

Ninety members completed both the VARK inventory and perception questionnaire. Each student's learning style result was recorded by capturing the highest score in a particular category: visual, aural, read/write or kinaesthetic. The participants with the same score in two or more categories were categorized as multimodal. During the second round of the data analysis phase, the members were reclassified according to Fleming's learning modalities: unimodal, bimodal, trimodal or multimodal. The students' modality preferences were calculated based on the research algorithm depicted by Fleming (2011).

Results

Traditional group v.s. online group

Descriptive statistics of the Kolb's LSI and students' course grades for both delivery formats are shown in Table 1. From these data it is apparent that the predominant learning styles in the traditional group were the Diverger (35%) and the Assimilator (37%), while in the online group most participants fell into the Accommodator (35%) and the Assimilator (38%) learning styles. The students with Assimilator and Accommodator learning style feel more comfortable taking online instruction (Federico, 2000), and the traditional students tend to be assimilators (Buerck, Malmstrom, and Peppers, 2003). Students with the Divergent learning style performed the best in the online environment, in agreement with the findings. While students with the Assimilator learning style were almost equally distributed between on-campus and online groups, Convergers in the F2F group and Divergers in the online group performed the best. Accommodators in the traditional group performed as well as Divergers, while the online group performed the best. To determine the answer to the first research question, a Pearson chi-square test was used to investigate the relationship between participant learning style and preference for online or F2F instruction. The results of this inferential test were non-significant, (3, 185) = 3.501, $p = 0.298$, suggesting that participants' learning style did not influence their selection of taking instruction in either a F2F or online format. This finding is consistent with the results of the previous several researches (Oh and Lim, 2005; Ross and Bell, 2007).

Table 1: The lists of the Kolb's LSI and course grades for two groups

Dependent variable: grade						
	Traditional			Online		
	N	*Mean*	*SD*	*N*	*Mean*	*SD*
Assimilator	36	69.01	22.65	35	65.57	18.36
Accommodator	12	66.63	21.15	32	70.48	19.64
Converger	13	73.94	20.46	10	64.25	19.81
Diverger	34	68.35	20.57	13	70.61	17.58
Total	95	68.66	21.22	90	67.80	18.86

Based on the results of participants' preferred learning style and their course achievement, a full factorial ANOVA (as shown in Table 2) was conducted to answer the second research question of this research. The second research question examined whether students' learning style influenced their academic performance (i.e. course grade) differentially contingent on whether they took the course in either a F2F or an online delivery format. The results revealed no significant difference in students' course grades between F2F and online group, $F(3, 176) = 0.687$, $p > 0.05$. This result is in accordance with the findings of the research conducted by Ross and Bell (2007) and Brittan-Powell, Legum and Taylor (2008).

Table 2: Results of a full factorial ANOVA

Source	SS	*df*	*Mean square*	*F*	*Sig.*
Corrected model	1334.264[a]	7	184.421	0.378	0.768
Instructional method	121.464	1	121.464	0.328	0.485
Learning style	984.548	3	328.248	0.687	0.475
Instructional method* Learning style					
Learning style	271.104	3	87.436	0.224	0.768

[a] R squared = 0.054 (adjusted R squared = 0.018)

Online group

Several one-way analyses of variance (ANOVAs) and factorial analyses were conducted to examine whether gender or learning styles had significant interaction with, and effects on, the four survey phases. Chi-square tests of association were performed to decide if the

relationships between learning styles and gender, and responses to questions existed. As for the learning styles in online group, the participant were classified into the following learning styles: auditory (24.7%), read/write (21.8%), kinaesthetic (21.5%), visual (12.6%) and multimodal (19.4%). Then, the participants were reclassified into four learning style modalities: multimodal (29.5%), trimodal (0%), bimodal (29.5%), and unimodal (41%).

The third research question aimed to find out what are participants' perceptions of the utility, accessibility, user interface, and learner performance of the ILGs. Several items on the questionnaire had a mean score of four or higher. Table 3 shows the mean scores and standard deviations of participant perceptions of the utility of the ILGs. The majority of the respondents agreed or strongly agreed with item 2 (89.3%) and item 1 (86.2%). Several items on the accessibility scale gave mean scores above 4.0. Many of the respondents agreed or strongly agreed with items 7 (96.1%), 9 (92.3%), 6 (91.1%). The majority of the participants (88.4%) disagreed or strongly disagreed with item 13, a negative item. The second highest mean score (M = 3.90) of the user interface scale was scored on item 15; most of the respondents (81.3%) agreed or strongly agreed with this item. None of the items on the learning performance scale had an M score at, or above, 4.0. Eighty-two percent of the participants agreed or strongly agreed with item 17, and the majority (77.3%) agreed or strongly agreed with item 16. Nearly 53.4% of the respondents agree or strongly agreed with item 20. Hence, the respondents' perceptions varied relatively for questions on this scale. The overall mean score of participants' perceptions of the accessibility scale (M = 4.21) was the highest, and the user interface scale received relatively high ratings. Participants' perceptions of utility and learning performance varied more widely.

Table 3: Means and standard deviations of participant perception for interactive learning guides

Phase	Item	*Mean*	*SD*
Utility	1. I enjoyed using the ILGs to review the learning contents that I learned in class	4.02	0.50
	2. The ILGs were useful in learning the robot engineering.	4.10	0.55
	3. The ILGs were unnecessary for me to know the learning contents	3.35	0.90
	4. The use of the ILGs made the lessons more interesting	3.44	0.74
	5. I would like to use other ILGs in the future	3.92	0.79
Accessibility	6. I liked that I was able to review the ILGs outside of class	4.25	0.55
	7. I felt comfortable using the ILGs	4.30	0.58
	8. Some technical difficulties accessing the ILGs prohibited my learning experience	3.83	0.91
	9. I was able to access the ILGs anywhere with Internet access	4.28	0.63
	10. The need for plug-ins made it difficult for me to view the ILGs	3.92	0.80
User interface	11. I liked that the windows of ILGs fit nicely on the computer screen	3.89	0.75
	12. The length of ILGs was appropriate	3.78	0.81
	13. It is difficult to me for navigating in ILGs	3.97	0.78
	14. The panel was useful in handling the speed of the ILGs	3.75	0.90
	15. The consistent design of user interface made it easy for me to follow the learning contents	3.90	0.62
Learning performance	16. The ILGs helped me improve my manipulated skills	3.84	0.75
	17. I could work efficiently on my project after reviewing the ILGs	3.88	0.70
	18. The is faster to study the learning contents by myself than to learn from the ILGs	3.50	0.68
	19. The ILGs played a inessential role on the completion of my project assignment	3.12	0.95
	20. I believe using the ILGs will have helped improve my project grade	3.54	0.79

The fourth research question investigated whether students' learning styles and gender have any effect on the survey phases. A series of ANOVAs were conducted to evaluate the effects of learning styles and gender on student perceptions of the four survey phases. The results of a 5 × 2 (learning styles × gender) factorial ANOVA showed no significant interaction effects between the five VARK learning styles and gender on the perception of utility but a

significant main effect for gender, $F(9, 84) = 4.14$, $p = 0.049$, partial $\eta^2 = 0.15$. Furthermore, results of a 3 × 2 factorial ANOVA (learning modalities × 2) reveal a significant interaction between the learning modalities and gender on the perception of learning performance, $F(1, 84) = 4.83$, $p = 0.035$, partial $\eta^2 = 0.13$, and a significant main effect for gender, $F(1, 84) = 4.46$, $p = 0.041$, partial $\eta^2 = 0.12$. Significant main effects for both learning styles, $F(2, 84) = 3.42$, $p = 0.040$, partial $\eta^2 = 0.17$, and gender, $F(1, 84) = 8.96$, $p < 0.01$, partial $\eta^2 = 0.15$, exists on participants' perceptions on utility. In addition, a Chi-square test of association between learning styles and gender was executed. The relationship between learning styles and gender was statistically significant at the $\alpha = 0.05$ level, $\chi^2(2, 84) = 13.04$, $p < 0.01$, $\eta^2 = 0.10$.

In order to evaluate whether the participants' responses differed on survey questions depending on their learning styles, Chi-square tests were conducted. The results of the test were statically significant for only one of the questions, item 18, $\chi^2(5, 84) = 13.69$, $p = 0.031$, $\eta^2 = 0.05$.

Discussions

Learning environment

As the Chi-square test revealed that the learning styles of the traditional and online members had no significant difference, the reasons for participants' preference of one of the two course formats must be explored in other factors highlighted by related literature. Regarding the impact of learning style on learner achievement, a factorial analysis of variance showed that there was no significant difference between F2F and online learning environments. That means that students can be just as successful in the online environment as they can in the F2F environment regardless of their learning styles.

There were several rules contained in proper online learning environments (Trinidad, Aldridge, and Fraser, 2004). Taking these recommendations into account, this research used a well-constructed course that offered an active learning with highly interactive elements such as practice activities, ILGs, and a broad range of communication tools and found that differing learning styles can be accommodated successfully in both F2F and online learning environments. Because no significant difference was found in learning styles and course grades between the two groups, it is self-evident that the learning activities used in the on-campus classroom had been also effective for the online learning mode. This course was designed to connect new concepts to previous ones by using different representations of concepts and methods, and employing a number of learning approaches, e.g. design and comparison of solution paths, identification of similar problems, and modification and reuse of previous solutions. Combining delivery technologies with constructivist pedagogy, this course emphasized dialogue between participants. With the instructor acting as a facilitator of shared understandings, students felt free and comfortable to take handle, collaborate, and implement complex tasks that required them to locate information that was presented in a variety of formats.

The absence of a significant difference ($t = 0.384$; $p = 0.546$) among the scores of participants in F2F ($M = 68.66$, $SD = 21.22$) and online ($M = 67.80$, $SD = 18.86$) sections is in accordance with the findings of previous studies arguing that there is 'no significant difference' between traditional learning and online learning in terms of learner achievement, satisfaction, and over course quality (Ross and Bell, 2007). Although the 2 × 4 ANOVA indicated that online members had no significant difference in their learning achievement when compared with the traditional students based on their learning styles, there is some indication that Divrgers and Accommodators are the greatest beneficiaries of the online environment and that Convergers perform better in the F2F setting. As Accomodators and Divergers share the same concrete experience orientation, which focuses on being involved in experiences and dealing with immediate human situations in a personal way, it seems reasonable to assume that the broad opportunities for experimentation, communication, and

interaction offered by the online environment had an important impact on these two learning styles. The higher scores for the F2F Covergers could be accounted for by the fact that they are drawn to and benefit from opportunities for guidance and feedback as they practice new skills or explore new knowledge (Fahy and Ally, 2005), preferring 'public' interaction (Buerck et al., 2003).

Learners' perceptions

Overall responses on the utility of the ILGs reveal that the ILGs were useful in learning and reviewing the learning contents. The Pearson correlation coefficient (r = 0.702) indicates a positive moderate relationship between the perceptions of the utility of the ILGs and the perceptions of the perceived performances. The responses imply that instructors could use ILGs as a complement to assist students in their learning. Furthermore, the majority of the participants though the ILGs helped them spend less time in learning the contents and completing the assignment. ILGs were accessed easily and most of the learners were able to handle within them without difficulties. Although the majority thought that the ILGs were necessary in order for them to understand the learning contents, some of the individuals disagreed. It is encouraging that 78% of the respondents revealed that they would be willing to use other ILGs in the future.

Effects of learning styles and gender on survey phases

The results indicated a relationship between the participants' learning styles and their gender with regard to their learning performance. The result of a Chi-square test of association supports a strong association between the learning modalities and gender. In other words, females and males appeared to have different preferences for learning styles. This outcome was anticipated because gender is one of many factors that have an influence on learning styles (Slater, Lujan, and DiCarlo, 2007). The result indicated more female were bimodal and multimodal than male participants. However, it is contradictory to the results of a research by Wehrwein et al. (2007). It was also unexpected that only males with a multimodal preference perceived a high level of improvement on their performance after reviewing the ILGs. Besides, learning styles and gender had significant main effect on the utility and learning performance phases. Individuals had different viewpoints regarding the utility of the ILGs and their perceived learning performance. Gender differences had an influence on both the perceptions of the utility and learning performance. Compare to females, the males found the ILGs more beneficial in promoting their learning performance. These results are not special because males and females tend to have different learning preference in learning (Slater et al., 2007).

Conclusion

The aim of this research was to explore the relationships between individuals' learning styles and perceptions pertaining to the application of ILGs used as supplements for a robot engineering course. The research contributes to the filed by providing insights into associations, interactions, relationships and main effects between learning styles, gender, and the utility, accessibility, user interface of ILGs and learning performance. In general, the ILGs were useful and benefited enhance the students' learning. The results indicate that the ILGs also had an appropriate user interface design and were easily accessible. In addition, learning styles did not have a large impact on how the learners responded to the survey items. According to the investigations, some of the results pertaining to the participants' learning styles are not surprising because the ILG introduced in the course combined text, visuals, and kinaesthetic components. The results reveal that ILGs accommodate a variety of learning styles and therefore, fit the requests of diverse learners. Evidently, gender is responsible for differences on their perceptions of the ILGs' utility and learners' performance.

Based on the results of this research, there are several important issues indicated: (1) the online classroom, either as a sole instructional way or as a complement for on-campus learning, provides the tools to address different learning styles. Because learners in the F2F or online classroom do not differ in the way they process information, the same learning activities could be designed and utilized in both environments. (2) Instructors may want to consider providing ILGs in their campus-based courses as supplemental materials and make their use optional. These types of ILGs may also be helpful to online learners. Regardless of the learning which they are implemented, the design should be consistent and user-friendly. (3) Understanding their learning styles, students can effectively choose the tools that will add the most value to the learning experience.

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