Does learning enviornment affect the students in introductory programming courses?

Thuy-Linh Nguyen and Geoff Warburton

School of Business
Australian Cathlic University
Melbourne, Australia

Dip Nandi

School of Computer Science and IT
RMIT University
Melbourne, Australia

Abstract— **This paper reports on the outcome of an educational empirical research project that aims to establish if there are any correlations between the level of acceptance of an introductory programming language "Alice" by students and the learning environments (online versus on-campus), taking into consideration the specific characteristics of Alice as well as the personal traits, learning style, and relevant background and experiences of the students. The findings indicate that it is more likely that online students like Alice than on-campus students. This deviation however, is not likely to be influenced by the learning environment or study mode per se, but rather by age, communication frequency, and English as the first language. Further research is needed to establish more precisely what works and what does not work for Alice, and in what situation.**

Keywords- Alice, introductory programming, computer science education, online learning environment.

I. INTRODUCTION

Teachers of introductory programming courses are very well aware of the difficulties many beginners face in learning programming concepts, because they cannot evaluate the steps in a computer program to solve a particular problem [6]. To address this issue, visualization has long been used to animate a program execution and proven helpful [11, 18, 19]. Alice takes visualization to a different level by providing a 3-Dimensional, animated, interactive environment, where students can create their own virtual world.

Alice is an innovative programming platform, launched by Professor Randy Pausch and his team around 2000 [16, 6]). This software, aimed to aid in teaching introductory programming, offers a revolutionary approach, using 3-D interactive graphics and animation. It has gained much publicity, wide acceptance and great appreciations globally [17, 1, 2, 13, 20], however has also received some criticism [5, 12].

At RMIT University Australia, it is felt that online students accepted the tool better than on-campus students. The *null hypothesis* (H0) is thus that there is no difference between the level of acceptance of Alice between online and on-campus students, and the *alternative hypothesis* is that there is a difference. This paper reports on data collected from students surveyed (Appendix A) at RMIT University who did Introduction to Programming in either online or on-campus mode over a period of one semester. The research project aims to confirm or reject the null hypothesis, and also establish factors that may relate to this deviation. The research project is part of a large investigation to improve the quality of student learning in introductory programming courses. In this paper, the following key research questions have been investigated:

1) Is Alice better accepted by online students than on-campus students and to what extent?

2) Why is the difference, if any? What factors in the learning environments, features of Alice and students' characteristics may contribute to this deviation?

Statistical analyses including multi-variate analyses [4] were carried out to identify and measure the influence of the factors that may be associated with students' attitude towards Alice. This research can help educators to adjust their teaching tools and methods, and/or design course curriculum, for the benefit of the students and ICT industry. It may also contribute to human understanding on the different characteristics relating to online and on-campus learning.

II. CONCEPTUAL FRAMEWORK

Although Alice has gained much popularity as an introductory learning tool, however there have also been mixed results – to the point that Alice's benefits to students are too mixed to justify keeping it in the curriculum [5] and criticisms – mainly because it is not a commercial tool and cannot be used professionally [12]. To our knowledge, none of the studies so far have aimed to identify the elements that contribute to the mixed results; in particular, the element of the learning environment has never been studied. The possible deviation of students' attitudes toward Alice between online and on-campus learning environments is of interest because of the particular characteristics pertaining to the online environment; these are well studied in the literature [12, 3, 8, 9].

This research, informed mainly by the literature of Alice, online teaching, and computer science and information technology education, provides a comparison between the online and on-campus learning environments, taking into account not only the attributes of these environments, but also those of the student and Alice. It is hoped to detect if there are discernible differences in students' acceptance level of Alice in the two differing learning environments, and if there is, how the attributes in Alice, the learning environment and the student, might contribute to such differences.
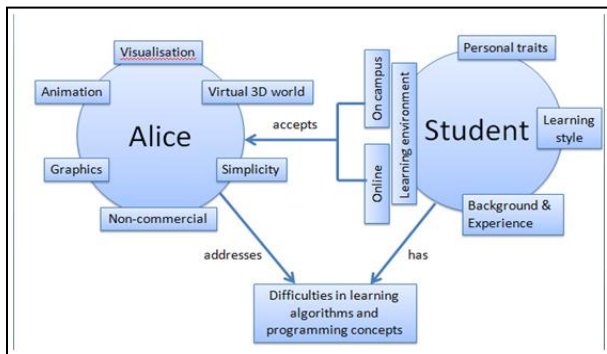

Figure 1: Concept map for conceptual framework

Fig. 1 above shows a concept map of the framework used in this research. The two main subjects, Alice and the Student in two different learning environments, are carefully investigated with questions that explore their many specific characteristics, as the Student and Alice interact with each other to address the common issue of difficulties in learning algorithms and programming concepts.

III. FINDINGS AND DISCUSSION

The two student cohorts (online and on-campus) differ mainly in language, international vs. local, age, programming experience, communication methods, being good at drawing, and being influenced by the fact that Alice is not a commercial tool. Differences are also found in their ratings of the various features of Alice.

40% of the on-campus students vs. 91.1% of the online students have English as their first language. 60% on-campus students are international, but all online students are local. Only 10% of the on-campus students are mature age (over 25) compared with 75.6% in the online cohort. 40% of on-campus students vs. 83.3% of online students have done some programming before. (See Fig. B1 & B2 below).
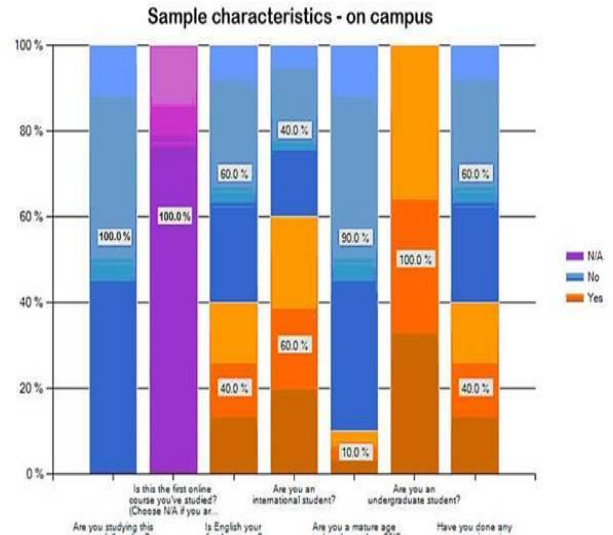

Figure B1. Students' characteristics – on-campus
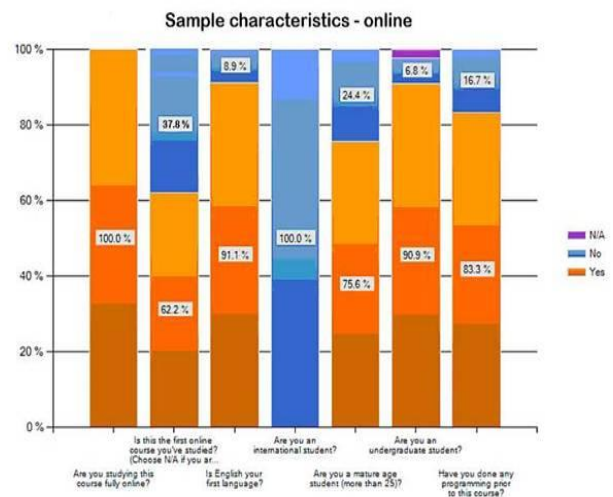

Figure B2. Students' characteristics – online students

As expected, the main communication method for on-campus students, on one hand, is overwhelmingly face-to-face; followed by other online communication means, phone, email, Blackboard forum, Blackboard or Elluminate chat, and Blackboard blog or wiki. Online students on the other hand, primarily use the Blackboard forum, followed by Blackboard or Elluminate chat, Blackboard blog or wiki, other online communication means, email, and phone. There are more on-campus students who say that they are good at drawing, and more online students being influenced by the fact that Alice is not a commercial tool. Generally the online students give higher ratings to the various features of Alice.

We have assigned values between 0 and 4 to the ratings in the survey questions 9 (communication method) and 15 (criteria statements) to compare the average ratings of the two cohorts, where 0 corresponds to "strongly disagree" or "never", and 4 to "strongly agree" or "5-6 times or more".

In both cohorts most students classify themselves as undergraduate, and the male / female ratios are similar (30% female on-campus vs. 24.4% online – see Fig. B1 to B3).
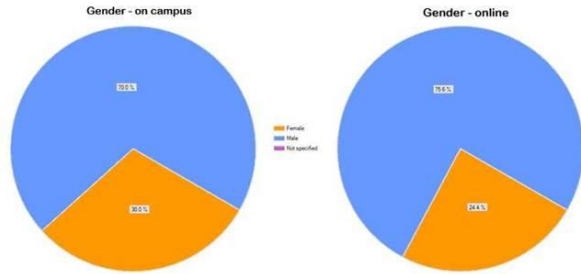

Figure B3 – Student gender

When cross-tabbing the variables of the primary and secondary questions with various variables, we find that, of the differences in the two students cohorts, only language, age, communication methods, and the features of Alice have significant associations with the liking of Alice (see Quantitative Analysis below).

The response rate is 17% for both online and on-campus student cohorts, with 45 out of 258 online, and 10 out of 58 on-campus students responding. Even though this is a bit higher than expected, the sample size for the on-campus population is quite small, and may have implications in the interpretation of some findings. The interpretation suggested here therefore, should be taken with reservation. We do not think that the small sample size of the on-campus cohort is due to the fact that the on-campus students are less mature in age, because the response rate is actually the same for both groups.
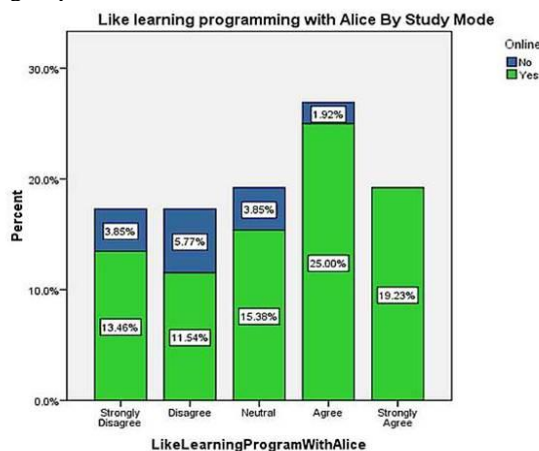

Figure B4 – Like Alice By Study Mode

The difference in students' attitude towards Alice between online and on-campus student cohorts however, is clear. 53.5% online versus 11.11% on-campus students choose "Agree" or "Strongly Agree" to the primary question. Likewise, 54.2% online versus 22.22% on-campus students choose "Agree" or "Strongly Agree" to the secondary question. Moreover, only the online students choose "Strongly Agree" in both questions. (See Fig. B4 above & B5 below).
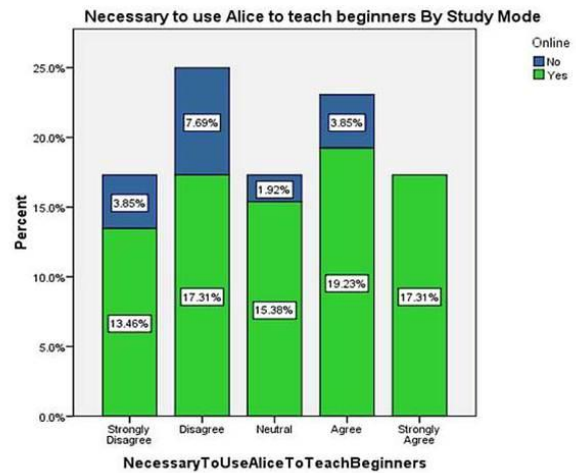

Figure B5 – Necessary to use Alice for beginners By Study Mode

Assigning numerical values of 0 to 4 to the responses, where 0 corresponds to strongly disagree and 4 to strongly agree, we are able to run T-tests for the two student cohorts. T-tests, which return p-values, can be used to compare two groups as follows:

P-value	Interpretation
$P < 0.01$	Very strong evidence against H0
$0.01 <= p < 0.05$	Moderate evidence against H0
$0.05 <= p < 0.10$	Suggestive evidence against H0
$0.10 <= p$	Little or no real evidence against H0

Our T-tests on the two online and on campus cohorts return p=0.013 for the primary question and p=0.045 for the secondary. Both values indicate that the differences in the two groups are significant (with the online group showing a higher level of acceptance of Alice). That is, the null hypothesis (H0) is rejected.
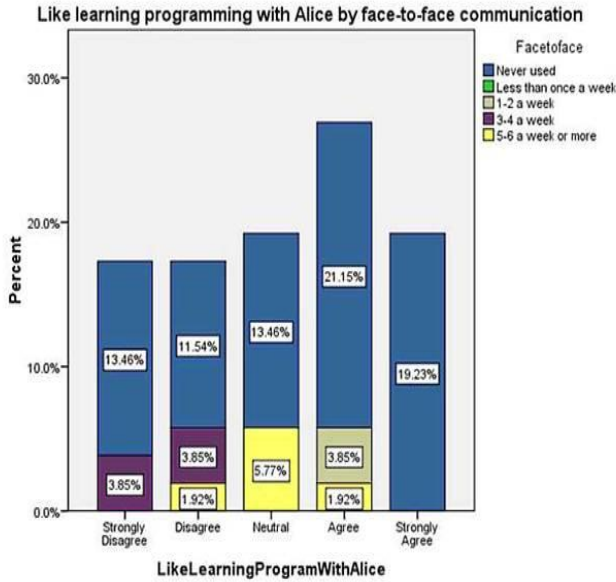
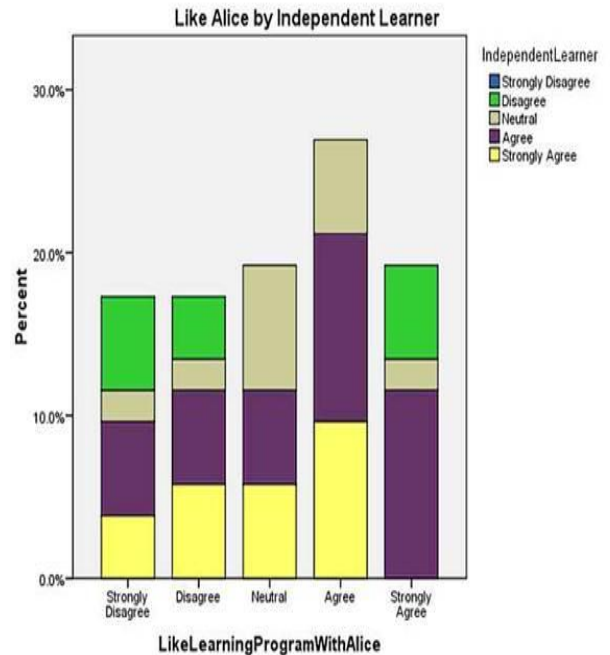**Figure B6 – Like Alice by Face-to-Face Communication**
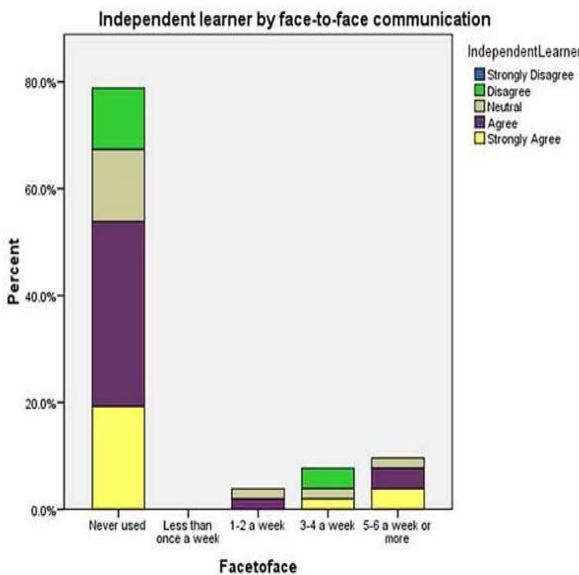

Figure. B7 – Independent Learners by Face-to-Face Communication

Figure B8 – Like Alice by Independent Learner

Below are more analyses to answer the research question 2. That is, why is the difference? What factors in the features of Alice, students' characteristics, and learning environment, which may contribute to this deviation?

A. Quantitative Analysis

Quantitative analysis was carried out on responses to Yes/No and multiple choice questions, where the choices mainly correspond to a multiple-scale rating such as "strongly disagree, disagree, neutral, agree, strongly agree", or something similar. Questions were designed in three areas: features of Alice, students' characteristics, and the learning environment, following the conceptual framework above. Statistical analyses were done with the help of SPSS Statistics 17.0 software package.

Cross-tabulations were done between each variable and the primary question to establish if there are any associations between them. Kramer's V (when the tables are larger than 2x2 in sizes) or Φ values (when the tables are 2x2 or smaller) are then calculated to measure the strength of the association. Kramer's V and Φ varies between 0 and 1, where values close to 0 show little association, and values close to 1 mean a strong association.

There may also be n-ary relationships among multiple variables. Results of the above tests were thus inspected to determine if there might be multi-dimension associations among the variables, and subject these groups of variable to multi-variate tests. Multi-variate tests were carried out for each of the variable that represents a significant difference between the two student cohorts (for instance, age, language, being an international student, etc.).

Results of these statistical tests and analyses are reported below.

1) Factors Related to Features of Alice

We found that the most significant factors that link to students' liking of Alice relate to the features of Alice rather than the learning environments or student's characteristics. Since the online students rate these features higher than on-campus students in most cases (see Tables B5 & B6 in Appendix B)
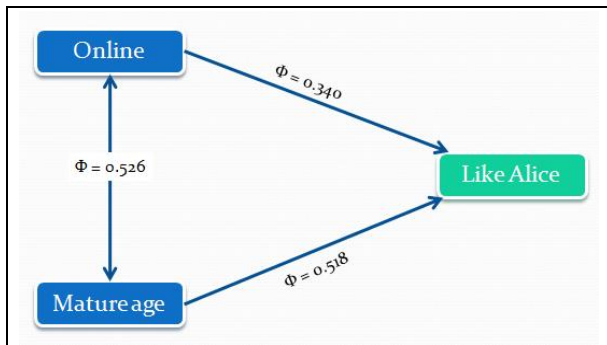

Figure 2: Three-way relationship between study mode, age and the liking of Alice.

It is obvious that these factors (features of Alice) contribute strongly to the deviation between the two student cohorts. Top of the list is the fact that students feel motivated that they can write programs graphically and can animate programs (Kramer's $V = 0.535$, indicating a pretty strong correlation). Other significant factors belonging to this category include graphics and animation which help or motivate students' understanding (Kramer's V ranging from 0.450 to 0.477), the ability to program by dragging and dropping things (0.454) and other features and facilities in Alice that assist in learning various programming concepts (Kramer's V ranging from 0.362 to 0.454). The factor that scores lowest in this category is that Alice is not a commercial tool (0.303).

2) Factors Related to Students' Characteristics

A student's characteristic that is strongly linked with student's liking of Alice is mature age (over 25 years old), with a Kramer's V value of 0.518 (moderately strong).

When analyzing the combined influence of study mode, age, and attitude towards Alice, we find a tri-variate relationship. Many online students are mature age (75.6% online versus 10% on-campus), and many mature age students say that they like learning programming with Alice (62.8% mature age compared to 12% non-mature age).

As elements of learning environment do not seem to directly relate to the liking of Alice (see further analysis below), this suggests that the driving factor that affects students' attitude toward Alice in this tri-variate may be mature age rather than study mode (see Fig. 2).

A similar tri-variate is that among study mode, English as the first language, and the liking of Alice. Students with English being the first language, is more likely to like Alice ($\Phi = 0.315$, a moderate association), and is quite likely to be an online student ($\Phi = 0.511$, a moderately strong association). Similar to the above case, this tri-variate also suggests that language may be the driving factor in students' attitude toward Alice rather than study mode (see Fig. 3).
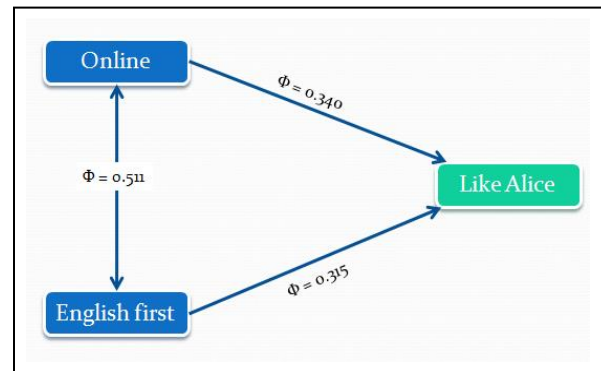

Figure 3: Three-way relationship between study mode, English as the first language and the liking of Alice.

Another note-worthy tri-variate is that among communication frequency, student being an independent learner and students' attitude towards Alice in the on-campus cohort. Regardless of the communication method used, we find that those who communicate less are more likely to say that they are independent learners and more likely to like Alice, especially when the method used is face-to-face, the exclusive and most used method among on-campus students (see Fig. B6 to B8 above).

The above tri-variate is not true in the online group, where the most used communication method, Blackboard forum, is proportionately linked to the liking of Alice (Kramer's $V = 0.30$) but disproportionately linked to independent learners (Kramer's $V = 0.328$). We think that for online students, it is logical that those who actively participate in online discussion forum are more likely to be interested in and appreciate Alice and the link to independent learner is perhaps not significant. This interpretation however is not conclusive.

This may suggest that non-independent learners, who communicate more with peers, may somehow be influenced more by peers for (negative) opinions about Alice. Fig. 4 depicts this three-way relationship for the face-to-face communication method. This interpretation however, must be taken with great reservation, because the association between independent learner and face-to-face communication method is very weak to negligible (Kramer's $V = 0.228$).

Other students' characteristics that may be associated with the liking of Alice are gender (0.295), good at drawing (0.288), visual learner (0.278), international students (0.251) and good at math (0.232). There seems to be no relationships between these variables and the study mode.

Interestingly, prior programming experience does not change the liking of Alice. Also, contrary to the expectation that female students might like Alice more (because of its female name), and also students who are good at drawing, the relationships between these two variables and the liking of Alice is the other way round. However with the small sample size, especially for the on-campus students, we think these associations and anyone's with Kramer's V or Φ values under 0.3 (which signifies a weak relationship) may be considered negligible in this project.
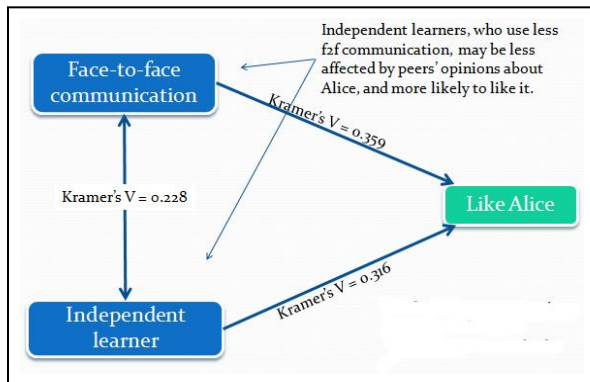

Figure 4: Three-way relationship between f2f communication, being an independent learner and the liking of Alice.

3) Factors Related to Learning Environment

Elements pertaining to the learning environment do not appear to strongly influence students' attitude towards Alice. The most significant ones in this category are feeling unmotivated in learning environment (0.261), feeling isolated in learning environment (0.245), and independent learner (0.228). However as we consider that associations with Kramer's V or Φ values under 0.3 negligible, these associations are not significant. Interestingly, there appear to be no significant relationship between these variables and the study mode.

Below is the list of all factors that link to the liking of Alice, in order of likely strength. The links are positive in most cases (i.e. higher rating in the factor means higher liking of Alice), except where indicated otherwise:

- Students feel motivated that they can write programs graphically (Kramer's V = 0.535), and can animate programs (Kramer's V = 0.535)
- Students feel motivated that they can animate programs (0.535)
- Mature age (0.518)
- Graphics and animation helps understanding (0.477, 0.470)
- Graphics and animation motivates learning (0.450, 0.471)
- Easy to learn control structures (0.454)
- Drag-drop (0.445)
- Helps grasp OO concepts (0.435)

- Improves problem-solving skills (0.433)
- Built-in methods / functions (0.406) and properties (0.382)
- Helps understand event-driven programming (0.383)
- Alice object library adequate (0.363)
- Array Visualisation facilitates understanding of arrays (0.362)
- Face-to-face communication (0.359, negative)
- Blackboard forum communication (0.30)
- Easy to learn to write own methods / functions (0.324)
- Independent learner (0.316)
- English is the first language (0.315)
- Alice is not a commercial tool (0.303)
- Gender (0.295, male is more likely to like Alice)
- Good at drawing (0.288, negative link)
- Visual learner (0.278)
- Feeling unmotivated in learning environment (0.261)
- International students (0.251)
- Feeling isolated in learning environment (0.245)
- Good at Maths (0.232)

IV. CONCLUSIONS

The findings confirm the alternative hypothesis (p=0.013). It is more likely that online students like Alice than on-campus students (a moderate association with Φ = 0.34). This deviation however, is not likely to be influenced by the learning environment or study mode per se, but perhaps by age, communication frequency, and English as the first language. Mature age may help students appreciate Alice more. In the on-campus cohort, there is a possibility that students who communicate more (thus are less independent learners), especially in the face-to-face fashion that is exclusively used by on-campus students, may be more influenced by their peer (negative) opinions about Alice, although this interpretation must be taken with great reservation. We cannot explain why English as first language may be linked to the liking of Alice, but this is only a lowly moderate link. The findings also confirm that Alice is most appreciated (33 out of 41 students) for its graphics, visualization and animation capabilities, and ease of use, which enables students to learn difficult programming concepts more easily, but most disliked (30 out of 41 students) for its buggy-ness and limitations.

These findings suggest that if we keep Alice, we should try to use it for mature age students and independent learners, and design our course materials to make the best use of the above features of Alice that are most appreciated by students. However the retention of Alice in the curriculum is questionable.

Even among the population in which Alice is more favorable (the online students), the percentage of students who do not say that they like Alice and are not convinced of the benefit of Alice are still high (46.5% and 43.8% respectively). Cliburn [5] did have to remove Alice from the

curriculum in a similar situation. We think unless we can deploy Alice for an "ideal" group of students (i.e. mature age and independent learners according to this study), its benefits are likely outweighed by its disadvantages.

As the sample size of the on-campus group is quite small however, the conclusion above should be taken with reservation. We are currently extending the project to survey more students, include qualitative analysis [10, 15] and hope to be able to reach a more definite conclusion about this.

ACKNOWLEDGMENT

REFERENCES

[1] Alice.org(a) (2010). "Alice in the news." Retrieved 18-06-2010, 2010, from http://www.alice.org/index.php?page=aliceinthenews.

[2] Alice.org(b) (2010). "Alice Testimonials." Retrieved 18-6-2010, 2010, from http://www.alice.org/index.php?page=testimonials.

[3] Bernard, R. M., Brauer, A., Abrami, P.C., & Surkes, M. (2004). "The development of a questionnaire for predicting online learning achievement." *Distance Education* 25(1): 31-47.

[4] Blaikie, N. (2003). Analyzing Quantitative Data,, SAGE Publications.

[5] Cliburn, D. C. (2008). Student opinions of Alice in CS1 Frontiers in Education Conference. FIE 2008. *38th Annual IEEE*.

[6] Cooper, S., Dann, W., Pausch, R. (2000). Alice: An Introductory Tool for Teaching Programming Concepts. *CCSCNE*, Ramapo, NJ, USA.

[7] Glaser, B. G. & Strauss, A. L. (1967). *The discovery of grounded theory*. Aldine, New York

[8] Kerr, M. S., Rynearsonb, Kimberly, Kerr, Marcus C. (2006). "Student characteristics for online learning success " *The Internet and Higher Education* 9(2): 91-105.

[9] Liu, Y. (2006). What are the Major Characteristics of Online Students? Proceedings of Society for Information Technology & Teacher Education International Conference, Chesapeake, VA, AACE.

[10] Marshall, C. and G. B. Rossman (2011). *Designing qualitative research*. Thousand Oaks, Calif, Sage.

[11] Maxim, B. R. and B. S. Elenbogen (1988). "Using computer animation to teach programming algorithms." *Collegiate Microcomput.* 6(4): 375-381.

[12] McKenzie, W. B. (2009). "Introductory Programming with ALICE as a Gateway to the Computing Profession." *Information Systems Education Journal* 7(38).

[13] Moskal, B., Lurie, Cooper, S. (2004). Evaluating the Effectiveness of a New Instructional Approach. *SIGCSE*, ACM.

[14] Neuman, W. L. (2006). Social research methods: Qualitative and quantitative approaches, 6th Ed.

[15] Palloff, R. M., Pratt, K. (2001). Lessons from the cyberspace classroom: *The realities of online teaching,* San Francisco, Jossey-Bass.

[16] Pausch, R., Burnette, T., Capeheart, A.C., Conway, M.,Cosgrove, D., DeLine, R., Durbin, J., Gossweiler, R., Koga, S., White, J. (1995). "Alice: Rapid Prototyping System for Virtual Reality." *IEEE Computer Graphics and Applications.*

[17] Salim, A. H., S.; Hamdi, S.; Youssef, S.; Adel, H.; Khattab, S.; El-Ramly, M. (2010). On using 3D animation for teaching computer programming in Cairo University. *The 7th International Conference on Informatics and Systems (INFOS)*, Cairo, IEEE.

[18] Shu, N. C. (1988). *Visual Programming*. New York, Van Nostrand Reinhold Co.

[19] Stasko, J. T. (1992). "Animating Algorithms with XTANGO." *SIGACT News* 23: 67-71.

[20] WebWire (2007). Professor Developed Alice Animation Tool to Teach Computer Programming. *WebWire*. 2010

APPENDIX A
Survey questions

1. Are you studying this course fully online? **Yes / No/ Not applicable**
2. Is this the first time you do an online course (choose not applicable if you are not an online student)? **Yes / No / Not applicable**
3. Is your first language English? **Yes / No / Not applicable**
4. Are you an international student? **Yes / No / Not applicable**
5. What is your gender? **Female / Male / Not specified**
6. Are you a mature age student (over 25)? **Yes / No / Not applicable**
7. Are you an undergraduate student? **Yes / No / Not applicable**
8. Have you had any programming experience in any programming or scripting language prior to this course? **Yes / No / Not applicable**
9. What methods do you use to interact with other fellow students in this course? Please rate the following methods:

Methods of interaction	5-6 times a week or more	3-4 times a week	1-2 times a week	Less than once a week	Never used
Face-to-face					
Email					
Phone					
Blackboard Discussion forum					
Blackboard or Elluminate chat					
Blackboard wiki or blog					
Phone					
Other online communication methods					

10. Alice is a teaching tool and not a commercial tool (like Java) for programming. In what way, if any, does this influence your motivation to learn Alice? (Please choose one) **More Motivated / Neutral / Less motivated / I am not aware of that / Other (please specify)**

11. How did you grade your attitude towards COMPUTERS PRIOR to this course? Please rate your attitude for each statement below:

Attitude	Strong Disagree	Disagree	Neutral	Agree	Strongly Agree
I feel anxious about using computers					
I feel confident about using computers					
I like using computers					
I find computers useful					
I enjoy computers because they help me be creative					

12. How did you grade your attitude towards COMPUTERS NOW that you have participated in this course? Please rate your attitude for each statement below: (same attitudes and ratings as question 11)

13. How did you grade your attitude towards PROGRAMMING PRIOR to this course? Please rate your attitude for each statement below: (same attitudes and ratings as question 11)

14. How did you grade your attitude towards PROGRAMMING NOW that you have participated in this course? Please rate your attitude for each statement below: (same attitudes and ratings as question 11)

15. Please answer the following questions by indicating the number that most closely corresponds with your judgments for each of the criteria statements below.

Criteria Statements	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. I am good with Mathematics					
2. I am good at drawing					
3. I am a visual learner – visualization helps me learn better					
4. I am an independent learner and do not interact much with peers					
5. I feel isolated in my learning environment					
6. I feel unmotivated in my learning environment					
7. I feel motivated to learn programming with Alice					
8. I feel motivated that I can write programs graphically in Alice					
9. I feel motivated that I can animate programs in Alice					
10. In general graphics helps me understand programming concepts better					
11. In general animation helps me understand programming concepts better					
12. In general graphics motivates me to learn programming					
13. In general animation motivates me to learn programming					
14. I feel that Alice helps me grasp object-oriented concepts more easily than other non-graphical object-oriented languages					
15. I think the library of objects in Alice is adequate for my course					
16. I think the built-in methods provided for objects in Alice are adequate for my course					
17. I think the built-in properties provided for objects in Alice are adequate for my course					
18. I think my problem-solving skills have been improved with the storyboarding technique used in Alice					
19. I can learn about control structures (IF/ELSE, LOOP, etc) in Alice easily					
20. The Array Visualisation facility in Alice helps me learn about arrays					
21. I can understand event-driven programming easily in Alice					
22. I can learn about how to write my own methods/functions easily with Alice					
23. I like the "drag-and-drop" way of writing programs in Alice					
24. I think it is good to use Alice to teach beginners programming FIRST before transitioning into Java					
25. I think it is good to use Alice SIMULTANEOUSLY with Java to teach programming to beginners					
26. I think it is necessary to use Alice to teach programming to beginners					
27. In general I like learning programming with Alice					
28. I will recommend this course to anyone who wants to learn introductory programming					