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การสร้างและประเมินประสิทธิภาพนวัตกรรมสื่อการสอน เรื่องกายวิภาคพื้นฐานของสัตว์ โดยใช้เทคโนโลยีความเป็นจริงเสริม

Basics Animal Anatomy Instructional Media by Augmented Reality Technology Creation and Efficiency Evaluation

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บทคัดย่อ

งานวิจัยครั้งนี้มีวัตถุประสงค์เพื่อ 1) สร้างสื่อการสอนเรื่องกายวิภาคพื้นฐานของสัตว์ด้วยเทคโนโลยีความเป็นจริงเสริม 2) นำสื่อการสอนมาใช้ในวิชาชีววิทยาแทนการใช้สัตว์ทดลอง 3) ประเมินความพึงพอใจของผู้เรียนต่อสื่อการสอน ตัวอย่างการวิจัยเป็นนักศึกษามหาวิทยาลัยเทคโนโลยีราชมงคลศรีวิชัยที่เรียนรายวิชาชีววิทยาในปีการศึกษา 2565 แบ่งเป็นกลุ่มควบคุม 26 คน และกลุ่มทดลอง 24 คน โดยสุ่มตามความสะดวก เครื่องมือที่ใช้ได้แก่ 1) แผนการสอนประกอบการใช้สื่อ 2) สื่อการสอนเรื่องกายวิภาคพื้นฐานของสัตว์ด้วยเทคโนโลยีความเป็นจริงเสริม 3) แบบทดสอบก่อนและหลังเรียน 4) แบบประเมินความพึงพอใจ

ผลจากการศึกษาพบว่านักศึกษากลุ่มทดลองและกลุ่มควบคุมมีความแตกต่างของคะแนนก่อนและหลังเรียนอย่างมีนัยสำคัญยิ่ง ($p = 0.00$) โดยกลุ่มทดลองและกลุ่มควบคุมมีความต่างของคะแนน 12.31±3.84 และ 7.58±5.42 ตามลำดับ เมื่อเปรียบเทียบระหว่างกลุ่มทดลองและกลุ่มควบคุมพบว่า กลุ่มทดลองมีคะแนนเฉลี่ยหลังเรียน และความต่างคะแนนก่อนและหลังเรียนสูงกว่ากลุ่มควบคุมอย่างมีนัยสำคัญยิ่ง ($p = 0.00$) โดยคะแนนสอบหลังเรียนเฉลี่ยของกลุ่มทดลองและกลุ่มควบคุม คือ 20.10±2.96 และ 13.92±4.04 ตามลำดับ ความต่างคะแนนสอบก่อนและหลังเรียนของกลุ่มทดลองและกลุ่มควบคุมคือ 12.31±3.84 และ 7.58±5.42 ตามลำดับ นอกจากนี้นักศึกษายังมีความพึงพอใจต่อสื่อการเรียนรู้ในระดับ ดีมาก (4.96 ± 0.04) สื่อการสอนกายวิภาคพื้นฐานของสัตว์

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ด้วยเทคโนโลยีความเป็นจริงเสริมดึงดูดความสนใจผู้เรียนได้ดี และเหมาะกับสถานการณ์ปัจจุบัน อย่างไรก็ตาม ข้อจำกัดของสื่อนี้คือใช้ไม่ได้กับอุปกรณ์โทรศัพท์เคลื่อนที่บางรุ่นที่ไม่รองรับแอพพลิเคชันเทคโนโลยีความเป็นจริงเสริม

คำสำคัญ: สื่อการสอน ชีววิทยา กายวิภาคพื้นฐานของสัตว์ เทคโนโลยีความเป็นจริงเสริม

Abstract

This research aims to: create instructional media on the basic anatomy of animals with augmented reality technology 2) use teaching materials in biology instead of laboratory animals 3) assess learners' satisfaction with teaching materials. The study sample was Rajamangala University of Technology Srivijaya students studying biology in the 2022 academic year. It was divided into a control group of 26 people and a 24-person experimental group, randomly at convenience sampling. Tools used in this study include 1) lesson plan incorporating the use of instructional media 2) instructional media on the basic anatomy of animals with augmented reality technology, 3) pre-test and post-test 4) satisfaction assessment form.

The results showed that the experimental and control groups had highly significant differences in pre-and post-test scores (p = 0.00). The experimental and control groups had difference scores of 12.31±3.84 and 7.58±5.42, respectively. There were highly significant differences in scores when compared between the experimental and control groups in the case of post-test scores and pre-and post-test difference scores (p = 0.00). The average post-test scores of the experimental and control groups were 20.10±2.96 and 13.92±4.04, respectively. The differences between the pre-and post-test scores of the experimental and control groups were 12.31±3.84 and 7.58±5.42, respectively. In addition, students were satisfied with the learning materials (4.96 ± 0.04). The basic anatomy of animal instructional media with augmented reality technology attracts learners well and is appropriate for the current situation. However, there was a limitation to this instruction media in terms of its usability by some mobile devices that do not support augmented reality technology applications.

Keywords: Instructional media, biology, basic animal anatomy and Augmented reality technology

Introduction

Learning is a basic cognitive activity that occurs throughout a lifetime and affects both mental and social development (Holzinger et al., 2005). Even though the world is three-dimensional, teachers tend to choose two-dimensional media when teaching. The usage of virtual technology made it easier and quicker to acquire the lesson since it helped spread and promote learning (Aivelo & Uitto, 2016; Nuanmeesri et al., 2019). Augmented Reality (AR) technology plays

a major role in education as it enables students to view the real world with digital information (Azuma, 2001). Therefore, a new category of automated applications is created to improve the efficiency of teaching and learning in realistic situations since it can excite and inspire students (Budiman, 2016; Kesim & Ozarslan, 2012). The development of mobile augmented reality has a huge opportunity for teaching and learning because learners can have better access to the material regardless of place and time. AR technology leads to flexible learning, particularly in higher education. (Jamali et al., 2015). Although this technology is not new, the potential influence of augmented reality to enhance student learning has been the subject of a sizable number of research investigations (e.g., Budiman, 2016; Jamali et al., 2015; Santos et al., 2016; Weng et al., 2019). The application of AR technology can raise students' academic performance as well as encourage them to develop categorization and observational abilities. It also engages learners by using real examples in learning abstract and confusing concepts (Chang et al., 2013; Suwancharas, 2016; Yapici & Karakoyun, 2021). For educators and technology developers interested in enhancing young children's minds with cutting-edge technologies, these several research initiatives can offer important information (Radu, 2014). Moreover, the qualities of AR technology help students understand difficult subjects, especially the subject of animal anatomy (Shelton & Hedley, 2002; Weng et al., 2019). Animal body structure and internal organ systems are exposed as part of this course's practical dissection laboratory component, which entails learning about animal anatomy. Filled with complicated and technical jargons, the original teaching tool for this lesson was a live or fixative-treated frog. The primary goal of employing augmented reality technology in teaching materials for fundamental animal anatomy course is to allow students to visualize virtual reality using augmented reality technology rather than real animals in line with the subject of responsibility for considering options that is covered in "Ethics and Experiments on Animals" (National Research Ethics Committees, 2019).

Materials and Methods

1. Research population and sample

The research population consisted of 50 first year students who studied biology at Rajamangala University of Technology Srivijaya in the first semester of academic year 2022. According to the research design, an example experiment is divided into a control group of 26 people and an experimental group of 24 people. A convenience sampling method was used to collect the samples in this study.

2. Data collection procedures

To begin, students were informed of the risk information. Before instructing them, the pre-test results were gathered. Then, the basic anatomy of animals using augmented reality instructional media was taught in the experimental group. Fixative treat frogs were used as the

teaching material for the control group (Figure 1). The post-test was administered to two groups of learners. The experimental group assessed students' satisfaction toward AR teaching materials. Finally, the data were calculated to obtain the mean differences between the experimental and control groups.

3. Instruments

The following tools were utilized in this research:

1. Lesson plan incorporating the use of AR instructional media.
2. Using augmented reality technology, instructional media relating to animal anatomy were provided for students in higher education.
3. A pre- and post-test was approved by three professionals. This form of test comprised five multiple-choice questions, fifteen four-choice questions, and two subjective questions.
4. The satisfied evaluation consisted of five Likert scales, 12 questions, and one open-ended question. This evaluation form was reviewed by three experts.

4. Satisfaction analysis

1. Means, standard deviations, and t-test were estimated to analyse the findings from the pre- and post-test. An independent t-test was used to compare the outcomes of the pre- and post-test scores between the experimental group and the control group.
2. Means and standard deviations were applied in statistical data analysis to obtain learners' satisfaction toward the teaching materials. The interpretation pinpoints the following Likert criteria (1967):

Score Interval (Mean)	Evaluation Criteria
1.00-1.50	Very low level
1.51-2.50	Low level
2.60-3.39	Medium level
3.40-4.19	High level
4.20-5.00	Very high level

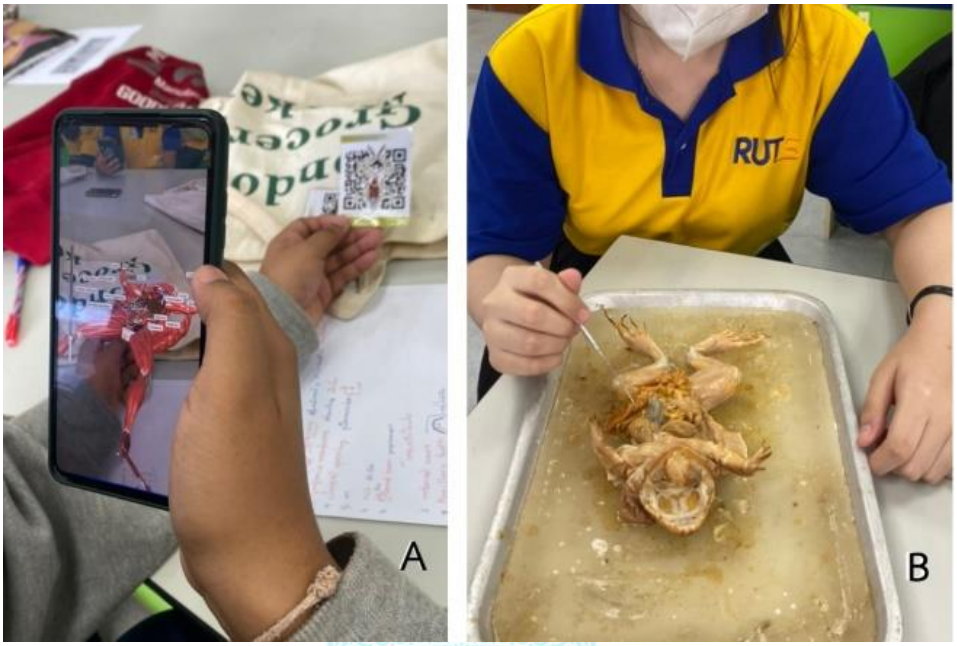

Figure 1 Biology teaching materials: For the experimental group, augmented reality educational materials were used. (A), Fixative treat frogs were employed as teaching medium in the control group. (B).

Results

1. Basics Animal Anatomy Instructional Media by Augmented Reality Technology

This instructional media consists of 3 markers, each displaying content using AR technology, covering three main topics: 1) external characteristics of frog 2) oral cavity of frog 3) internal organs of frog. For each of these topics, the labels are provided in English to indicate the names of the anatomical structures. When you press on a label, it will produce an audio narration in English, followed by the Thai name, and an explanation of the function or role of that particular structure.

2. Average pre- and post-test scores for the experimental and control groups

The control group was made up of twenty-six individuals. The total score for the test was 24. For the control group, the pre-test mean score was 6.35, with a standard deviation of 2.61, and the post-test mean score was 13.92, with a standard deviation of 4.04. The growth in the post-test score in the control group was 7.58, with a standard deviation of 5.42. The findings showed that there was a statistically significant difference between the pre-test and post-test scores ($p = 0.00$) (Table 1).

The experimental group was composed of twenty-four students. The exam's full score was 24. For the experimental group, the pre-test mean score was 7.79, with a standard deviation of 2.73, and the post-test mean score was 20.10, with a standard deviation of 2.96. The post-test

growth difference in the experimental group was 12.31, with a standard deviation of 3.84. Table 1 exhibits a statistically significant difference be-tween the pre-test and post-test scores (p = 0.00).

Table 1 The number of average scores and standard deviations ($\bar{X}$ ± SD) of pre-test and post-test scores, as well as the difference between pre-test and post-test scores of the control and experimental groups.

Group	Number	Pre-test score	Post-test score	Growth in post-test score	Sig
Control	26	6.35±2.61	13.92±4.04	7.58±5.42	0.00
Experiment	24	7.79±2.73	20.10±2.96	12.31±3.84	0.00

Comparing between groups, the experimental group outperformed the control group in the pre-test, post-test, and growth in the test score. The pre-test mean scores for the experimental and control groups were 7.79±2.73 and 6.35±2.61, respectively. However, there was no significant difference among means in the pre-test scores between the two groups (p = 0.06). The experimental group had higher post-test mean scores than the control group, which were 20.10±2.96 and 13.92±4.04, respectively. The difference was statistically significant (p = 0.00). The growth differences in the pre- and post-test scores between the experimental and control groups were 12.31±3.84 and 7.58±5.42, respectively. According to statistics, there were significant differences (p = 0.00).

3. Satisfaction evaluation scores of AR teaching materials

Students are satisfied with the augmented reality instructional resources ($\bar{X}$ = 4.96 ± 0.04). The following statements represent the highest degree of satisfaction for all inquiries: the stereoscopic image is displayed; the narrative voice is clear; the labels are explicit; students' vocabulary memorization is improved; lessons are learned according to their interest without sorting; the lesson review is utilized at any time or location; the marker matches the content; there was rapid and precise scanning; the AR is simple to re-use; the media is trendy and motivated by novelty; learners' attention is drawn; and the AR is appropriate for the circumstances (Table 2).

Students in the experimental group who utilized media of fundamental animal anatomy using augmented reality expressed their opinions for the teaching materials:

1. They are conducive to learning as they offer contemporary, convenient, quick comprehension and learning.
2. They are simple to learn and easy to comprehend since they provide a useful strategy for remembering.
3. More animal models are something that students would like to see.

4. Students wish them to be animated.
5. Students want them to work with any mobile phones.

Table 2 Show the satisfaction level of the experimental group with the augmented reality technology teaching materials.

Category	List	$\bar{x}$ ± SD	Meaning
Content quality	1. The stereoscopic image is clearly displayed	5.00 ± 0.00	Very high
	2. The narrative voice is clear	5.00 ± 0.00	Very high
	3. The labels are explicit	5.00 ± 0.00	Very high
	4. Improve student vocabulary memorization	4.92 ± 0.28	Very high
	5. Learn according to interest without sorting	4.96 ± 0.20	Very high
	6. Utilize the lesson review at any time or location	4.96 ± 0.20	Very high
Media quality	7. The marker matches the content	5.00 ± 0.00	Very high
	8. Rapid and precise scanning	4.92 ± 0.41	Very high
	9. Simple to reuse	4.88 ± 0.45	Very high
	10. The media is trendy and motivated by novelty	4.96 ± 0.20	Very high
	11. Draw learners' attention	4.96 ± 0.20	Very high
	12. Appropriate for the circumstances	5.00 ± 0.00	Very high

Discussion

1. Basics Animal Anatomy Instrctional Media by Augmented Reality Technology

Based on the observations made by biology students of past generations, it was discovered that frog phobia was present in some students. Real or fixative-treated frogs cannot be used for operations. It impacted how this chapter was learned.

AR-based teaching resources are appropriate for teaching and learning in the contemporary classroom since they are easily accessible to students. They are free to pursue autonomous learning whenever and wherever they want. It is possible to translate abstract and unintelligible concepts into tangible language (Santos et al., (2016); Suwancharas, 2016; Yapici & Karakoyun, 2021). Universities may make the practice of online education public, especially in the case of a coronavirus outbreak as it is not permissible for students to study in the classroom. As a result, fresh frog or with fixative frog cannot utilize. Students may download the application and print the marker from anywhere they are using AR technology.

2. Average pre- and post-test scores for the experimental and control groups

The degree of knowledge of learners who use augmented reality technology media is statistically significantly greater than that of those who utilize other media (Budiman, 2016; Nuanmeesri et al., 2019; Radu, 2014), particularly augmented reality technology in three dimensions. (Godoy, 2020). In contrast to fixative treat frog media which require students to use worksheets and look for the organs in a frog, this developed medium displays frog details on labels, and when they press the label, a voice says the name of the structure in English and Thai along with the function of the organ. This makes it simpler for students to comprehend the labels.

3. Satisfaction evaluation scores of AR teaching materials

It has been discovered that a lot of contemporary students utilize tablets rather than notebooks (Fig 2A). Because of this, there is a lot of interest in AR education resources that allow students to download applications on their own devices (Fig 2B) which course, students have a very high satisfaction with AR teaching media.

However, AR technology teaching materials have some device limitations. The program may not work on Android phones that do not support AR applications; however, iOS devices are not affected by this problem.

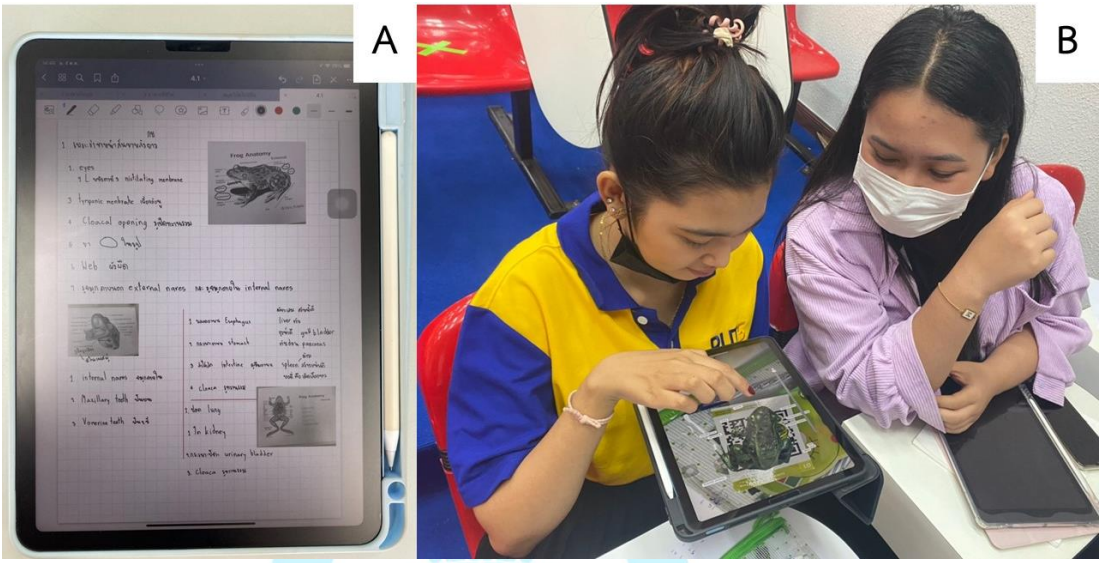

Figure 2 Students are drawn to the AR educational materials: Instead of using paper notebooks (A), students utilize tablets to access AR technology resources (B).

Conclusion

The results of this study show that students who use augmented reality technology in their studies achieve greater learning success than those who use traditional media. In terms of the students' opinions, they are satisfied with the displayed stereoscopic image, clear narrative voice, explicit labels, vocabulary memorization improvement, learning without sorting by interest, lesson review at any time or place, marker matching the content, rapid and precise scanning, simplicity in reuse, media being trendy and motivated by novelty, increasing attention, and appropriate media for the circumstances. In addition, learners have a positive opinion of the teaching materials as they provide contemporary, convenient, and quick comprehension for learning. However, some Android devices that do not support augmented reality applications restrict the use of this type of media.

Suggestions

All students have access to basic animal anatomy teaching resources that use augmented reality technology. They prefer to utilize AR technology rather than genuine or fixative-treated frogs since some of them are afraid of real animals. As a result, this format is appropriate for today's learners who prefer to utilize tablets instead of paper notebooks. Furthermore, AR teaching resources are appropriate for learners during the pandemic conditions as laboratory lessons are not available to them. This sort of material would be very beneficial for teaching and learning inside and outside the classroom.

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References

Aivelo, T., & Uitto, A. (2016). Digital Gaming for Evalutionary Biology Learning the Case Study of Parasite Race, an Augmented Reality Location-based Game. *Lumat*. 4(1), 1-26. https://doi.org/10.31129/LUMAT.4.1.3

Azuma, R., Baillot, Y., Behringer, R., Feiner, S., Julier, S., & MacIntyre, B. (2001). Recent Advances in Augmented Reality. *IEEE Computer Graphic Application* 21(6): 34-47. https://doi.org/10.1109/38.963459

Budiman, R. D. A. (2016). Developing Learning Media Based on Augmented Reality (AR) to Improve Learning Motivation. *Journal of Education, Teaching and Learning*. 1(2), 2477-4878. https://doi.org/10.26737/jetl.v1i2.45

Chang, R., Chung, L., & Huang, Y. (2013). Developing an Interactive Augmented Reality System as a Complement to Plant Education and Comparing Its Effectiveness with Video Learning. Interactive Learning Environments. 24(6), 1245-1264. https://doi.org/10.1080/10494820.2014.982131

Godoy, C. Jr. H. (2020). Augmented Reality for Education: A Review. *International Journal of Innovative Science and Research Technology*. 5(6), 39-45. https://doi.org/10.38124/IJISRT20JUN256

Holzinger, A., Nischelwitzer, A., & Meisenberger, M. (2005). Lifelong-learning support by m-learning: example scenarios. *eLearn*. 2005(11): doi: 10.1145/1125180.1125284

Jamali, S. S., Shiratuddin, M. F., Wong, K. W., & Oskam, C. L. (2015). Utilizing Mobile-Augmented Reality for Learning Human Anatomy. *Procedia-Social and Behavioral Sciences*. 2015(197), 659-668. https://doi.org/10.1016/j.sbspro.2015.07.054

Kesim, M., & Ozarslan, Y. (2012). Augmented Reality in Education: Current Technologies and the Potential for Education. *Procedia – Social and Behavioral Sciences*. 47(2012), 297-302. https://doi.org/10.1016/j.sbspro.2012.06.654

Likert, R. (1967). The Method of Constructing and Attitude Scale. In Fishbeic, M. (Ed.), *Attitude Theory and Measurement* (pp. 90-95). New York: Wiley & Son. https://doi.org/10.4324/9781315128948-23

National Research Ethics Committees. (2019). *Ethical Guidelines for the Use of Animals in Research*. https://www.forskningsetikk.no/en/guidelines/science-and-technology/ethical-guidelines-for-the-use-of-animals-in-research/.

Nuanmeesri, S., Kadmateekarun, P., & Poomhiran, L. (2019). Augmented Reality to Teach Human Heart Anatomy and Blood Flow. *The Turkish Online Journal of Educational Technology* 2019(18), 15-24.

Radu, I. (2014). Augmented Reality in Education: A Meta-review and Cross-media Analysis. *Personal and Ubiquitous Computing*. 18(6), 1533-1543. https://doi.org/10.1007/s00779-013-0747-y

Santos, M. E., Lubke, A. W., Taketomi, T., Yamamoto, G., Rodrigo, M. M. T., Sandor, C., & Kato, H. (2016). Augmented Reality as Multimedia: The Case for Situated Vocabulary Learning. *Research and Practice in Technology Enhanced Learning*. 11(1), 1-23. https://doi.org/10.1186/s41039-016-0028-2

Shelton, B. E., & Hedley, N. R. (2002, 29 September). *Using Augmented Reality for Teaching Earth-Sun Relationship to Undergraduate Geographic Students*. The First IEEE International Augmented Reality Toolkit. Darmstadt, Germany. https://doi.org/10.1109/ART.2002.1106948

Suwancharas, T. (2016). Development of Multimedia using Augmented Reality (AR) for Improving Undergraduates' English Listening Skill. *APHEIT Journal*. 5(2), 2-13.

Weng, C., Otanga, S., Christianto, S. M., & Chu, R. J. (2019). Enhancing Students' Biology Learning by Using Augmented Reality as a Learning Supplement. *Journal of Educational Computing Research*. 58(4), 1-14. https://doi.org/10.1177/0735633119884213

Yapici, I., & Karakoyun, F. (2021). Using Augmented Reality in Biology Teaching. *Malaysian Online Journal of Educational Technology*. 9(3), 40-51. https://doi.org/10.52380/mojet.2021.9.3.286