ASSESSING ONLINE INSTRUCTION: AN EVOLUTIONARY APPROACH

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ABSTRACT
In evolutionary biology, the contribution of those traits evolved by the natural selection process determines the fitness of an organism, that is, the degree to which it is successful in surviving and reproducing in its environment. The frequency of occurrence and usefulness of the traits determines the extent to which they contribute to that success. In an analogous manner, the contribution of those online courses traits identified by the instructional design process determines the fitness of the courses, that is, the degree to which they are successful in providing learning opportunities in their instructional environment. Again, their frequency of occurrence and usefulness of the traits determine the extent to which they contribute to that success. By 1) specifying those traits that contribute to success of online courses, 2) examining their frequency and evolution in existing courses, and 3) assessing their usefulness, this paper outlines a strategy for evaluating the fitness of online courses. As an example, the paper describes the application of the strategy to the population of online courses taught at the author's institution by first identifying the necessary instructional traits associated with successful online courses; namely; 1) the use of different pedagogical approaches that encourage student/student, student/faculty, and student/content interactivity and 2) the implementation of multiple strategies for the assessment of learning. An analysis of data from surveys completed by current online instructors reveals the frequency, evolution, and usefulness of these traits. The paper then provides a procedure for evaluating the overall fitness of the courses and making recommendations for improvement of their fitness. The paper concludes by demonstrating the applicability of this evolutionary approach to the evaluation of individual online courses.

KEYWORDS
Monitoring, assessment and evaluation in online environments, web-based learning environments

THE BASIS FOR THE EVOLUTIONARY APPROACH

In biology, an organism is a complex structure of interdependent and subordinate elements (molecules, cells, organs, etc.) whose function in the whole (to provide continued existence and opportunities for reproduction) determines their relationships and properties. In particular, evolutionary biology defines fitness as the degree to which the organism is successful in surviving and reproducing in its natural environment. The contributions provided by those evolved traits resulting from the natural selection process,, in turn, determine the degree or level of fitness. In addition, two types of traits are possible: namely, behavioral traits and physical traits. An example of a human behavioral trait is bipedalism, a very successful trait that contributed strongly to the survival and reproducibility of pre-humans as their environment changed from arboreal to terrestrial. However, bipedalism did not arise independently; it emerged as a result of the individual contributions to success of selected and evolved physical traits. With a spine to support and balance the cranium, a wider pelvis and angled femur to provide balance and permit more efficient locomotion, and arched feet to absorb the impact of upright walking, bipedalism evolved into a successful human behavioral trait (Figure 1 and Table 1).

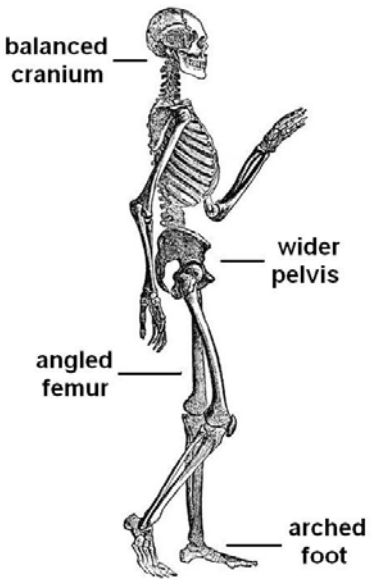


Figure 1. Skeletal physical traits

Table 1. Bipedalism physical traits

Behavioral Trait	Physical traits
Bipedalism	balanced cranium wider pelvis angled femur arched foot

Thus, the combined contributions of these successful physical traits enabled the successful behavioral trait of bipedalism to emerge and thus provide an enhanced level of fitness for pre-humans. Human speech and tool-making are further examples of this interdependent action of traits.

In an analogous manner, a population of online courses taught at an institution may function as an organism in that it possesses a complex structure of interdependent and subordinate elements (students, instructors, courses, etc.) whose relations and properties are largely determined by their function in the whole (to provide continued opportunities for learning). In a similar manner, the fitness of a population of online courses is the degree to which they are successful in providing learning opportunities in their instructional environments. This level of success is found by assessing the contributions to success of those traits identified as essential by the instructional design (ID) process. More specifically, the ID process identifies interactivity and assessment as two "behavioral" or instructional traits necessary for successful online courses (Swan, 2004). In particular, successful courses should

1) Use different pedagogical approaches to encourage student/student, student/faculty, and student/content interactivity and
2) Implement multiple strategies for the assessment of learning.

In this paper, interactivity corresponds to the technological system's ability to establish the traits stated in 1) rather than social or behavioral interactions (Roblyer and Ekhaml, 2000).

Just as the combined contributions of physical traits enabled the emergence of successful behavioral traits, the necessary instructional traits previously identified arise as a result of the contributions to success of selected pedagogical traits. As shown in Figure 2 and Table 2, these pedagogical traits specified by the instructional design process consist of demonstrated techniques or methodologies selected to enable the emergence of the necessary "behavioral" or instructional traits (California State University, Chico, 2004; University System of Georgia, 2005).

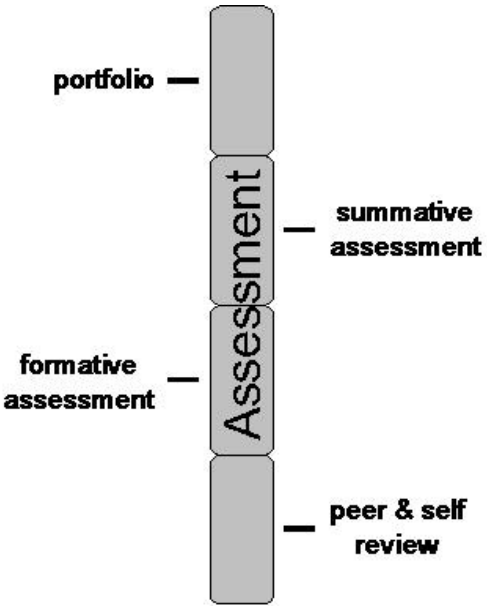


Figure 2. Assessment instructional trait

Table 2. Instructional and pedagogical traits

Instructional Traits	Pedagogical Traits
Interactivity Student/Student	threaded discussions collaborative group projects group problem solving resource and information sharing peer review of projects or reports learning style matched activities
Student/Instructor	regular communication ice breaker activity course calendars automated testing and feedback chats (synchronous or asynchronous)
Student/Content	PowerPoint (or similar) presentations audio/visual materials interactive simulations animations games/puzzles
Assessment	portfolio summative assessments formative assessments self and peer review

Thus, an evaluation of the pedagogical traits contributions to success leads to an assessment of the overall success of the instructional traits and ultimately the fitness level for the online course population.

EVALUATING TRAIT SUCCESS

The success of a specific instructional trait depends upon two factors: the frequency at which the pedagogical traits occur in the online courses and their usefulness in these courses. For instance, pedagogical traits appearing at a high frequency and usefulness result in a positive contribution to the success of the instructional trait and, ultimately, the fitness. If, on the other hand, the pedagogical traits do not occur very often and when they do appear have little use, the result is a negative contribution to the success of the instructional trait and overall fitness. Furthermore, pedagogical traits occurring infrequently but with high usefulness or frequently occurring traits of limited usefulness contribute either positively or negatively to the success of the instructional trait. Consequently, these contributions are marginal. The Instructional Trait Success (ITS) diagram shown in Figure 3 summarizes these and other possibilities by graphically representing the contribution to success for any combination of frequency and usefulness. As indicated, the range of frequency is from 0 (no appearance of the traits) to 1 (the traits appears in every case) and the range of usefulness of the traits extends from 1 (not very

useful) to 5 (very useful). Choosing a frequency of appearance of 50% or higher and a usefulness rated at 3 or above as the minimum criteria for a positive contribution to success allows for the division of the diagram into four quadrants of positive, marginal, and negative contributions to success.

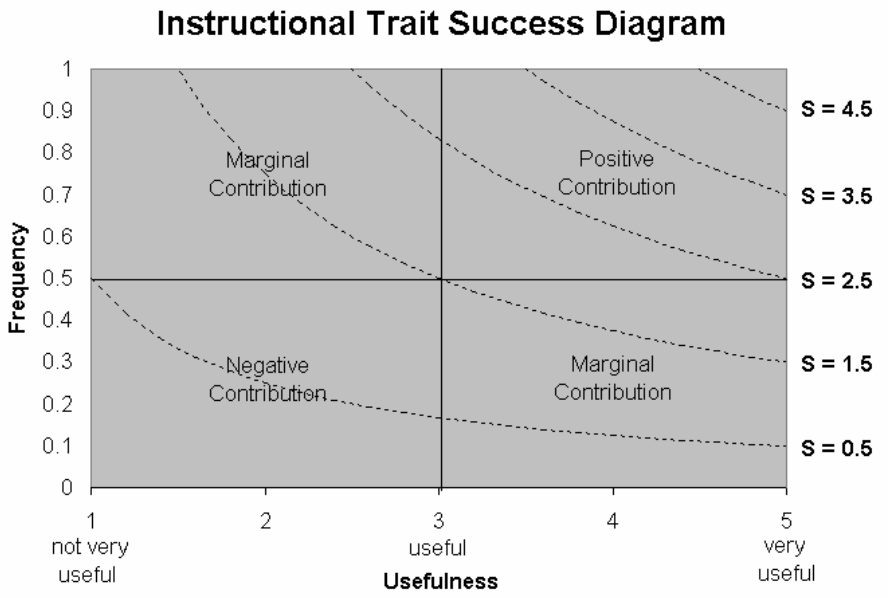


Figure 3. Instructional trait success diagram

As previously mentioned, the success of a specific instructional trait depends both the frequency at which the associated pedagogical traits occur and their usefulness. To quantitatively refine the ITS diagram, the overall success level **S** of an instructional trait is algebraically defined as the product of the average usefulness and average frequency of the contributing pedagogical traits, or

S = Average Usefulness x Average Frequency

Thus, possible instructional trait success levels range from 0 (pedagogical traits were not present in any case) to 5 (pedagogical traits were present in every case and were found to be very useful in all cases). In addition, the value of **S** increases in magnitude in the direction from the lower left-hand corner to the upper right-hand corner of the ITS diagram. Using the relationship between the usefulness and frequency for various values of **S** (indicated by the dotted lines in Figure 3), the ability to determine the level of success within each quadrant emerges. For example, **S** values that are located on the diagram in the positive contribution quadrant between the S = 3.5 and S = 4.5 confer a higher success level than values found between S = 2.5 and S = 3.5. Just as importantly, success levels found in the upper left-hand quadrant with $S \leq 1.5$ denote a greater potential to make a negative success contribution than levels in the same quadrant but located between S = 1.5 and S = 2.5. Thus, the ITS diagram functions as a tool to specify and compare success levels for instructional traits, thereby allowing for the determination of fitness. The following strategy serves as an example of the ITS diagram's part in finding the fitness of the population of online courses taught at the author's institution.

FITNESS EVALUATION STRATEGY

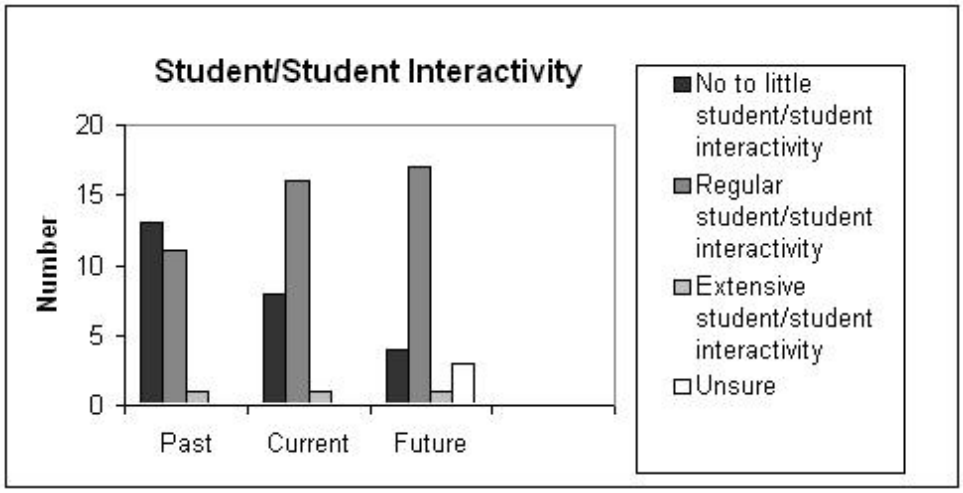
As shown in Table 3, three steps comprise the strategy for determining the fitness of the population of online courses.

Table 3. Fitness evaluation strategy

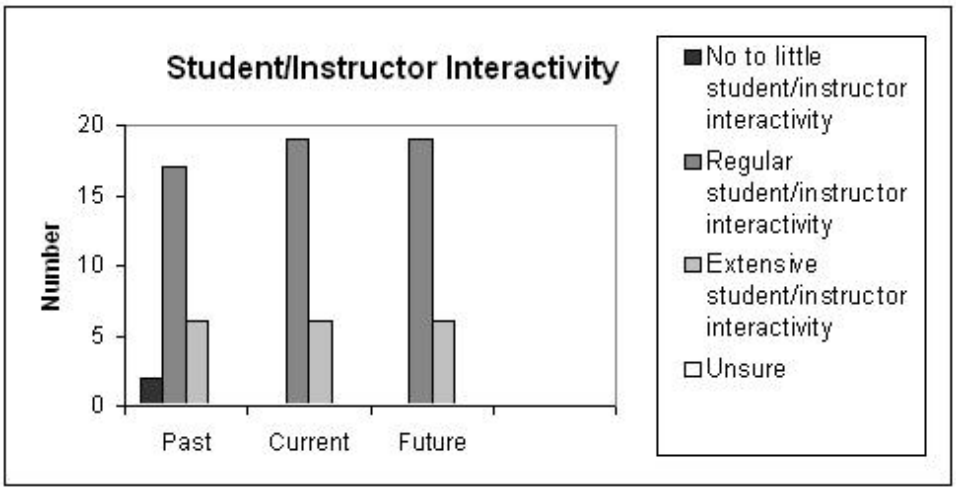
Fitness Evaluation Strategy
1. Identify those necessary instructional traits in the current population of courses under investigation. In addition, determine the emphasis given to those identified traits in the design of past, current, and anticipated future courses. 2. Determine the frequency and usefulness of the pedagogical traits associated with each instructional trait and the success level of the identified instructional traits. 3. Evaluate the fitness of the population of courses and list recommendations to improve the fitness.

Step 1 - Identify those necessary instructional traits in the current population of courses under investigation. In addition, determine the emphasis given to those traits in the design of past, current, and anticipated future courses.

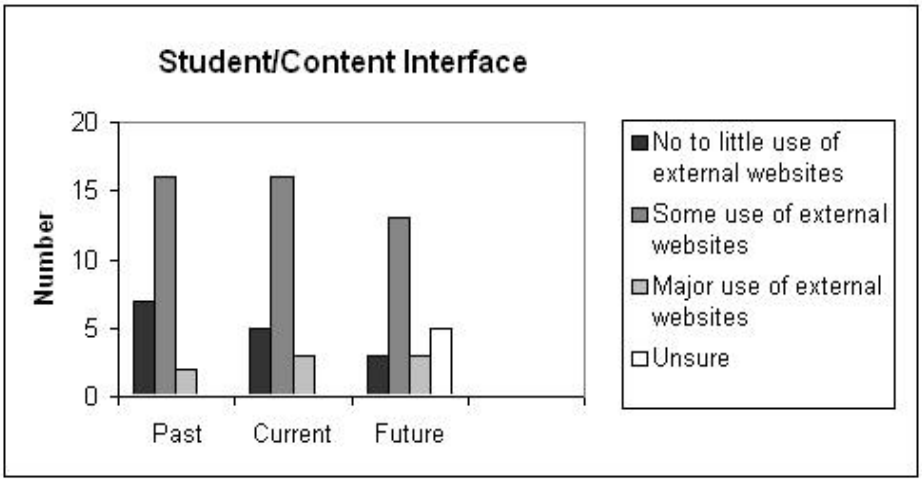
An online survey of the current online instructors at the author's institution yielded the information necessary to complete this step. In addition to determining the presence of an instructional trait, the survey asked what emphasis this trait was or would be given by the instructor in past, current, and future courses. From a total of 32 current instructors, 25 responded to the survey, with the results shown in Figure 4.



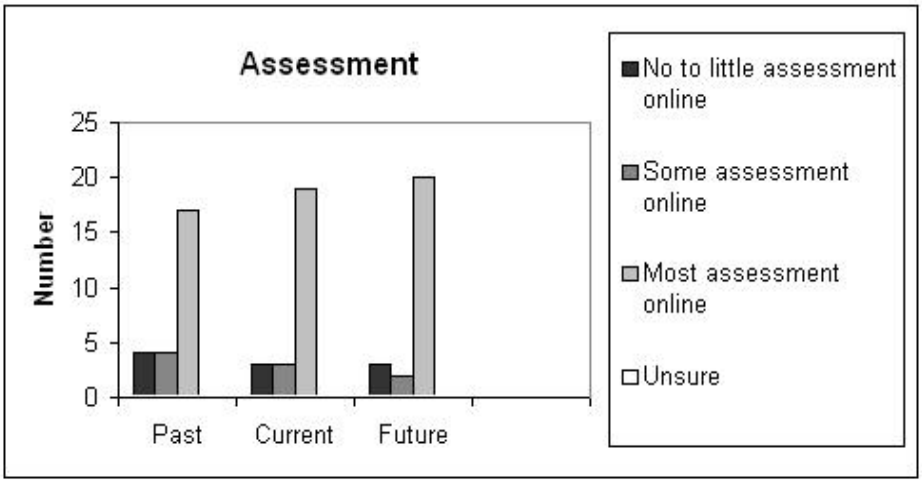
As seen, the Student / Student Interactivity data, this instructional trait occurs in at least 68% of current courses. In addition, this trait is evolving toward a greater than 84% presence in the future.



Survey results indicate that Student / Instructor Interactivity is present in all current online courses and will continue at this level in the future. Initially, only two courses did not have this trait.



Student / Content Interactivity data shows this trait present in 79% or more of current courses with the number increasing to 88% or more in the future. Again, the data shows an evolving trend toward a greater presence of this trait.



The results for the Assessment trait indicate a presence of 88% or greater for both current and future courses, with a slight trend toward a higher occurrence of this trait in the future.

Figure 4. Evolution of instructional traits

In summation, the four necessary instructional traits occur in greater than 68% of all online courses. Furthermore, the survey results indicate a possible evolution to higher occurrence of the Student/Student, Student/Content, and Assessment traits.

Step 2 - Determine the frequency and usefulness of the pedagogical traits associated with each instructional trait and their contributions to the success of the identified instructional traits.

This step requires the use of the Instructional Trait Success diagram (Figure 3). As previously discussed, the ITS diagram graphically represents the contribution of the pedagogical traits frequency and usefulness to the success level of the instructional traits. A follow-up survey to online instructors gathered the data used for this step. Specifically, the instructors identified the pedagogical traits present in their class or classes and then rated their usefulness on the scale 1 – not very useful, 2, 3 – useful, 4, 5 – very useful. Table 4 shows the results of the follow-up survey, along with the average frequency and usefulness for each trait and the calculated success levels for each instructional trait.

Table 4. Pedagogical trait frequency, usefulness, and success data

Pedagogical Traits for Student/ Student Interactivity Trait	frequency	Usefulness
Threaded discussions	0.83	3.58
Collaborative group projects	0.52	2.33
Group problem solving	0.39	2.78
Resource and information sharing	0.87	3.16
Peer review of projects or reports	0.26	3.17
Learning style matched activities	0.17	3.00
Average	0.51	3.00
Success level **S**	1.5	

Pedagogical Traits for Student/ Instructor Interactivity Trait	frequency	Usefulness
Regular communication	0.96	4.72
Ice breaker activity	0.91	3.67
Course calendars	1.00	4.41
Automated testing and feedback	0.91	4.00
Chats (synch/asynch)	0.74	3.41
Average	0.90	4.00
Success level **S**	3.6	

Pedagogical Traits for Student/ Content Interactivity Trait	frequency	usefulness
PowerPoint (or similar) presentations	0.83	3.79
Audio/visual materials	0.65	3.80
Interactive simulations	0.31	3.43
Animations	0.22	3.40
Games/puzzles	0.26	3.00
Average	0.45	3.48
Success level **S**	1.6	

Pedagogical Traits for Student/ Assessment Trait	frequency	usefulness
Portfolio	0.27	4.17
Summative assessments	0.96	4.27
Formative assessments	0.96	3.41
Self and peer review	0.32	3.00
Average	0.63	3.71
Success level **S**	2.5	

Figure 5 shows the plot on the ITS diagram of the average frequency and usefulness values for the pedagogical traits of each instructional trait shown in Table 4.

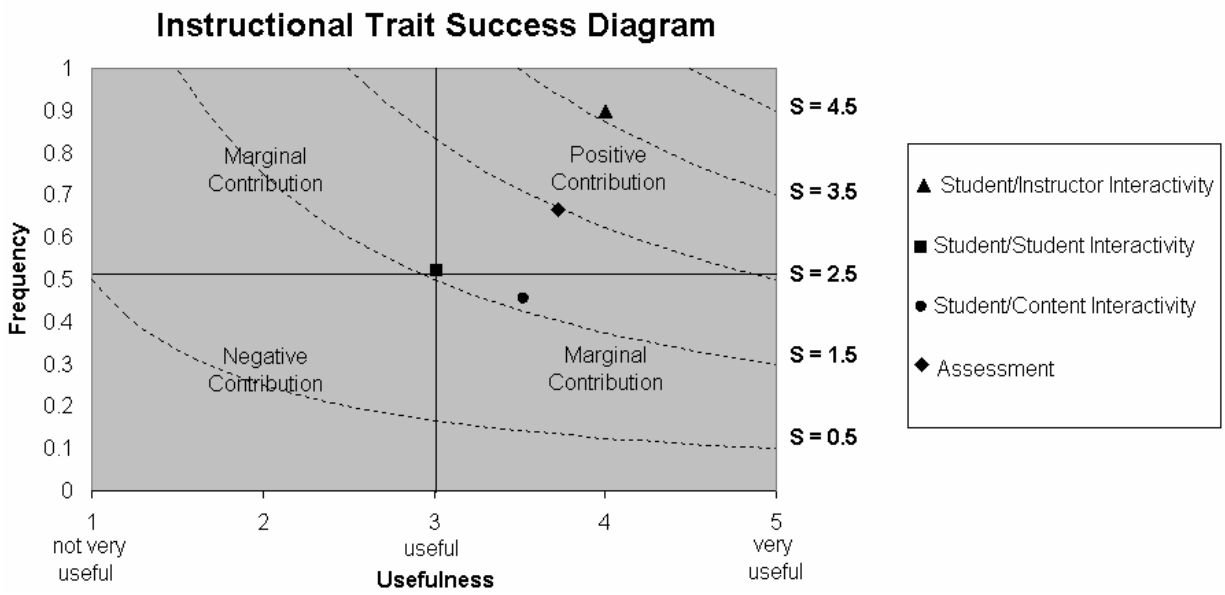


Figure 5. Online courses instructional trait success diagram

Step 3 - Evaluate the fitness of the population of courses and list recommendations to improve the fitness.

As seen from the ITS diagram, the pedagogical traits contribute positively to the success of both the Student/Instructor Interactivity and Assessment instructional traits. As mentioned previously, the contribution to success increases approaching the upper right hand corner of the diagram. Thus, the Student/Instructor interactivity trait contributes at a high success level to the overall fitness with the Assessment trait making a moderately positive success contribution. Since the fitness of a population of online courses is the degree to which they are successful in providing learning opportunities in their instructional environments, the success of these two instructional traits confer a moderate to high degree of fitness to the online courses. The use of more portfolios and more frequent and useful self and peer review offers possible ways to further increase the contribution of the Assessment trait to the overall fitness.

Of particular interest are the locations of the Student/Student Interactivity and Student/Content Interactivity success levels. The pedagogical traits associated with these instructional traits make marginal contributions to success and therefore do not contribute either positively or negative to the fitness of the population of courses. The marginal contributions of the Student/Student and Student/Content Interactivity traits offset the moderate to high degree of fitness due to the Student/Instructor Interactivity and Assessment instructional traits resulting in an overall fitness level for the online courses of low to moderate.

Raising the frequency and or usefulness of the associated pedagogical traits provides a possible route to increasing the contributions of the Student/Student and Student/Content Interactivity and improving the overall fitness. In addition, a review of the survey data in Table 5 suggests that an increase in the usefulness of resource and information sharing and an enhancement in both the frequency and usefulness of collaborative group projects, group problem solving, peer review of projects or reports, and learning style matched activities offers a potential path to higher fitness. Similarly, improvement of the Student/Content Interactivity trait success level may require improvements in the frequency and usefulness, when applicable, of interactive simulations, animations, and games/puzzles. For those applicable pedagogical traits of low frequency and or usefulness as previously identified, faculty in-

service or workshops and mentoring by experienced online faculty present a means to assist in bettering the contributions to success and, therefore, the fitness of the instructional traits in question.

Importantly, the trends in Figure 4 toward more inclusion of student/instructor and student/content interactivity present the possibility of increased contributions to the success of these instructional traits. Survey comments offered by instructors, such as

"… I gained more confidence in handling things online. I also wanted to get some group work started to simulate classroom discussions and activities … As the course matured, I was able to find more materials and more course related websites … I [now] require live chats … More current and updated materials available … I reworked the course so that all student questions would be answered in the syllabus …Part of the beauty of my traditional courses is the student-student interactions. That was lacking from my online courses, so I made changes to rectify that …Quite frankly, I wanted to design something that relieved my workload – answering redundant questions via emails, etc. …More sites with good/reliable information … moved to an online video lecture format that is prepared and delivered via CD-ROM to reduce long download times …",

suggest that the contributions of these traits to the overall fitness has the potential to improve as the skills of the instructors improve. In the same sense, the consistently high occurrence of both the Student/Instructor Interactivity and Assessment traits found in Table 4 suggest that there has been greater time for the associated pedagogical traits to evolve and contribute at higher levels to the success and fitness.

Furthermore, not all pedagogical traits listed in Table 2 are applicable to all courses. The comment by one instructor "*The amount of student/student interaction depends upon the course. In one course I don't require any at this point. In another, regular forum participation is a required component of the course*" is indicative of this variable applicability. For example, the use of interactive simulations may occur with a high frequently and usefulness in a physics course, yet are not applicable or even available for a mathematics course. However, the lack of interactive simulations in mathematics may provide an opportunity for their development in such courses where they are not currently found. In addition, a decrease in a particular trait contribution may occur, as evidenced by the instructor comment that student/student interactivity was "*too difficult and time consuming to monitor*".

Survey comments also reveal other pedagogical traits that work well in courses. Instructor review of assignments prior to due dates and reflection papers to identify important concepts and applications may possibly contribute to the success of the Assessment instructional trait. Instructor-provided examples are another very useful pedagogical trait that may contribute to the success of the Student/Content Interactivity trait.

From the above discussion, three factors which affect the previously determined low to moderate overall fitness level for the online courses emerge: 1) the evolving abilities and needs of the instructors, 2) the applicability of certain traits, and 3) the possibility of useful pedagogical traits other than those listed in Table 2. These factors suggest that the results shown in Table 4 may represent a lower limit of success levels in the population of online courses and not an complete measure of success.

The fitness evaluation strategy described here now may be adapted to determine the fitness of an individual course.

EVALUATING THE FITNESS OF INDIVIDUAL COURSES

The fitness of the online Astronomy course taught by the author provides an example of the application of the previously discussed evaluation process to an individual course. Table 5 illustrates the results of the first two steps of the evaluation strategy by showing the pedagogical traits present, the supporting activities used to develop these traits and the frequency and usefulness values of these activities (shown

in parenthesis). The following adaptations must be made when evaluating the information found in the table.

1) An online survey completed by students in the course, not the instructor, determined the frequency and usefulness data for those activities supporting the pedagogical traits of individual courses**.**
2) Two or more pedagogical traits may address a particular supporting activity and a particular activity may support more than one pedagogical trait. Such is the case as shown in Table 5 for group essays, external websites, weekly homework, and quizzes. In these cases, the average frequency and usefulness calculation included all the supporting activities.
3) A supporting activity present in a course automatically has a frequency equal to 1 as indicated in the table. This has the effect of causing potentially large increases in strength values. Furthermore, if a trait is not present, required, or applicable, the frequency is equal to 0 and large decreases in calculated strength levels are possible. Therefore, the success level values **S** extended over a range from minimum values determined by the inclusion of all non-present traits shown in Table 5 to maximum values found using only those traits present.

Table 5. Individual course pedagogical trait frequency, usefulness, and success level data

Instructional Traits	Pedagogical Traits	Supporting Activity	**S** range
Interactivity			
Student/Student	threaded discussions	group essays (1/3.4)	0.85 - 3.4
	collaborative group projects	group essays (1/3.4)	
	group problem solving	not present (0/0)	
	resource/information sharing	not present (0/0)	
	peer review of projects/reports	group essays (1/3.4)	
	learning style matched activities	not present (0/0)	
Student/Instructor	regular communication	weekly updates/homework (1/4.6) / (1/4.3)	2.8 – 4.0
	ice breaker activity	not present (0/0)	
	course calendars	timeline (1/4.9)	
	automated testing and feedback	quizzes (1/4.3)	
	chats (synch/asynch)	synchronous chats (0.68/3.4)	
Student/Content	PowerPoint (or similar)	PowerPoint tutorials (1/4.2)	2.2 – 3.5
	audio/visual materials	external websites (0.93/3.5)	
	interactive simulations	external websites (0.93/3.5)	
	animations	external websites (0.93/3.5)	
	games/puzzles	not present (0/0)	
Assessment	portfolio	not present (0/0)	2.8 – 4.0
	summative assessments	online exams/group essays (1/4.4) / (1/3.4)	
	formative assessments	weekly quizzes/homework (1/4.3) / (1/4.3)	
	self and peer review	group essays (1/3.4)	

When graphed, the information in Table 5 results in an ITS diagram for the course, as shown in Figure 6.

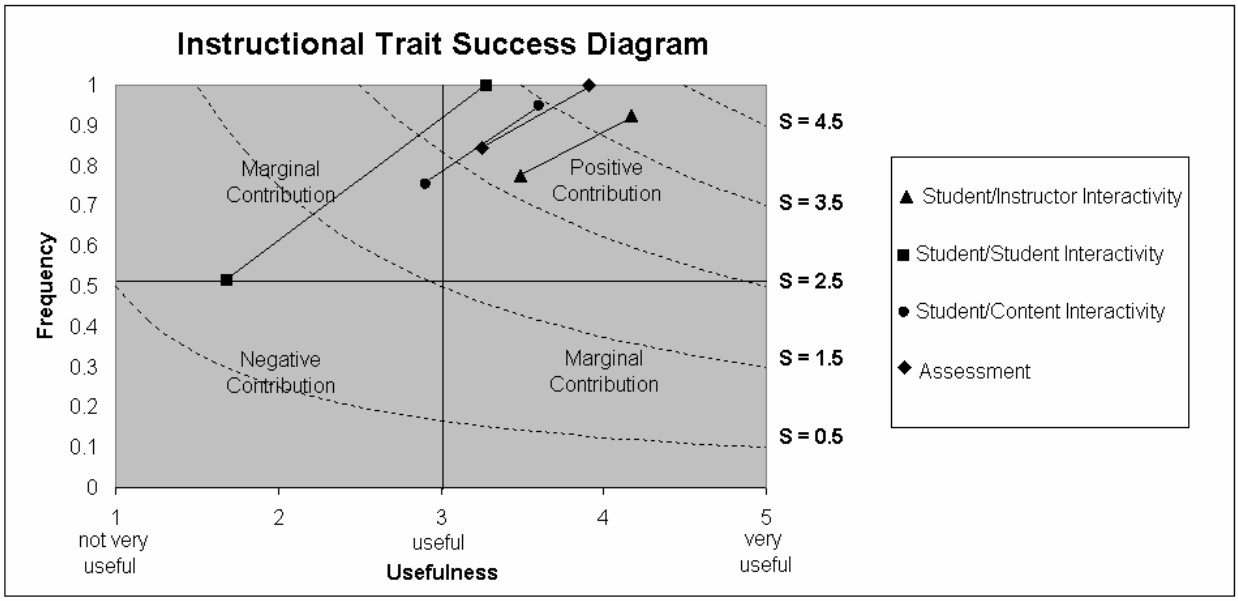


Figure 6. Individual course instructional trait success diagram

The fitness evaluation strategy now proceeds to the final step. The results as indicated in the diagram are similar to those seen in Figure 5 for the population of online courses. The Student/Instructor Interactivity and Assessment success level values suggest a moderate to high degree of fitness for the course. The inclusion of course calendars and portfolios are the only additional supporting activities that may improve the success levels. Similarly, the incorporation of games or puzzles as supporting activities suggests a way to increase the strength level of the Student/Content Interactivity trait. However, the wide success level range for the Student/Student Interactivity trait weakens the contribution to the course fitness, as was the case in the total online population of courses. Thus, the outcome of the assessment is a low to moderate overall fitness level determination for the course.

As highlighted in Table 5, the source of this weakness is two-fold – the absence of several supporting activities and moderate success levels for those supporting activities present in the course. Hence, the use of group problem solving, resource/information sharing, and learning style matched supporting activities at success levels above 3.5 suggests the most direct way to improve the success level of the Student/Student Interactivity trait and thus the fitness of the entire course. In addition, improvements in the fitness levels of existing supporting activities (threaded discussion, collaborative group projects, and peer review of projects/reports) are also crucial for increasing the trait success and, in turn, the overall course fitness level.

CONCLUSIONS

Adapting ideas from evolutionary biology, this paper demonstrates a strategy for assessing the fitness of a population of online courses by evaluating the success of pedagogical traits in supporting necessary instructional traits. In carrying out this assessment, areas of improvement in the success of traits emerge. In particular,

- The results show the student/instructor interactivity and assessment instructional traits provide a high degree of fitness resulting from moderate to high success levels of the pedagogical traits.
- Conversely, the contribution of the pedagogical traits supporting the student/student interactivity and student/content instructional traits reflect the low levels of success of the

associated pedagogical traits. These levels reduced the overall fitness of the courses to low to moderate.

- Increases in the frequency and usefulness of collaborative group projects, group problem solving, peer review of projects or reports, and learning style-matched activities are specific ways to achieve a higher fitness level. The use of faculty workshops and mentoring are a means to achieve these improvements. Additionally, the course management systems (CMS) used for course delivery may have an important impact on both the frequency and usefulness of a pedagogical trait.

When applied to an individual course, the assessment strategy resulted in the following outcomes –

- As was the case for the overall population of courses, the student/instructor interactivity and assessment instructional traits, along with the student/content interactivity trait, provide a moderate to high degree of fitness resulting from the high success levels of the associated pedagogical traits.
- As with the overall population of courses, the individual course fitness diminished as a result of the lower contribution to success of the student/student interactivity instructional trait.
- Increasing the success levels through improvements in the usefulness and frequency of existing pedagogical trait supporting activities (threaded discussion, collaborative group projects, and peer review of projects/reports) offers a possible means to improve the course fitness.
- The use of group problem solving, resource/information sharing, and learning style matched supporting activities at sufficiently high success levels suggests the most direct way to improve the overall fitness level of the course.

The author wishes to thank Dr. Steven Aquilani, Assistant Professor of Biology at Delaware County Community College, for many invaluable discussions regarding evolutionary biology.

Note: The surveys referred to in this paper may be found at the following URLs –

The Evolution of Online Instruction: http://chnm.gmu.edu/tools/surveys/2369/
Instructional Traits in Online Courses: http://chnm.gmu.edu/tools/surveys/2502/
Introduction to Astronomy Course Survey: http://chnm.gmu.edu/tools/surveys/2707/

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