



A Diverse Observance of Life: Multiple Intelligences in Biology

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Abstract <p>The International Baccalaureate (IB) Program requires all diploma candidates to complete a minimum of one course from each group of its curriculum. Beyond this, candidates must complete a Theory of Knowledge course, which focuses on learning and what knowledge entails from various viewpoints, and a Creativity, Action, and Service requirement involving collaboration with surrounding communities. This is meant to ensure that diploma recipients are well-rounded, internationally-minded citizens of the 124 countries where IB schools can be found. Within the classroom setting, it promises that students are exposed not only to subject matter from a variety of different fields, but also that they may fathom the different ways of thinking found in different fields or different cultures and even appreciate different methods of learning the same material.</p> <p>Howard Gardner's theory of Multiple Intelligences (MI) is applied to the IB Biology course at Joensuu Lyseon Lukio in Joensuu. It is believed to be a most appropriate approach to such a course, where several students are attending out of obligation, others are attending out of a passion for science, and others aren't sure why they are attending. A Moodle workspace that features various materials meant to stimulate various intelligences has also been established. The purpose of the workspace is to compliment rather than supplement the biology course. The social constructivist nature of the workspace is also meant to appeal to an experiential learning style. It is the first such workspace for any biology course at the school.</p> <p>The twenty students of the course were asked to complete a brief survey concerning their individual intelligences. Upon the completion of the survey, individuals could see a representation of their individual intelligence makeup. All of the eight intelligences of MI theory were represented as a high score for at least one individual in the group. Galvanizing all intelligences has required a diverse approach to teaching that requires the teacher to view familiar material in new ways. It also lends the course a sundry flavour while remaining scientifically coherent and effective in the delivery of learning material. To date, students have been active in the Moodle workspace, but they have mainly used it to retrieve information. It is hoped participants will realize the impacts they might have on the information found on the workspace in the future.</p>		
Keywords Multiple Intelligences, Moodle, International Baccalaureate Program, Intelligence, Learning styles, Biology		
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1 INTRODUCTION

This paper summarizes the final project for the Vocational Teacher's Education at Jyväskylä University of Applied Sciences. The project was carried out for and at Joensuu Lyseon Lukio, International Baccalaureate (IB) Diploma Program Line, in Joensuu. The aspirations for this project were twofold. The first and foremost aim considered teaching and learning strategies for a diverse group of international students beginning the two-year IB biology course. The second and related goal of the project was to provide the IB Biology students with an online workspace.

In a similar manner to previous IB biology classes, the intentions for taking the course varied from serious academic scientific pursuit to fulfilling a science course requirement. In previous years, a failing grade in the biology course had led to a handful of students not receiving the IB diploma and therefore having to retake exams or continue without a high school diploma. This is a tragic outcome for students who are, quite frankly, smart. This occurred in different years with different teachers. It is believed that a possible reason for the failing grades may be related to the manner in which the course material is presented, i.e. it may have primarily appealed to the scientifically inclined. This produced several stimulating and cascading questions:

- How can biology be taught in ways that appeal to all styles of learning?
- What role does intelligence play in determining the type of learner?
- Is intelligence one fundamental unit, or are there several intelligences?
- If intelligence is indeed multi-faceted, whether independent intelligences exist or if they are related, how should the biology teacher challenge and invigorate these intelligences?

Howard Gardner's theory of Multiple Intelligences is reviewed in this paper. Of the various viewpoints on intelligence, this one seems rather feasible to apply in a classroom as a means of appealing to diverse learners. It has been a favorite application of a vast number of teachers, mostly but not limited to those in the United States. It does not, however, seem appreciated by a large number of educational researchers, the reasons for which are discussed later. The theory can be applied to theories based on learners. To understand a learner, one must also understand the essential role the intelligence or *intelligences* of each learner plays. Both Kolb's (1984) learning styles and experiential learning theories can be applied through the lens of Multiple Intelligences; however, it must be stressed here that experiential learning in a pure form is probably best applied

in teaching adults. Considering Kolb's constructivist approach and that Multiple Intelligences is greatly concerned with cognition, the project does not claim to stick solely to any paradigm, for knowledge in high school biology can be conceived of as both positivistic and constructivistic. Much of the knowledge is outside of the learner, particularly at the outset of a course, but applications and analysis of knowledge (which the International Baccalaureate Program considers critical) are also crucial.

I chose to apply Multiple Intelligences theory to the biology course for other various reasons as well. Firstly, I believe students have certain intellectual assets that cannot be categorized into language or logic and which are rarely tapped by teachers in a science course. Secondly, exposing these assets through a student-centered approach may and should help students realize their own strengths as learners as well as areas where development is needed. Lastly, a biology course which is taught with pedagogic diversity, provided that the approach does not impede the learner from the scientific truths of the subject or from understanding how science works, will avoid becoming mundane both for the teacher and all students. Additionally, and admittedly unscientifically, it will also be enjoyable.

The author recognized a need for an online space, and was also encouraged to create one by the assistant principal of the school, Mr. Viljo Hurskainen. The workspace is the first of its kind for any biology course at the school. For most of the second year students attending the IB biology course in the fall of 2006, it is their first exposure to an online workspace. Moodle Web pages are the format for all such workspaces at Joensuu Lyseon Lukio. The design of the workspace and the materials that can be found are meant to appeal to all intelligences found in the Multiple Intelligences theory. Furthermore, the social constructivist possibilities of Moodle provide for active experimentation, a further formation of abstract concepts, and possible reflection, all of which are essential aspects of Kolb's (1984) learning cycle.

2 THE STUDY OF BIOLOGY

Pinpointing the parameters of the study of biology is time- and sociologically dependent. As a natural science, biology's fundamental rules and theories are based on the scientific process. Its subject matter is based on a blend of physics, chemistry, mathematics, even geology (Dowdeswell 1981). Its uniqueness is apparent in that it deals with living organisms. While the chemist views a beaker of water as a landscape of hydrogen and oxygen atoms bound together, the biologist envisions a potential habitat for numerous organisms, whose relations with one another and the aquatic environment itself will be loosely governed by several norms, physical, chemical, and specifically biological. Biology can and should be separated from other subjects; the living criterion for the subject sets it apart and warrants the entity as something more than an extension of chemistry or physics.

Because biology concerns living things, it may be an appealing option for younger students. The concepts of exploring, invention, and discovery in natural sciences and particularly biology may be likened to children exploring and discovering in backyards, gardens, parks, etc (Lawson & Renner 1975). From an early age, children are curious about their surroundings, including in large part the sights, sounds, feelings, and smells associated with other living things. Furthermore, children readily apply living characteristics to inanimate objects (toys made from any material, rocks, dead branches, etc.). An initial curiosity may or may not mature into a formal, academic interest and pursuit of biological understanding. Adding to the appeal of biology is that the subject also requires its students to consider the human condition, from ecological relations to our species' story as told through evolution.

One feature of the subject is the tendency to undergo spurts of enormous growth in the amount of subject information (Novak 1970, Dowdeswell 1981). One only needs to consider the discovery of the structure of DNA by Watson, Crick, Franklin, and Wilson in 1953 to appreciate the groundbreaking discoveries that reshape the world, not to mention the study of biology. Such discoveries should lead to consideration, reviewing, and revision of syllabuses and science curricula. The focus of the study of biology at the secondary and higher levels has notably shifted from a form-and-function anatomical emphasis to a strategy which is more student-oriented (practical work) and acknowledges issues such as conservation, population growth, and even personal relationships (Dowdeswell 1981). This focus should not become too blurred though. "Biologists have accumulated huge amounts of information about living organisms and it would be easy to confuse

students by teaching large numbers of seemingly unrelated facts” (IBO 2001; 35). A sound biology curriculum for the high school level should include some specific factual knowledge, but more importantly it must encourage students to develop a wide-ranging general understanding of the subject. The grand scale of biology makes pinpointing its essential aspects and applying these essentials in school curricula a challenge.

The two-year International Baccalaureate biology course includes four basic ideas that run throughout and link all information covered. These ideas are (IBO 2001): structure and function, universality versus diversity, equilibrium within systems, and evolution. It is hoped that these central concepts would unite the various topics the syllabus includes. However, a curriculum published in 2001 may not do justice to the biological world of 2006. While the essentials may remain relatively static, the details and highlights constantly “evolve” (pun intended). Biology teachers therefore need to stay on top of recent developments in the subject and incorporate this new knowledge not found in a syllabus into learning material.

Conversely, methodologies applied in teaching biology need to enhance competency in society. Anatomy dominated curricula surely will fall short of providing students with competency or even a literate understanding of today’s living world. A shift towards individual focus in learning requires a degree of metacognition from instructors in any attempt to understand learners. The manner in which the subject is taught impacts not only the learning of students, but possibly how those individuals perceive science learning and even the work of scientists in general (Finson, Pedersen, & Thomas 2006).

Methods of instruction inherently make assumptions. When giving contact lessons, it is assumed that for learning to take place, a student needs to be present. In the case of web-based learning, it is assumed that students have access to the Internet. Ideally, all students would have equal access to computers of equitable value. This may be true concerning computers in the school; however, the situation in students’ homes may vary greatly, and some students may not have access to the Internet at home. With this in mind, it is still believed that a student will have access to some computer even every day if needed. If a student has not attended a certain contact lesson, the material covered might not be learned. Many students try to compensate missed lessons by borrowing notes from their peers, or simply asking the teacher for some sort of handout from the missed lessons. Student-centered learning, however, requires to a great extent active participation of learners, and for example group work can hardly be accomplished on one’s own. A web-based

environment could provide solutions for such a situation. In a web space, students would have practically instant access to material covered in class as well as an opportunity to review class material in the form of a variety of Internet links and discussion boards.

2.1 Secondary Level Biology

Students learn differently and have different ways of reasoning. Science teachers might be surprised to find that their students have a method of reasoning different from each other as well as that of the teacher with regard to scientific investigations. Selecting variables, recognizing the parts of a collective whole, and understanding or applying ratios may all illustrate how students rationalize differently (Karplus et al. 1980). At the high school (secondary) level, students can be broadly grouped into one of two categories: those students with an avid interest in the subject and possible aspirations to pursue a career in the sciences, and those students who take a biology course for other reasons (e.g. a compulsory course, a vague interest in the subject, friends are attending the course). This inevitably leads to a classroom filled with numerous learning styles, and as will be argued later, possibly different kinds of intelligences.

2.2 The IB Diploma Program

Students entering IB high schools in Finland face an academically rigorous road ahead. The program undoubtedly strives to establish the study skills and learning abilities that are necessary later on in the academic realm. The workload in general combined with numerous deadlines serves as a preparatory tool for working life as well. Factual information is plentiful but definitely not the sole means of learning. The IBO aims to (IBO 2005; A1), “develop inquiring, knowledgeable, and caring young people who help create a better and more peaceful world through intercultural understanding and respect.” Learning goals for individuals in the two-year program are to (IBO 2005):

- ask challenging questions
- learn how to learn
- develop a strong sense of their own identity and culture
- develop the ability to communicate with and understand people from other countries and cultures.

The program is divided into six large groups understood as six areas of competence in members of society. These groups, as shown in Figure 1, are: mother tongue (A1), second language, individuals and societies, experimental sciences, mathematics and computer science, and the arts. Within the center of the “IB hexagon”, three crucial and in some ways unique elements can be found. They are 1) the extended essay, in which a student must prepare an academic paper of his/her own, 2) Theory of Knowledge, which could be described as a course in philosophy/ethics viewed through the six different lenses of the hexagon, and 3) CAS, in which students must be active members of a local community through creativity, action, and service.

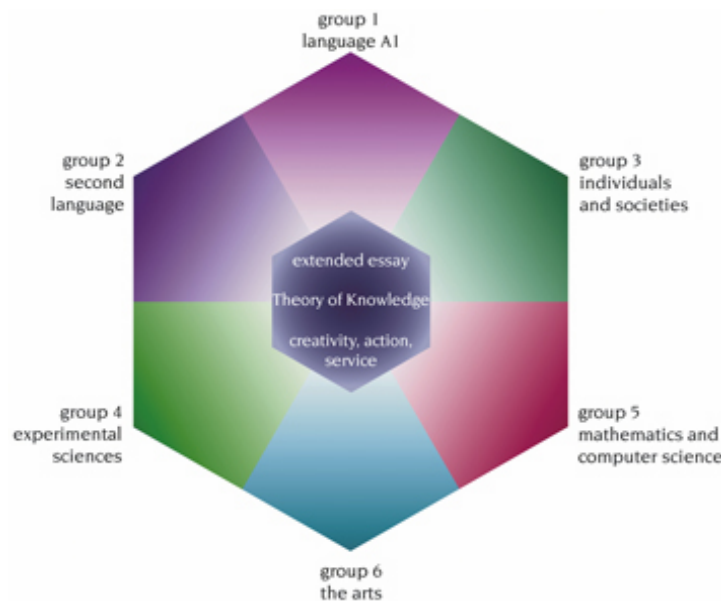


Figure 1. The IB hexagon, complete with six groups and the core.

Completion of the IB diploma requires students to complete a minimum of six subject courses, and at least one from each group. Students at Joensuu Lyseon Lukio are currently allowed to choose from 5 of the groups, as funding and demand for the arts does not currently exist (IB students may choose to pursue art studies in the national line). Typical students take on the six-subject load, while other students pursue an even more demanding seven-course load. Whatever the case may be, all groups must be represented. If a student is particularly interested in language learning, he/she still must complete a course in the natural sciences (biology, chemistry, or physics). Likewise, the aspiring scientist must study a first and second language as well as pursuing a course from group 3 (e.g. psychology, economics, or history). The rather obvious intention here is the development of well-rounded minds for citizens of the world. The scientist ideally has awareness of the society in which he/she exists, and linguists and sociologists should be scientifically literate, at least to some

minimal extent. Furthermore, one can argue that when learning in a subject outside the realm of expertise, a broadening of the perspective of that very subject may occur. For example, the young biologist stands to gain much from learning Latin or from understanding basic principles of economics, as knowledge in these subjects may enhance understanding of how living organisms are named or the intricacies of the medical industry, respectively.

Nonetheless, this pursuit of well-roundedness poses some difficulties. Learning outside the realm where one is most comfortable requires an adaptation of the learning process, a refocusing of the learning lens. This ability to adapt one's view on diverse subject matter is more often assumed than actually realized. Exactly why some individuals excel in some facets of a curriculum while struggle in others is not entirely understood.

The focus of this paper next turns to the main theory behind the project and eventually how the theory has been implemented. The following investigates one fundamental aspect of the learning process: namely, the concept of intelligence. It provides a glimpse into perspectives of intelligence, focusing on the consideration of several intelligences and the role they play in learning.

3. CONCEPTS OF INTELLIGENCE

It is beyond the scope of this project paper to address in detail the numerous theories, theorists, and components of intelligence. This section briefly focuses on one fundamental aspect of intelligence by considering whether there is one all-encompassing intelligence, if separate and distinct intelligences exist, or whether the truth is more so a combination of the two.

The traditional consensus in the 1900s considered the exemplification of intelligence through test performance. A unitary view of intelligence assumes the existence of a general intelligence, often abbreviated *g*. Empirical evidence supporting this data would show individuals scoring high on various, unrelated tests. In other words, if an individual would score high on a mathematics test, that same individual would be expected to score high on a language test, due to the high level of general intelligence (Willingham 2004).

Theories that distinguish between intelligences come in two basic forms. One views intelligences as independent from one another; the other takes a hierarchical viewpoint. If intelligences are completely distinct, performance on a math test would have no correlation to performance on a language test (see Figure 2). The second of these viewpoints may observe correlations between test scores (thus arguing for the existence of *g*), but scores in one subject are more related to each other than they are to scores from other subject areas. The hierarchical viewpoint would here argue that a student who scores high on a language test has done so both due general intelligence, but also due to a distinct linguistic intelligence. Much data, including a landmark 60 year study of over 100,000 people from around the world by researcher John Carroll, supports this latter viewpoint (Willingham 2004).

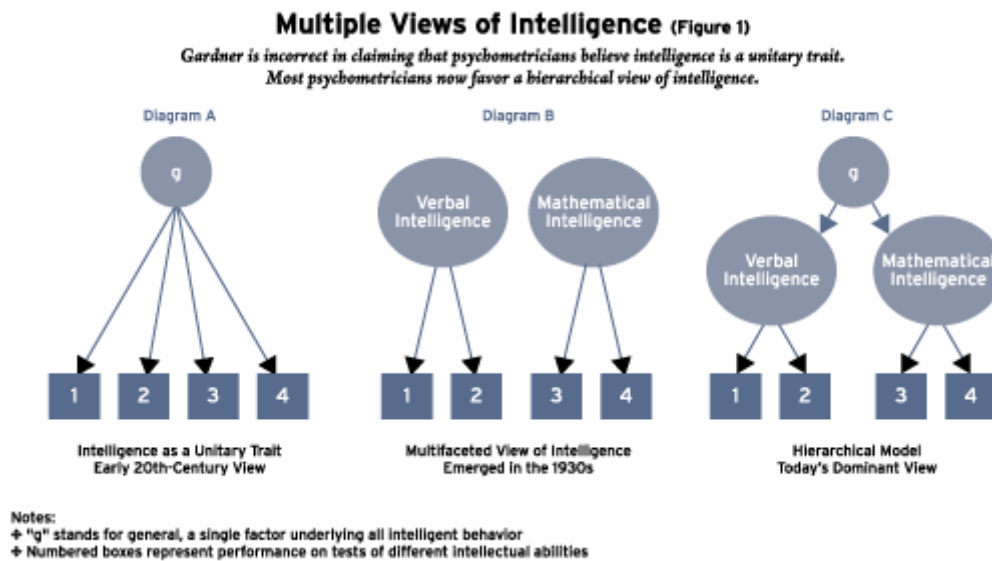


Figure 2. Unitary, Multifaceted, and Hierarchical Views of Intelligence (Source: Willingham 2004).

Empirical support for the hierarchical model of intelligence is not universal. In fact, none of the three viewpoints can claim a monopoly on supportive data (Gardner 1999). This only further complicates educators' understanding of intelligence as a means to boost learning. Furthermore, one must consider the manner in which data for such studies is gathered. Educational researchers need to consider the means of collecting empirical data. For example, is the often used method of pen and paper testing correlated with validity and reliability? Can such tests disprove the existence of various intelligences? Is testing even the sole means by which to measure intelligence? What are the differences between testing and assessment? For which age groups is it best to measure achievement/performance and for which groups is it best to measure potential?

3.1 Multiple Intelligences by Howard Gardner

“A young girl spends an hour with an examiner. She is asked a number of questions that probe her store of information (Who discovered America? What does the stomach do?), her vocabulary (What does *nonsense* mean? What does *belfry* mean?), her arithmetic skills (At eight cents each, how much will three candy bars cost?), her ability to remember a series of numbers (5, 1, 7, 4, 2, 3, 8), her capacity to grasp the similarity between two elements (elbow and knee, mountain and lake). She may also be asked to carry out certain other tasks—for example, solving a maze or arranging a group of pictures in such a way that they relate a complete story. Some time afterward, the examiner scores the responses and comes up with a single number—the girl's intelligence quotient, or IQ. This number (which the little girl may actually be told) is likely to exert appreciable effect upon her future, influencing the way in which her teachers think of her

and determining her eligibility for certain privileges. The importance attached to the number is not entirely inappropriate: after all, the score on an intelligence test does predict one's ability to handle school subjects, though it foretells little of success in later life," (Gardner 1993a; 1).

Such numerical representations of intelligence are gathered every day in similar forms around the globe from test subjects of all ages. This tried method is far and away the most common in establishing how intelligent humans are. This however does not sit well with many people, and experts in many areas have felt a need for another way or other ways to determine and define intelligence. Can societies define intelligence in a narrow sense of mathematics or languages? How many of us are or know somebody who is not too good with numbers, relatively slow with words, or even both, yet a brilliant actor, tap dancer, or painter? Would we dare consider such people unintelligent due to their struggle with numbers or the word? Would we dare consider such people intelligent because they can paint? Has Western society so skewed our perception of intelligence that it becomes difficult to consider anything but math and language competence as intelligence?

Howard Gardner, an educational stalwart in the United States, formulated a ground breaking theory that not only can and should intelligence be measured in different ways, but intelligence itself is multi-faceted and can be expressed in subtle, everyday ways. Such ways don't warrant or can't be expressed in a one-hour, pencil and paper or interview test. When Gardner first published this work over 20 years ago, he determined it was not a lack of technology that limits our ability to test intelligences, but rather the tendency in many societies to have a limited view of intelligence itself. For example, one who navigates a ship by using the stars is surely exhibiting a competence based on intelligence of some sort. The mime on the street pouring an imaginary cup of tea and comically accidentally spilling it on himself may convince an audience of certain things based on bodily movements alone. Not everyone can be so convincing with the body; does that mean some people are more "bodily smart" than others? With numerous other examples of ways to exhibit intelligence abound, Gardner formulated this idea and termed the theory behind it Multiple Intelligences.

Before revealing the intelligences, Gardner (1993a; pp. 62-68) first established the criteria each individual candidate intelligence must fulfill in order to be considered a distinct intelligence:

- Potential isolation as a brain function/potential isolation by brain damage
- Prodigies, savants, and other exceptional individuals
- An identifiable core operation or set of operations

- A distinctive developmental history, along with a definable set of expert 'end state' performances
- An evolutionary history and evolutionary plausibility
- Support from experimental psychological tasks
- Support from psychometric findings
- Susceptibility to encoding in a symbol system.

Gardner initially determined there to be seven distinct intelligences found in humans. After the initial publishing of the book, Frames of Mind: The Theory of Multiple Intelligences, Gardner and his colleagues accepted an eighth intelligence, namely naturalist intelligence. Table 1 lists the intelligences as well as a brief description and in which professions they are most appreciated. One should keep in mind that the theory of multiple intelligences is just that—a theory. In his early works on the subject, Frames of Mind: The Theory of Multiple Intelligences and Multiple Intelligences: The Theory in Practice, Gardner presents strong arguments supporting the existence of several intelligences. Such arguments, he acknowledges, may not be persuasive for all who come across the idea. He states he is fairly certain of the existence of certain intelligences, while other people may simply refer to them as “talents”. In respect to this, he argues that he groups together several segregated bodies of knowledge while attempting a serious reconsideration of many elements of educational and cognitive psychology (e.g. traditional forms of intelligence testing). Of great importance to this work is the hope to “develop a model of how intellectual competences may be fostered in various cultural settings,” (Gardner 1993a; 10).

Ultimately, Gardner strived at providing sound and influential arguments which he hoped would prove useful to “policy makers and practitioners charged with ‘the development of other individuals,’” (Gardner 1993a; 10). He considers cognition through biological, psychological, and cultural (multi-cultural) lenses. Gardner doesn’t feel the theory is flawless nor does he feel he has come up with the idea. He notes that the different ideas on multiple intelligences share the feature that there are large differences among individuals concerning strengths and weaknesses intellectually, and the means by pursuing knowledge vary greatly. Furthermore, such differences are in large part evident before formal education has begun (Gardner 1993b).

Table 1. Eight Intelligences as described by Gardner

Type of Intelligence	Brief description
Linguistic	Ability to speak in normal individuals. Necessary for poets, journalists, lawyers, etc.
Musical Intelligence	Creating, communicating, and understanding based on sound. Often requires much training.
Logical-mathematical	Use and appreciation of abstract relations. Application of numbers. Necessary for the financial analyst, accountant, mathematician, etc.
Spatial	Perception, transformation, modification, and recreation of visual images without the need of an original physical object. Progression may halt in childhood unless education is provided. Necessary for visual artists, surgeons, geographers, etc.
Bodily-kinesthetic	Use of the body in problem solving or creation of a product. Necessary for e.g. rock climbers, dancers, athletes, etc.
Intrapersonal	Knowing ones own abilities and perceiving how they may be best used. Distinguishing among one's own feelings.
Interpersonal	Recognizing and differentiating the feelings of others.
Naturalist	Skill at recognizing flora and fauna or other environmental aspects, including non-living specimens. Necessary for e.g. biologists and ecologists, even astronomers.

The following pages outline the theory of Multiple Intelligences by considering individual intelligences, considering implications in education and namely high school biology, paying heed to criticism of the theory, and lastly, addressing the role Multiple Intelligences (MI) could possibly play in online learning environments.

The scope of each intelligence is for the most part limited to Gardner's own ideas. The passages are therefore not to be taken as definitive nor indisputable. Possible ways in which high school biology can appeal to each intelligence are included after each summary. Possible areas in which IB Biology stresses various intelligences are also given consideration, most notably in the sections pertaining to linguistic, spatial, and the personal intelligences.

3.1.1 Linguistic Intelligence

Along with intelligence in the mathematical realm, the ability to effectively manipulate languages has been traditionally stressed in Western educational systems. It is also therefore emphasized when measuring intelligence. Spoken language development begins in infancy with babbling, and within five years, an amazing linguistic command can be observed in most individuals. The learning curve is sheer and the method(s) still not completely understood.

Syntax and phonology are the basis of linguistic intelligence, and other linguistic aspects such as semantics and pragmatics may draw from several intelligences. Gardner believes writers and poets have exceptionally high levels of linguistic intelligence. However, individuals display linguistic intelligence in non-aesthetic ways as well when they take part in everyday conversations or prepare legal briefings. Linguistically intelligent individuals are often able to decipher written codes at very young ages. Furthermore, they often show great enthusiasm for reading at an early age. In MI theory, linguistic intelligence is predominated by but not limited to spoken language and auditory reception. It is rather obvious deaf individuals can be quite skilled in languages. Furthermore, auditory reception is also imperative in musical intelligence. Reading skill is considered to be indicative of linguistic intelligence rather than spatial intelligence. This is supported by studies showing reading ability is hampered by damage to the language system, while it may remain strong when visual-spatial centers of the brain are damaged. (Gardner 1993a)

High school students are bombarded with a vast array of new vocabulary during science courses, including biology. Wellington and Osborne (2001) comment that many students get through a given science course without even understanding much of the terminology thrown around. This can only be magnified when students are studying in their non-native language, as is the case for most in this project. However, students accepted to the IB Program have already indicated relatively high linguistic intelligence during the preparatory year in which the classroom language becomes English. Figure 3 shows some of the difficult words students encounter in science courses, as found by Cassels and Johnstone (1985).

abundant	adjacent	contrast
incident	composition	contract
complex	component	converse
spontaneous	emit	exert
relevant	linear	negligible
valid	random	sequence

Figure 3. Difficult words in Science (Source: Cassels and Johnstone 1985).

Beyond this, the IBO has a list of action verbs used throughout the course and furthermore on the final exams, in which non-native speakers are not allowed to use dictionaries of any sort (Figure 4). These action verbs “determine the depth of treatment required for a given assessment statement” (IBO 2001; 8-9). Several of the words (e.g. annotate) are hardly everyday English, while discerning between the meanings of two or more of the words (e.g. deduce, derive, determine) offers another challenge. Skill or intelligence in languages will assist individuals in their comprehension of these words as well as the extensive and specific vocabulary of the field of biology.

define	draw	list
measure	state	annotate
apply	calculate	compare
describe	distinguish	estimate
identify	outline	analyze
construct	deduce	derive
design	determine	discuss
evaluate	explain	predict
solve	suggest	

Figure 4. The IBO’s Action Verbs for Group IV subjects (Source: IBO 2001)

Linguistically intelligent individuals may find the classification and nomenclature of organisms an appealing aspect of biology. Test taking requires students to label drawings, create own labeled drawings, retrieve names of organisms, parts of the body, biochemical terms, etc., and maybe most importantly be able to construct concise and informative essays. The use of mnemonics may also be an invaluable learning tool for these individuals when considering the expansive vocabulary of the subject.

3.1.2 Musical Intelligence

Musical talent is apparent at rather early ages. With rigorous training, a deep understanding may be acquired. Musical intelligence may also be exhibited along with intelligence in mathematics (the fascination with patterns of any sort) as well as bodily-kinesthetic intelligence (the ability to manipulate an instrument fluently). Musically intelligent individuals are believed to constantly have

a tune ‘running through their head’. Musical intelligence may be exhibited through an ability to repeat a song on an instrument, an ability to compose, an ability to single out the sounds a particular instrument may make in e.g. an orchestra, the ability to note pitch and keys of several sounds, etc. Musical intelligence may also be displayed through the ability to apply music to what at first consideration is a non-musical element (e.g. the sounds in a city center, construction work, footsteps, etc.). (Gardner 1993a)

A vast amount of research has investigated the effects of music on the human psyche. However, applying musical intelligence to a high school biology course may seem like a stretch at first glance. Nature is however undoubtedly musical (e.g. singing of birds) and rhythmical (e.g. flowing water). Appreciation of these phenomena may not lead to success on final exams, but it may nonetheless refresh or invigorate a student. Songwriting based on biological topics may be one form of exhibiting musical intelligence in the realm of biology. This project will investigate the use of classical music during various activities throughout the course, including: practical exercises, group work, station work, etc. It is believed by the author that the mathematical patterns found in much classical music may enhance individuals’ abilities to concentrate. At the very least, it will provide an atmosphere different from that found in the traditional laboratory, provided of course that the music is not the emphasis of a given exercise but rather a complimentary aspect. An enhanced aesthetic appeal to the laboratory may capture the interests of several types of learners and not solely the musicians in the classroom. Laboratories in the working world often include a radio; why not apply it to the high school lab?

3.1.3 Logical-Mathematical Intelligence

“In contrast to linguistic and musical capacities, the competence that I am terming ‘logical-mathematical intelligence’ does not have its origins in the auditory-oral sphere. Instead, this form of thought can be traced to a confrontation with the world of objects” (Gardner 1993a; 128). Logical-mathematically intelligent individuals have a great amount of understanding resulting from great curiosity about the surrounding world and how it operates. Gardner bases much of logical-mathematical intelligence on the work of Jean Piaget, who addressed the progression of learning from early to late childhood. Basically, Piaget claimed a child’s growth consist of the following stages: sensorimotor, preoperational, concrete operation, and formal operations. While later research trends have not supported the clear cut progression from one stage to the next, Gardner (1993a; 129) appreciates Piaget’s reasoning that logical-mathematical knowledge “derives in the

first instance from one's actions upon the world." In other words, a child develops his/her basic mathematical knowledge (from the basic concepts of counting and numbers to understanding the relationship between actions) in large part through interaction with the outside world. Mathematically intelligent individuals have the great ability to discover problems and solve them. In this light, "science and mathematics are closely allied" (Gardner 1993a; 145). Breakthroughs in mathematics nearly always benefit the scientific community at large. Mathematics often organizes what seems to be chaos; it can therefore be a tool for the construction of models and eventually theories in the sciences. These models and theories describe the world for humans. The goals of the scientist and that of the mathematician may not always compliment one another. The mathematician is first and foremost concerned with the recognition of patterns, while the scientist is concerned more so with the implications of such patterns. In Western cultures, mathematical intelligence has traditionally existed on a pedestal along with linguistic intelligence. This is not the case in all cultures.

In biology, mathematical models often explain the operations of living things, their relationship with the non-living environment, and their relationship with each other. Understanding of arithmetic, geometry, and in later stages calculus will benefit the aspiring biologist. Individuals with strong logical-mathematical intelligence seem to be drawn to the natural sciences, most likely due to the general curiosity about how the world functions. High school students are required to carry out several basic mathematical calculations as well as have an appreciation of scientific units of measurement, understanding magnification, exponentials, etc.

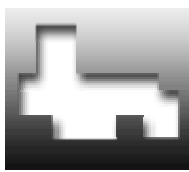
3.1.4 Spatial Intelligence

"Central to spatial intelligence are the capacities to perceive the visual world accurately, to perform transformations and modifications upon one's initial perceptions, and to be able to recreate aspects of one's visual experience, even in the absence of relevant physical stimuli" (Gardner 1993a; 173). In contrast to logical-mathematical intelligence, which increasingly progresses towards the abstract, spatial intelligence in essence remains concrete. For most individuals, spatial information is directly and nearly solely linked with visual perception. Both the ability to perceive (e.g. noticing lines, angles, distances) as well as the ability to reproduce (e.g. drawing, painting) are indicative of spatial intelligence, although spatially intelligent individuals may not demonstrate both abilities equally. The development of spatial intelligence appears to be more difficult to study than e.g. linguistic intelligence. Piaget notes that mental imagery is possible for children towards the end of the

sensorimotor stage. At some point in development, children are able to imagine scenes or events without having to be physically present. Such imagination is limited to actual previous, concrete exposure to that which is being considered.

The onset of concrete operations during school is a fundamental landmark in the development of a child. The manipulation of objects in a spatial domain leads to various degrees of reversible mental operations in which an individual can picture a given object in different surroundings, viewed from different perspectives or angles, or how the same object may look when rotated. This is known as decentration (Gardner 1993a; 179). The degree to which individuals can operate in this realm, both through perception and reproduction, may be representative of their level of spatial intelligence. (Gardner 1993a)

Which of the following shapes fits into the puzzle?



A



B



C



D

Correct answer: C



Figure 5. An example of a question measuring spatial intelligence (Source: IQ test labs).

Spatial intelligence will assist individuals in their ability to apply three-dimensional models to what often times are two dimensional models shown on paper, e.g., in books. The drawing of several anatomical structures as well as microscopic images is an emphasized constituent in the IB Biology syllabus. Students are required to recreate structures using pencil only both during the two-year course and on the final exam as well. Beyond recreation, students are also required to exhibit an

understanding of the ratio between what they have drawn and actual size. This is most notable when microscopic images are drawn and students are required to display magnification or scale bars. Spatial intelligence will also assist individuals in grasping the concepts of molecules such as DNA, glucose, and several amino acids. Through decentration, students may be able to visualize or reproduce these molecules. In regards to experientialism, instructors should allow students the possibility to produce their own models, drawings, animations, and other biological visuals by using a variety of methods, including pencil-and-paper, flash animations, molecular model kits, etc (see Figure 6).



Figure 6. Building a 3-D model of glucose (photo by author).

3.1.5 Bodily-Kinesthetic Intelligence

“Psychologists in recent years have discerned and stressed a close link between the use of the body and the deployment of other cognitive powers. There is a discernible tendency to focus on the cognitive facts as well as the neuropsychological basis of skilled body use, and a clear trend to analogize thought processes with ‘sheer’ physical skills” (Gardner 1993a; 209). Physical activity has traditionally been considered a lesser mental function than sheer thought. A superficial glance at coordinated use of the body for various purposes is rarely connected to intelligence. Gardner argues that dancers, mimes, athletes, circus performers, etc. display high levels of bodily-kinesthetic (or

simply body) intelligence. This is probably the intelligence proposed by Gardner that has received the brunt of the abundant criticism. Tradition in Western societies considers it more of a talent. Furthermore, athletes in many societies are infamously and stereotypically considered the antithesis of intelligent individuals. At the heart of the issue is determining or defining the role of the body in relation to the brain. One understanding is that the body serves the brain by executing movements. A contrasting viewpoint states that cerebration brings about adaptation, purification, and clarification in bodily movement. Gardner (1993a; 211) supports the latter.

It must be understood that the relation between mind and body is amazingly labyrinthine. Considering hand-eye coordination alone, the intricate network of neurons, impulses, and muscle fibers interacting through the various feedback mechanisms involved could fill a textbook and then some. Motor movements affect how we perceive the world. The results or consequences of our motor movements are instantaneously evaluated in the mind, or they may be pondered in retrospect. This occurs with even the simplest of movements, e.g. the typing of this sentence. Some motor activity occurs so quickly that feedback mechanisms don't have time to run full cycle. Movements that seem automatic or involuntary proceed so rapidly that a certain amount of programming must have taken place before. Consider the virtuoso musician, the contemporary dancer, or the black belt martial artist.

Gardner (1993a) further states his claim for a distinct body intelligence by considering injuries to the areas of the brain's left hemisphere involved in motor movement. Certain individuals who have received an injury to these zones may mentally understand and be physically able to carry out a desired movement, but upon request are unable to do so. This does not only concern impaired individuals; many of us can observe and be instructed on a sequence of bodily movements (e.g. a pirouette in ballet), but inappropriately carry them out.

Homo sapiens are undoubtedly physically weak and even clumsy compared to its primate counterparts. The speed, strength, and agility of our closest genetic counterparts put our species to shame. This is a likely evolutionary concession made in connection with brain size. The complete story of this is unknown, and although the fossil record may fill in gaps, a complete apprehension remains a distant goal. How then can humans be considered body intelligent? Several species, including non-primates, are known to manipulate simple tools to complete various tasks. A well-known example concerns the chimpanzee, which 'fishes' for termites by using a stick. This skill develops sequentially as chimps age, and a refined version of termite fishing can normally be

observed around six years of age. Variations in termite fishing exist depending on the population of chimps, likely a result of imitation in isolated areas. Notably, innovation and adaptation are seemingly absent. If a favored type of stick were to be hypothetically removed from a habitat, or if only one type of stick would function in termite fishing, a chimp population would not be likely to instigate 'Plan B'. Humans on the other hand would likely proceed with trial and error in search of response to change. Such 'primitive' use of tools by primates is likely indicative of a common ancestor. (Gardner 1993a) It is this author's opinion that such a case fortifies the claim of the existence of a unique human body intelligence. The uniqueness of human bodily-kinesthetic intelligence lies in the innovation and adaptation exhibited in the reproduction of motor skills. Our species' degree of dexterity further distinguishes. Practically, this is exhibited e.g. when humans follow a complex series of precise dance moves or devise a more hydrodynamic swimming style. Kinesthetic ability is undoubtedly dependent on genetics to a great extent, but the course of developing motor skills is largely dependent on an ability to learn about the body, with the body, and by using the body.

Bodily-kinesthetic intelligence need not be limited to formal physical education. In biology, students are required to carry out a number of tasks requiring precision, dexterity, and reproduction of motor movements. Examples of these are found in: dissections, preparation of tissue slides, handling of delicate materials, and competent manipulation of technological equipment. Bodily-kinesthetic intelligence depends upon experience. Experiential methods of teaching biology may appeal to bodily-kinesthetic intelligent individuals. Beyond the previously mentioned examples, some students may learn a great deal about biology by: observing the bodily movements of animals (including humans), using the body to move from station to station, and investigating exercise and physiology, to name a few. Furthermore, this author has brought performance art into the high school biology classroom. Students act out certain complex biological processes through role playing. This has been a successful method teaching some rather complicated material (cell respiration, photosynthesis, cell division, etc.). Acting out the role of an electron in the electron transport chain in mitochondria, in which students must display 'excited' characteristics, may appeal to some learners more so than reading about it or observing an animation. Beyond this, it is simply fun!

3.1.6 Intrapersonal and Interpersonal Intelligences

These two intelligences are unique to Gardner's work in the sense that they cannot develop independently of one another under most circumstances. While the exhaustive literature which attempts to define the 'self' or the 'sense of self' varies depending on the field in which research took place (e.g. geography, psychology, education), one issue seems clear: interpretation of inner feelings and influences from other individuals both act to form some 'sense of self'. Some researchers, e.g. Freud, focused their work on the former, while others, e.g. William James, paid more attention to the latter (Gardner 1993a). Both intelligences in all their various forms are tied to the frontal lobes of the brain (Gardner 1993a).

"To feel a certain way – paranoid, envious, jubilant – is to construe a situation in a certain way, to see something as having a possible effect upon oneself or upon other individuals" (Gardner 1993a; 255). Intrapersonal intelligence is the capacity one has to discern among feelings and emotions such as those quoted by Gardner as a means to understanding and adjusting behavior and therefore the complex notion of the self. How well we know ourselves allows us to share this knowledge with others. Undoubtedly, connections can be made both to bodily-kinesthetic and interpersonal intelligences, and while the cognitive aspects of the latter may differ (Gardner 1993a), the two personal intelligences may be difficult to consider independently. The human body and the mind are in a constant multi-faceted discourse. Knowledge and perception of the body is an integral aspect of knowledge and perception of the self (Gardner 1993a). Conversely, what one knows and understands about him/herself will likely effect his/her body. "At its most advanced level, intrapersonal knowledge allows one to detect and to symbolize complex and highly differentiated sets of feelings. One find this form of intelligence developed in the novelist (like Proust) who can write introspectively about feelings, in the patient (or the therapist) who comes to attain a deep knowledge of his own feeling life, in the wise elder who draws upon his wealth of inner experiences in order to advise members of his community" (Gardner 1993a; 240).

Assessment in Group IV of the IB subjects includes several criteria which may depend on personal intelligences. These include foremost the criteria Personal Skills (a) and Personal Skills (b), and arguably Manipulative Skills.

Scientists do not operate solitarily; they rather must rely on one another in their quests for understanding of the surrounding world. On the professional level, this takes place in the form of

peer review, article critiques, and information sharing, to name a few. Consider a histology laboratory at a hospital. Beyond the knowledge required of workers to identify various tissue samples, possible pathogens, regularities, or irregularities, an atmosphere of communication and cooperation must exist. Each individual worker carries out tasks with an assumption that his/her colleagues will work in a safe manner and furthermore, these colleagues may be needed in completing certain tasks. Lab technicians, doctors, and nurses often need to cooperate to successfully and efficiently fulfill certain tasks. This can simply be termed ‘teamwork’; arguably it requires what Gardner considers interpersonal intelligence. Before such cooperation can exist, teaching or training at any level requires interpersonal intelligence from both teacher and student. The Group IV criterion, Personal Skills (a), essentially requires individuals to display this intelligence. It consists of three aspects: teamwork, contributing to a group, and recognizing others’ contributions in a group (see Figure 7). Concrete examples of personal intelligences are so wide-ranging, an exhaustive list is not here necessary. The three aspects found in Personal Skills (a) are indicative of characteristics people with high interpersonal intelligence should have. That they have been tweaked to fit into science assessment is both a rather unique aspect for the IB, but also in some sense, it could be thought of as a necessity in a well-rounded science curriculum. An individual student with a weaker grasp of the biological fundamentals may benefit from high interpersonal intelligence while taking part in practical investigations.

Personal Skills (a)

	ASPECTS		
LEVELS	Working within a team*	Recognizing the contributions of others	Exchanging and integrating ideas
Complete	Collaborates with others, recognizing their needs, in order to complete the task.	Expects, actively seeks and acknowledges the views of others.	Exchanges ideas with others, integrating them into the task.
Partial	Requires guidance to collaborate with others.	Acknowledges some views.	Exchanges ideas with others but requires guidance in integrating them into the task.
Not at all	Is unsuccessful when working with others.	Disregards views of others.	Does not contribute.

* A team is defined as two or more people.

Figure 7. The Personal Skills (a) criterion and assessment grid (Source: IBO 2001; 22).

The second type of personal skills criterion involves a more inward approach, although some aspects require a general awareness of the surroundings. Motivation, perseverance, ethics, and environmental impacts are assessed (Figure 8).

Personal Skills (b)

LEVELS	ASPECTS		
	Approaching scientific investigations with self-motivation and perseverance	Working in an ethical manner	Paying attention to environmental impact
Complete	Approaches the investigation with self-motivation and follows it through to completion.	Pays considerable attention to the authenticity of the data and information, and the approach to materials (living or non-living).	Pays considerable attention to the environmental impact of the investigation.
Partial	Approaches the investigation with self-motivation or follows it through to completion.	Pays some attention to the authenticity of the data and information, and the approach to materials (living or non-living).	Pays some attention to the environmental impact of the investigation.
Not at all	Lacks perseverance and motivation.	Pays little attention to the authenticity of the data and information, and the approach to materials (living or non-living).	Pays little attention to the environmental impact of the investigation.

Figure 8. The Personal Skills (b) criterion and assessment grid (Source: IBO 2001; 22).

Assessment of the Manipulative Skills criterion (Figure 9) may in fact depend on several intelligences. It basically is meant to test individual's capacity to competently use various instruments related to practical investigations in the sciences. It also includes an assessment of safety in the laboratory. Safety procedures need be followed in any laboratory to ensure both the safety of the individual as well as his/her counterparts. This may be a manifestation of a very basic degree of personal knowledge. Adherence to safety regulations indicates at the very least an absence of personality pathology.

Manipulative Skills

	ASPECTS	
LEVELS	Carrying out techniques safely	Following a variety of instructions*
Complete	Is competent and methodical in the use of the technique(s) and the equipment, and pays attention to safety issues.	Follows the instructions accurately, adapting to new circumstances (seeking assistance when required).
Partial	Requires assistance in the use of a routine technique. Works in a safe manner with occasional prompting.	Follows the instructions but requires assistance.
Not at all	Does not carry out the technique(s) or misuses the equipment, showing no regard for safety.	Does not follow the instructions or requires constant supervision.

* Instructions may be given in a variety of forms: oral, written worksheets, diagrams, photographs, videos, flowcharts, audiotapes, models, computer programs etc.

Figure 9. The Manipulative Skills criterion and assessment grid (Source: IBO 2001; 21).

3.1.7 Naturalistic Intelligence

Over ten years after publishing *Frames of Mind*, Gardner included an additional eighth intelligence. He labeled this naturalistic intelligence, a phenomenon illustrated by noting patterns as well as drawing connections between natural elements. From an early age, individuals with high levels of naturalistic intelligence possess a keen sense of environmental awareness and are therefore likely to notice even very subtle changes in their surroundings. (Wilson 1998) These individuals may simply like to work with and make distinctions between natural objects (The Gardner School 2004). They also display a developed ability to link the effect one occurrence in a given environment may have on the environment as a whole. It appears to be an intelligence of 'the sum of its parts'.

Biology courses will undoubtedly (though not exclusively) contain several highlights for individuals with naturalistic intelligence. Field trips, animal observation, categorization activities, or simply interacting with something natural may all activate this intelligence. In the IB Biology course, Topic 4, "Ecology and Evolution", and Option G, "Ecology and Conservation" involve both the theoretical and practical study of subject matter concerning natural ecosystems, environmental conservation, and the impacts humans have on the planet. The International Baccalaureate Organization stresses classification skills on final exams. The proximity of Joensuu Lyseon Lukio to rather natural ecosystems (forests, ponds, rivers, and lakes) makes practical investigations, i.e. field studies, of this topic both relatively simple and practically possible. Such excursions have in

the past seemed well-liked by the vast majority of students. Beyond the appeal to naturalistic intelligence, it is often a welcomed change of scenery from the classroom setting. While primarily requiring naturalistic intelligence, such field studies are kinesthetic and depend on personal skills as well.

3.1.8 Further Intelligences

These eight intelligences have withstood a relatively short test period. They may still be considered in many ways candidate intelligences, in a constant state of evaluation and critique by peers of Gardner. Gardner has concluded that ample evidence exist that qualifies the naturalistic intelligence. He further notes there is ‘suggestive evidence’ for an existential intelligence, which is the intelligence of big questions (Gardner 2003). Several educators do indeed base MI theory on nine and not eight intelligences, but this particular work consider those which have fully qualified under Gardner’s criteria.

3.2 Critiquing MI Theory

MI theory burst into the educational research field with all the subtlety of a tornado speeding through an unsuspecting town. One of its most prominent features calls for an end to testing that disproportionately or even solely focuses on linguistic and mathematical skills. In light of MI theory, traditional paper and pencil testing sense becomes arbitrary in the quest to measure intelligence. Undoubtedly, this radical approach to intelligence has had its fair share of critics. Gardner himself preemptively commented on possible alterations that may need to be made to MI. From the onset, he noted that any of the seven original intelligences may be proven to fail to meet vital criteria for an intelligence. He also commented on the possibility of additional intelligences, which actually did occur with the inclusion of naturalistic intelligence. A more substantial revision, Gardner noted, would involve additional components being added to the definition of an intelligence. Gardner also understood that competing theories and advancements in neuropsychology may shed light on possible fundamental deficiencies in MI, thus disproving it. He finally pays heed to the fact that distinguishing between intelligences may be an entirely Western idea and not proper. Indeed, Gardner’s work has been criticized along the very lines he initially recognized, most notably in the foundational understanding of intelligence itself. The scientific methodology of the formation of the theory has also received ample criticism.

“In the 15 years since the publication of Gardner’s *Frames of Mind*, multiple intelligences has gone from being a widely disputed theory to a rallying cry for school reformers to a cultural commonplace. And, amazingly, it has done so without ever winning over the scientific establishment” (Traub 1998, p. 1). Gardner and his supporters of multiple intelligences have considered a wide variety of independent research projects and trends in educational, cognitive psychological, and developmental psychological research. The theory of MI has been based on this research; however, the theory itself isn’t supported by empirical or statistical data. Besides making the entire concept difficult to term a theory, the lack of empirical data is a source of discredit among several of Gardner’s peers. Critics of Gardner and MI have had a hay day with this shortcoming (Klein 1997, 1998; James 1998; Eberstadt 1999). That Gardner’s ideas have proved largely influential in several school curricula (mainly, although not limited to the USA) without raw data even further confounds or angers many. Gardner himself duly notes shortcomings from the onset, noting that the candidate intelligences reflect artistic judgment more so than scientific assessment (Gardner 1993a). Controlled experiments observing any correlations between intelligences would serve well to disprove the theory or parts of it, as it would strongly support the significance of universal intelligence, or *g*. Arguments against MI further point out that the research used seems selected and plenty of research remains unheeded. This selectivity may give it the appearance of a trivial theory. Gardner (1993a, b) feels that all theories must ignore certain data, for considering all data would be both impractical and impossible. He further reaffirms that MI is based on wide-ranging and independent research.

Another issue to be taken up with MI theory lies with respect to the consideration of a general intelligence, often abbreviated *g*. *g* can be statistically measured rather accurately in tests. Gardner (1993b) quickly dismisses this criticism, pointing out that *g* very well may exist, but its limited scope of formal school testing allows it no significance in other environments. The existence of *g* is argued for in both unitary and hierarchical intelligence design, while the multifaceted viewpoint would typically argue it does not exist (Figure 2). The multifaceted viewpoint may also consider *g* to exist, but in a different form. Intelligence testing that attempts to argue for the existence of *g* is often times formatted with a narrow range of questions that require a narrow range of problem solving skills (Gardner, Kornhaber, & Wake 1996).

3.3 MI theory and the classroom

An application of MI theory has been selected in this particular project for several reasons. One has to do with the age of students. Much of Gardner's work concerning MI seemed focused on younger individuals, and the majority of its applications can be seen in primary education. By the time one reaches high school, his/her potential (a possible manifestation of intelligence) in several areas has probably been noticed and in many ways, it is in the process of becoming realized. Individuals may have even had the opportunity to consider what type of learner they may be, or what facets of life they know much about in comparison to others.

In the case of this study, the instructor sought to initially look at the unique intelligence profiles of each individual. The students involved had their intelligences 'measured' via an online 'test' (Appendix 1, 2). Upon completion of this test, individuals were able to view scores in the different intelligences with respect to one another. The author was simply interested in observing the intelligence profiles of each individual. The profiles were, however, returned anonymously. This was done to encourage response from all students and also to avoid labeling, both literally and figuratively, of students based on their intelligence makeup.

Both the reliability and validity of this test may be questionable. However, it does require respondents to give honest answers to questions directly related to how they think, learn, view their environment, etc. Whether or not honest answers were indeed provided is debatable. However, an individual taking the test in one place would be likely to produce similar results in another setting, assuming the test was completed with some degree of principle. This strengthens the reliability. How well-grounded the test is in regards to MI theory and, consequently, how valid the scoring on the test is, may be subject to speculation. Participation in the test does also require students to consider what they think about, how they think about it, and what they like/dislike thinking about. Completion of the test provides students (and the teacher) with a diagram comparing intelligence level in regards to one another. Several other online tests provide students only with numerical scores (e.g. ned Production's version www.nedprod.com), but are often based on simple 'yes' and 'no' answers. The test chosen for this project allowed students to choose from a range of answers ranging from 'that's a lot like me' to 'that's not like me at all' (see Appendix 1). The results are presented in a comparative format in a circular grid (see Appendix 2).

3.4 Investigating and Stimulating the Intelligences of the Biology class

Students were asked to complete a multiple intelligences test. Although the reliability and validity of these tests may be questionable, they are believed to give a solid general description of an individual's intelligences in various fields. In other words, while assignment of numerical scores in certain intelligences may not be a valid measuring stick, the relation of one score to another can be thought to indicate where one intelligence is more developed or another is less so.

Having students complete this online test and then print the results also allowed students to consider how they themselves learn, and maybe even where they may excel. Awareness of intelligences may lead students to consider their overall learning process up to the moment, i.e., why they have always been "good" in math, or why physical education has always been easy. Such self consideration may be an effective motivator (Dennison & Kirk 1990). How many of us go through all stages of education without even considering this?

The test did require students to consider how they learn, and how much they believe they know about e.g. themselves, others, music, mathematics. This in and of itself provided the instructor with a clearer picture of the makeup of the biology class. The fact that the individual intelligences are displayed in comparison to one another shows where individuals excel, and where their intelligence might be less developed. If the class had reported high scores in the logical-mathematical and naturalistic intelligences, the work of the teacher would have been made easy, and the completion of the project would have been arbitrary if not unnecessary.

The goal of testing students' intelligences was to gather a clearer picture of the individuals in the biology classroom. The main intention was not to look at particular individuals and their various intelligences, but rather to understand what type of intelligences each individual score highest in. Table 3 displays the number of students who scored highest in each of the eight intelligences. Students were given the option as to whether or not they would remain anonymous.

Table 3. The highest scores by intelligence.

Intelligence	Number of students scoring highest in this intelligence
Linguistic	2
Musical	3
Logical-mathematical	3
Spatial	1
Bodily-kinesthetic	1
Intrapersonal	2
Interpersonal	5
Naturalistic	3

Upon reviewing the test results, several aspects became immediately clear. Notably, even considering the small number of respondents (20), all eight intelligences were represented as a top score for at least one student. Secondly, although logical-mathematical and naturalistic intelligences are well represented (3 and 3, respectively), they are not the dominating top intelligences of the group. Even more notably, half of the respondents scored lowest in either logical-mathematical or naturalistic intelligence. The group is not composed solely of up-and-coming scientists. Test results were not necessarily needed for such a determination; several of the students had already stated their proficiencies are in other realms.

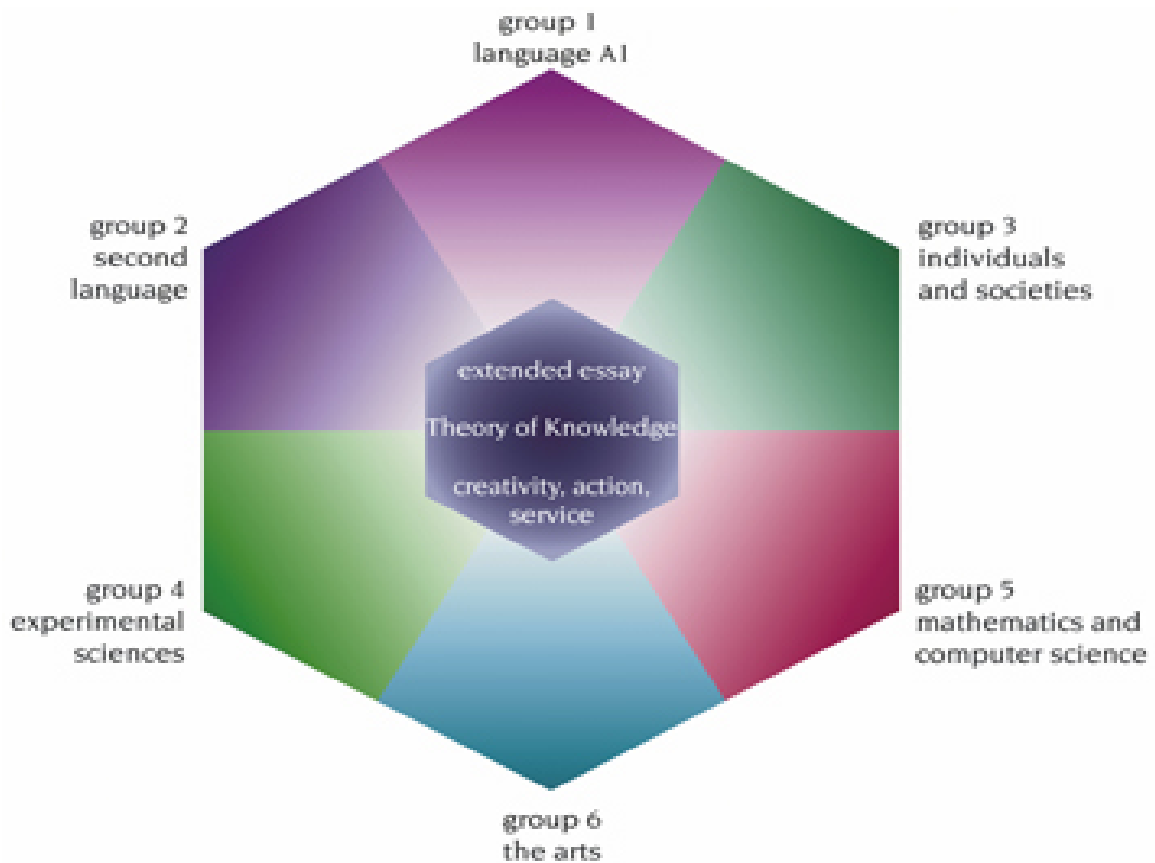
It must be noted that this project will stress the use of many entry points that primarily taps one intelligence. This will be the overriding methodology used in the quest to stimulate individual intelligences. Based on the results of the intelligence testing, entry points for all the intelligences as defined by Gardner will be included. Much of this will be done in the classroom; additionally, due to time restraints, the online learning environment will be an ideal forum to position such entry points. Students can in this manner become acquainted with various topics in various ways, and additionally, on their own time and at their own pace. Each individual will more than likely prefer one or a handful of the entry points to others, and they may even be inclined to view only those resources that initially seem intriguing.

The use of various entry points will intrigue diverse learners, but one intelligence will not take the place of another. Students will not learn biology through music. This is simply due to the fact that the intelligences are not substitutable (Gardner 1993a, b; Willingham 2004). When learning biology, students will have to stress certain intelligences so as to properly grasp the subject matter. This will be the case even when the desired stressed intelligence is not an individual's strongest.

The diverse entry point method will seek to prevent students from tuning out at the first instance of difficult subject matter. Furthermore, Gardner (1993b) argues that a thorough appreciation of a topic can only be obtained through manifestations using different intelligences. The subject matter must stimulate the classroom and all its intelligences as a whole. Additionally, the individual will best learn when all intelligences are used (though not necessarily equally) to understand a given topic. This need not take place in the classroom only, as initial aspirations to

In both the classroom and online learning space, one goal of the project is to ensure all the needs of the diverse learners are met. Redenich (1997) used a model of Gardner's to incorporate of the ways of knowing into an integrated assemblage to study adolescent literature. The project ideally will follow in these footsteps. Accommodating all the needs of all learners is not practical for one instructor (Stahl 1999). It is more feasible to adapt a multidimensional instruction style for an entire group than to segregate a classroom so that groups of students can receive one dimensional instruction. Individuals often have one intelligence that is the strongest, and this will normally determine preferred learning style (Gardner 1993a). However, they also have the ability to develop each intelligence (Gardner 1993a, Smink & Schargel 2004). The work of this project, materialized both in the classroom and in the online learning environment, will allow the best of both worlds, i.e. individuals will be encouraged to find or continue to use a preferred style based on intelligence while an emphasis will inherently be placed on the two vital intelligences for biology.

3.5 Multiple Intelligences and the International Baccalaureate Program



Group number and name	Primary Intelligence(s)
1. Language A1 (mother tongue)	Linguistic, personal
2. Second Language	Linguistic, personal
3. Individuals and societies	Personal, logical-mathematical
4. Experimental sciences	Logical-mathematical, naturalistic
5. Mathematics and computer sciences	Logical-mathematical
6. The Arts	Spatial, musical, personal
The Extended Essay	One of any
Theory of Knowledge	All
Creativity,	Spatial, Musical, bodily-kinesthetic, personal
Action,	Bodily-kinesthetic, personal
Service	Personal, any (depending on service)

Figure 10. The IB hexagon and primary intelligences.

Attention has been given to how individuals with different intelligences may excel in different facets of biology. It is the hope of the author that instruction in IB Biology which considers diverse learners with varying levels of the multiple intelligences will enhance understanding of the material and lead to success in the course. This is not limited to final exam scores, but also includes a general, even minimal scientific or biological literacy which individuals can carry with them throughout their lives, as well as an increased appreciation of the pursuit of scientific or biological truths.

Logical-mathematical intelligence still however remains at the core of scientific reasoning and learning. Individuals with a high degree of logical-mathematical intelligence will most likely grasp the abstract concepts found in the biology syllabus more fluently than others. It would be erroneous to believe depending on e.g. linguistic intelligence alone will lead a student to success in biology. The intelligences are not substitutable, and the necessary representations needed for understanding are unique to each topic (Garnder 1993a, b; Willingham 2004). However, as Gardner would argue, all individuals possess to varying degrees some level of each of the intelligences. It therefore becomes the instructor's role to both appeal to the range of intelligences while concurrently stimulating the logical-mathematical and naturalistic intelligences.

The fact that the IBO does stress e.g. personal skills, drawing ability, and language skills in and of itself is testimonial to the fact that logical-mathematical intelligence alone will not suffice. Developing all intelligences while not ignoring the fundamental importance of solid scientific reasoning will hopefully appeal to learners across the spectrum.

The IB hexagon (see Figure 10) is a visualization of the division of the various IB courses into fields of study. Learners with individual intelligences corresponding to certain courses will probably be likely to emphasize such courses in their studies (see Figure 10). However, all IB Diploma candidates are required to fulfill a course in each group of the hexagon (sometimes with the exception of Group 6, the Arts). This means the aspiring linguist must complete a Group IV subject, no matter his/her possible lack of enthusiasm towards sciences. In a similar manner, the young scientist must be linguistically competent enough to pass both a mother tongue as well as at least one foreign language course. In this manner, the IBO can be considered to have a solid, well-rounded and internationally renowned curriculum which both appeals to multiple intelligences and demands use of all intelligences (see Figure 10).

In the case of Joensuu Lyseon Lukio, the majority of students not initially keen on sciences select biology. The reasons for this are probably various, but more than likely they are linked to a commonly held but far from true perception of biology as a 'soft science'. Ideally, the IB Biology course would be divided into two groups, Standard Level and Higher Level, and instruction for each group would be separate. The aims for teaching and learning at both levels are different. However, limited resources and the relatively small number of students in the IB Program at Lyseo require a combined course. This enhances the learner diversity of the biology classroom and therefore creates a need for diverse instruction methods as well as student-centered experiential techniques where learners can learn from one another.

4 THE DEVELOPMENT OF WEB-BASED LEARNING

Understanding individual needs of students is compulsory for today's teachers. This does not imply catering to all possible individual circumstances beyond reason, but rather a keen awareness of both general needs of a classroom as a whole as well as its individuals.

Traditionally and still today, high school education in Finland is synchronized. Students are expected to attend contact lessons and furthermore realize the consequences of missing these lessons. Numerous factors impair the efficiency of a strictly synchronized structure for some individuals. Some students in the IB line are so-called double degree students, in that while they are working towards an IB diploma, they are concurrently pursuing studies e.g. at the local music conservatory. This noble and demanding path often leads to students being 'double booked', in which students are expected to be in two places at the same time. The demands from both sides can be equally strong. Familial obligations also require missed contact lessons. These may be due to receptions, emergencies, travel, etc. Although family vacations during the school year are highly discouraged, they inevitably arise. Sport-related trips, school trips abroad, and even special projects or events inside the school may also prevent students from making it to class. None of these are necessarily recent trends, but it does appear that reasons for missing lessons are diversifying. What was once an invalid reason for not attending might actually have its merit in today's world. Teachers and administration have to establish acceptable grounds for extended absences, and at the same time work with individual cases. The days of erroneously assuming that one's subject and contact lessons are the only thing going on in a student's life need be in retrospect, no matter how difficult this concept may seem to subject teachers.

Students may find themselves missing a week or even more of contact lessons, which may set them back. Receiving second-hand notes from peers or getting in-class assignments has probably been the most common method of counter-acting this, but its effectiveness pales in comparison to being present in the classroom environment. Teachers cannot even be certain a student has made any attempt to retrieve the information missed, nor is it the duty of a teacher to chase students in all directions trying to verify such an attempt. This is one area where a web-based environment may prove vital to both the learning processes of individuals as well as a teacher's overall ability to facilitate these processes. The unsynchronized aspect of a web-based environment, used as a tool to counteract the detrimental effects of information and learning missed due to absences, stands high

on a podium of practicality and necessity at the high school level. This facet is also a driving force of the project.

Beyond a practical means of providing students with an opportunity to catch up or review classroom material, online environments are more than likely the most up-to-date source of information available (Butler 1997). The lengthy time frame of publishing a biology textbook may even render some of its information obsolete as it is being published. While the core subject matter of biology rarely takes drastic, quick turns, current information from valid Internet sources strengthens any delivery of course material. In the case of this project, a calendar will highlight any dates on which current events related to biology occurred, and provide links to Web pages with information on such events.

4.1 Multiple Intelligences and technology

From the teacher's perspective, a minimal scientific literacy stands as the main goal for many students. Implied and included in this idea is the belief that this basic literacy will also show when a student is tested on the subject, i.e., he/she will pass the course. A web-based environment may enhance classroom learning. For some individuals, it may exist as a necessary tool for reviewing; for others, the web environment may have additional or more appeal than the classroom setting due to its unsynchronized structure. It is hoped that the addition of a web-based environment to the two-year IB biology course will expand the overall appeal of that course. Furthermore, its addition will help to realize a course which encompasses aspects of all intelligences as understood by Gardner. In this manner, the course will consider diverse learners and multiple intelligences while being based on the published IB syllabus.

The web-environment need not be solely a support system for absent students. The diversification of learning is also of great importance. As previously mentioned, biology is often times a course taken by students to fulfill a natural science requirement. Individuals may not be geared towards, greatly inspired by, or even remotely interested in several of the key concepts of biology at the onset of the course. Furthermore, they might display relatively low levels of naturalist and logical-mathematical intelligences, the two traditionally deemed of great importance for biologists. Scientific problem-solving skills are characteristic of logical-mathematical intelligence (Gardner 1993a). Such skills are also expected from students in most high school biology courses. The major challenge is hence pinpointing areas where individuals with high degrees of traditionally "non-

scientific” intelligences can utilize these intelligences towards achievement in biology while at the same time optimizing their scientific understanding.

Along with a daily approach that will consider multiple intelligences in the classroom, an online learning environment which is inclusive of all learners and all intelligences will serve to strengthen and deepen understanding through the diversification of learning. It is in the online environment that the use of entry points stimulating typically ‘non-science-based’ intelligences may prove most effective. In the least, it allows for experimentation that classroom time would not. It also provides students with the possibility to reflect on learning. Students are encouraged to develop mnemonics for various biological phenomena. They are asked to scan certain drawings they have made, or to produce images electronically to be made available to all. They are provided with discussion forums in which they can address questions to the group as a whole. All participants are allowed to answer or comment on the questions in the forums, which are monitored by the instructor. They are provided with links to music which they can listen to while studying or taking a break. At some points, students will be required to complete assignments or at least turn in material in the online space. Furthermore, data collected by the group as a whole for certain investigations will be made available in the online space. The students will both be in charge of gathering such data and determining what to do with it. Lastly, the Internet links provided in the online environment are intended to remain diverse and appealing to all kinds of learners.

4.2 Moodle

Joensuu Lyseon Lukio is one of several high schools in Finland which has incorporated Moodle into many of its courses. It is a software package, which operates in support of a social constructionist style of education. This entails that learning is improved when individuals produce and provide access to things experienced. Furthermore, Moodle provides the opportunity to establish social networks in which students from a given course are all teachers while at the same time learners. (Moodle Web pages: <http://docs.moodle.org/en/Philosophy>) Of great benefit for many schools is the fact that the environment is free of charge.

Moodle is ideal for social learning. Group work, collaborations, communication, critical reflection, and a variety of other activities are possible in the online environment. A particular Moodle course site can be set up so that e.g. Kolb’s (1984) steps to learning can be realized.

The establishment of a Moodle space for the two-year IB Biology course is one aspect of this final project; it is an extension of the course as a whole. It therefore hopefully reflects the diverse approach the course takes as a whole. It must be kept in mind that the course is first and foremost dependent upon contact lessons and in-class experience. The online space will support classroom learning rather than replace it. Most assignments found in the Moodle space will be optional to the students, but some activities will be course requirements. Concerning this project in particular, the aims for the online environment are various:

- to introduce second-year IB students to online environments
- to establish an online environment conducive to experiential learning, including a range of active and reflective aspects for both individuals as well as the class as a whole
- to establish an online biology environment that appeals to learners in the wide-ranging spectrum of Gardner's MI theory
- to provide a resource where students can obtain materials from missed contact lessons
- to provide additional information to what is presented during the contact lessons (e.g. links to web sites, animations, discussion forums)
- to provide as much material as feasible and reasonable in an electronic form, thereby reducing the use of paper and consequently environmental impact. This particular feature corresponds to the sections of the course syllabus concerning e.g. conservation.

4.3 Results of the project to date

As previously mentioned, this is the first exposure to an online environment for most of the IB students. It may also be their first exposure to learning which consciously considers Multiple Intelligences. All individuals possess some degree of all intelligences. They have certainly used all intelligences both in and out of the classroom before attending this course, but whether or not biology or another experimental science course has deliberately operated in light of MI theory is unknown.

The IB Biology students have so far been active in the Moodle environment. All participants have visited the environment on at least one occasion. The manner in which they have used the environment to date seems, based on observation of user reports, to be to retrieve data or course

information. The observable trends at the onset of the provision of the online environment do not seem to indicate an acknowledgement of the proactive ways in which it can be used. Students have not typically provided their own work (drawings, mnemonics, diagrams, etc.) thus far. This is probably less indicative of an unwillingness to do so, and more indicative of a lack of awareness or a lack of a need to do so up to this point. When exams draw nearer, it is expected and hoped that such activity will increase. An on-going goal of the instructor is to continue to introduce and encourage such usage by the students. Currently, it appears the students view the environment as a teacher-centered extension of the contact lessons. In my point-of-view, it is a student-centered space which will exhibit the unique characteristics of each student as well as the group as a whole. It is hoped that students will realize the stake they hold in the progression of the web environment and use that realization to become more interested in that progression, much like in the study by Powell and Stiller (2005).

5. CONCLUSIONS

5.1 The project today and tomorrow

The overall effectiveness of the pedagogic approach to the two-year IB Biology course concerning this project may not be fully realized until the summer of 2008, when the students who are now beginning the course will receive their final grade report from the International Baccalaureate Organization. At Joensuu Lyseon Lukio, IB students do receive grade reports twice in the first year, once in the middle of the second, and an additional predicted grade before final exams are taken. Grading in the IB system runs from 1-7, with seven the highest score. Such grade reports will hopefully serve as benchmarks which may be indicative of the success of the approach. While grade reports alone will not determine success, they must be considered as marquee at the high school level, and they are imperative for students continuing studies at institutes of higher education. Students will be provided ample opportunities to provide feedback to several elements of the course, including teaching styles, the Moodle Web site, and test format. Furthermore, students are required to provide and assessed on evaluative feedback on several written practical reports.

Due to increased amounts of data, shifts in focus, the progress of technology, and other changes in societies, theories should be considered as fluid-like entities that must constantly change shape. Approaches to teaching must therefore avoid being static. Applying MI theory to the classroom demands such an avoidance, as one lesson may consist of activities focused on one or a few intelligences, while the next may consider alternatives. The theory itself has undergone and will most likely continue to undergo changes (Gardner 2003), which I plan to stay on top of. I also realize the possibility that the theory itself or more likely elements of it may be empirically disproved. However, if e.g. bodily-kinesthetic intelligence is proven not to be an independent intelligence but rather, as many authors (e.g. Carrol 1993) argue, a talent or simply a subset of a higher intelligence, this will do little to discourage me from applying kinesthetic activities to the classroom. It will require a reshaping but not a complete removal, particularly if it is deemed effective by both students and myself.

The Moodle Web site will best exemplify the fluidity of the pedagogic approach. Students have plenteous opportunities to provide feedback on both classroom activities and the Web site itself. It is even probable that each successive group of students will influence the design and material available in a unique way. What works for the current first year students may be tweaked to better

suit successive groups. Feedback will help the instructor to determine the effectiveness of current activities and resources, as well as foster the creation of new ones. Furthermore, the entire IB Biology syllabus is scheduled to change for those students beginning in the fall of 2008, which will inherently demand various adjustments.

5.2 Intelligence revisited

A universally definitive construct of intelligence may not be a tangible realization. Cognitive, behavioral, and other branches of psychology and educational research, not to mention e.g. neurology have seemed to branch out in several directions while in search of the same answer. What becomes readily apparent is that there just might not be one answer that can or even should be considered. Isolation of regions of the brain in performing certain tasks do indeed strongly argue for a multi-faceted explanation of intelligence such as MI theory. However, most working psychologists argue for the hierarchical model (Traub 1998). What seems to be the point of greatest consideration is whether or not the completion or attempted completion of a given task is actually indicative of intelligence. What criteria are to determine what intelligence is? Gardner (1993a) claims his criteria for an intelligence are soundly based, a sentiment not shared by several peers. Gardner's and most educational researchers/psychologists' are indeed culturally relative, even though one of Gardner's criteria is that the intelligence must span all cultures.

Research trends in the study of intelligence may need to become more specific. It is apparent that linguistic and musical ability are learned at a more rapid pace in children compared to adults. However, the progressive nature of learning or the development of an intelligence means that an adult educated in either field will be better with words or more musically sophisticated. This arouses a speculation that any view of intelligence must consider age. Furthermore, any application of intelligence theories must acknowledge the significance of the learners' ages.

Determination of intelligence(s) may lead to labeling individuals, whether literally speaking or figuratively in the mind of an educator. It may lead to an individual attending a specialized school, e.g. one emphasizing music, even at a very young age. While this will undoubtedly improve the individual's understanding of music, his musical intelligence, it just as easily may compromise his other intelligences. A deeper understanding of intelligence will assist in the determination of when specialization should begin so as to avoid compromising well-roundedness.

When implemented in a classroom setting, MI theory draws many parallels to other ideas of diverse learners and unique learning styles. Basically, the diverse methods of learning exercises based on MI theory could be implemented to keep the classroom from becoming stagnant. Educators around the world apply concrete exercises that would correspond to MI theory, often times without the realization of the theory itself. An MI theory approach to a high school biology course raises the possibility that in one lesson or one 10 minute span of a lesson, an individual not scientifically inclined will keep a window of interest open. Too often, these individuals are detrimentally affected by a teaching approach that assumes proficiency in 'thinking like a scientist' from the onset. An MI approach also demands the scientifically gifted to observe the subject in new lights.

It is hoped and expected that a diverse approach to teaching and learning in biology will continually adjust, reform, and reconsider. I plan to stay aware of research trends in the field of intelligence. I also plan to seek out further implications of MI theory in the classroom. Most significantly, I plan to closely monitor the effectiveness of such an approach, through observation of test results, laboratory reports, and feedback from students.

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APPENDIX 1. Questions used to test students' intelligences. Found at:

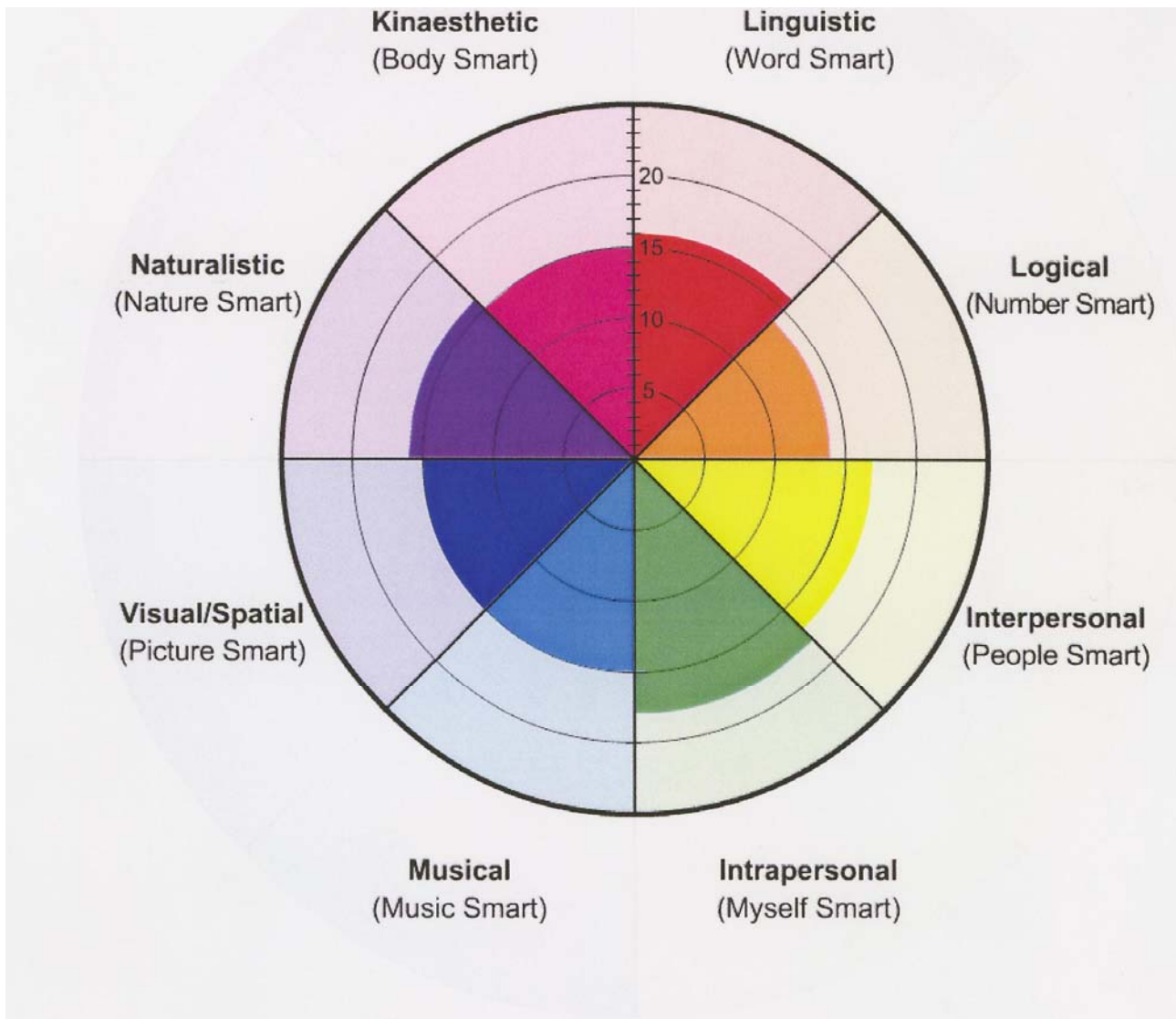
www2.bgfl.org/bgfl2/custom/resources_ftp/client_ftp/ks3/ict/multiple_int/questions/questions.cfm

Respondents were asked to indicate the extent to which they agreed with each of the following statements. The agreement ranged from 'This is not like me at all' to 'This is a lot like me'.



1. My mood changes when I listen to music.
2. I am observant. I often see things that others miss.
3. I can picture scences in my head when I remember things.
4. I can pick out different instruments when I listen to a piece of music.
5. I can use lots of diferent words to express myself.
6. I am sensitive to the modds and feelings of others.
7. I like to work with my hands.
8. I like working and thinking on my own and quietly.
9. I can take things aparnt and put them back together easily.
10. I like to use charts and diagrams in my learning.
11. I have a good sense of direction.
12. I find it easy to explain to others.
13. I like to work with a team.
14. I am good at mathematical problems and using numbers.
15. Pollution makes me angry.
16. I enjoy making music.
17. I am an independent thinker. I know my own mind.
18. I can remember pieces of music easily.
19. I can sort out arguments between friends.
20. I have a good sense of balance and like to move around a lot.
21. I keep or like pets.
22. I enjoy logic problems and puzzles.
23. I can recognize and name different types of birds, trees, and plants.
24. I enjoy writing things down.
25. I can link things together and pick out patterns easily.
26. I enjoy being outdoors when I learn.
27. I get restless easily.
28. I know myself well.

29. I enjoy working on my own.
30. I am interested in why people do the things they do.
31. I like to think through problems while I walk or run.
32. I need to see something in it for me before I want to learn something.
33. I learn best when I have to get up and do it myself.
34. I learn well from listening to others.
35. I like to make lists.
36. I always do things one step at a time.
37. I enjoy games involving other people.
38. I remember things like telephone numbers by repeating them to a rhythm.
39. I like to think out loud.

APENDIX 2. A sample of the results displayed after taking the MI test



APPENDIX 3. Joensuu Lyseon Lukio's IB Biology's MOODLE front page




IB BiologyYou are logged in as [Adam Lerch \(Logout\)](#)[Lyseo » BiHLSL](#)[Turn editing on](#)**People** [Participants](#)**Activities** [Assignments](#) [Forums](#) [Resources](#)**Search Forums** [Advanced search ?](#)**Administration** [Turn editing on](#) [Settings](#) [Edit profile *](#) [Teachers](#) [Student](#) [Groups](#) [Backup](#) [Restore](#) [Import course data](#) [Scales](#) [Grades](#) [Logs](#) [Files](#) [Help](#) [Teacher forum](#)**My courses** [IB Biology](#)[All courses...](#)**Topic outline**

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Here students can find the biology study guide (including the entire IB Biology syllabus), tips on practicals, and web links to IB biology web pages

 [.PDF file of study guide and syllabus](#) [IB Biology: Nease High School](#) [Practical Reports](#) [WHFreeman companion site](#) [Plant and Animal Cells](#) [Ask a scientist](#) [Cell Theory Power Point](#) [How to make drawings in Biology](#)**2 Topic 1: Cells: The building blocks of life**

What is a cell made of? Where did cells come from? How do things get into and out of cells? Find those answers here...

 [Bacteria](#) [Origin of cells?](#)