International Baccalaureate®
Baccalauréat International
Bachillerato Internacional

Middle Years Programme

MYP guide to interdisciplinary teaching and learning

Verónica Boix-Mansilla, Harvard Graduate School of Education

International Baccalaureate®
Baccalauréat International
Bachillerato Internacional

Middle Years Programme

MYP guide to interdisciplinary teaching and learning

Verónica Boix-Mansilla, Harvard Graduate School of Education

Middle Years Programme
MYP guide to interdisciplinary teaching and learning

Published May 2010

International Baccalaureate
Peterson House, Malthouse Avenue, Cardiff Gate
Cardiff, Wales GB CF23 8GL
United Kingdom
Phone: +44 29 2054 7777
Fax: +44 29 2054 7778
Website: http://www.ibo.org

The International Baccalaureate (IB) offers three high quality and challenging educational programmes for a worldwide community of schools, aiming to create a better, more peaceful world.

This Work has been written by Verónica Boix-Mansilla of the Harvard Graduate School of Education and published by the IB.

IB merchandise and publications can be purchased through the IB store at http://store.ibo.org. General ordering queries should be directed to the sales and marketing department in Cardiff.

Phone: +44 29 2054 7746
Fax: +44 29 2054 7779
Email: sales@ibo.org

MYP184

Contents

Preface

The importance of quality interdisciplinary education

Quality interdisciplinary education invites students to integrate concepts, theories, methods and tools from two or more disciplines to deepen their understanding of a complex topic (for example, how cities grow, why the climate is changing, how to make new media art). In so doing, interdisciplinary instruction enlists students' multiple capabilities (aesthetic, social, analytical) and prepares them to solve problems, create products or ask questions in ways that go beyond single disciplinary perspectives.

Today, educators seeking to prepare students for the work of their generation call for interdisciplinary education for multiple reasons. Some point out that changing global labour markets require individuals who are able to frame and address new problems, employ expert thinking in a flexible manner, and communicate effectively with people who hold different perspectives on the problems at hand. Others argue that today's knowledge societies, where scientific and technological advancements are transforming everyday life, demand a public that understands how knowledge and technologies in areas such as communication, genetically modified food, or stem cell research are produced, who can think critically about the relationship between science and society. Indeed, for many observers the urgency of interdisciplinary education stems from the fact that the most important problems of environmental and cultural survival—from mitigating climate change to legislating immigration, from eradicating poverty to ensuring human rights—cannot be satisfactorily addressed by individual disciplines.

With a renewed interest in interdisciplinary education there is a legitimate concern about the lack of rigour or direction observed in certain interdisciplinary teaching practices from elementary school onward. Experienced educators worry if interdisciplinary instruction should be embraced at the expense of learning in the disciplines, or should interdisciplinary teaching build on individual disciplines? Are "thematic units" in which all teachers in a school are required to address a single theme effective, "Water" or "Ancient Egypt", for example? Or do they fail to establish meaningful connections among perspectives? To address questions of this kind and support quality interdisciplinary learning in the Middle Years Programme (MYP), the International Baccalaureate (IB) and researchers at the Harvard Graduate School of Education initiated a collaboration designed to produce the research-based model for quality interdisciplinary education in the MYP introduced in this guide written by Verónica Boix-Mansilla. In it, a pedagogical model of principles and recommendations grounded in empirical research conducted at Project Zero, Harvard Graduate School of Education, are used to illuminate the interdisciplinary nature of the MYP and offer practical guidance.

About this guide

This publication is a guide to interdisciplinary teaching, learning and assessment in the MYP. It offers an in-depth definition of interdisciplinary learning and presents the MYP's recommended approach to interdisciplinary teaching. It offers a practical framework that teachers in the programme are encouraged to use to design quality assignments, projects and units of work, as well as to support students in their personal project inquiries.

These principles are illustrated by multiple examples of MYP practices from around the world. Model units of instruction, assignments, samples of student interdisciplinary work and personal projects are included. To bring core principles of interdisciplinary practice to life, reflections by experienced interdisciplinary teachers within and outside of the MYP are featured.

"Reflection point" sections in each chapter invite readers to engage in thought experiments as they become acquainted with, and master, the principles of quality interdisciplinary instruction in the MYP. "Connections" boxes point the reader to related relevant sections in the guide.

Specifically this publication offers:

- a conceptual definition of "interdisciplinary understanding"
- an MYP approach to interdisciplinary teaching that lays out core principles to design instruction geared to fostering student interdisciplinary understanding in the MYP
- concrete ideas about how to enhance the quality of interdisciplinary teaching in MYP classrooms
- examples of teachers' interdisciplinary planning and teaching
- examples of students' interdisciplinary work
- criteria to be used to evaluate the quality of interdisciplinary student learning as well as teachers' interdisciplinary instruction in the MYP
- recommendations to administrators seeking to support the teachers and interdisciplinary learning communities in their schools.

Schools are expected to read this guide in conjunction with *MYP: From principles into practice* (August 2008), which offers an overview of all aspects of curriculum, assessment, teaching and student learning in the programme. Within each subject group this guide is to be read together with the subject group guides that offer subject-specific information, such as aims, objectives and assessment criteria, and a subject view of the areas of interaction.

MYP coordinators and school administrators should have access to and read this publication, as it provides guidance that can lead to successful interdisciplinary teaching in the areas of interaction and across subject groups. In the MYP, it is recognized that successful interdisciplinary instruction demands administrative support and coordination. Therefore, school leaders have a key role to play in setting the necessary conditions for collaboration and planning required for an adequate implementation of interdisciplinary teaching in the programme.

This guide should inform individual teachers interested in designing quality instruction for interdisciplinary learning, as well as whole-school planning teams and teachers' continuing professional development initiatives in the MYP.

To maximize the use of this guide, readers are encouraged to:

- begin with the introductory chapters, chapters 1 to 4, but feel free to browse through chapters 5 to 11 as there is no linear order in the process of instructional design
- keep their own practice in mind as they become acquainted with the numerous examples and perspectives presented in the guide
- seek partners with whom to read, discuss and experiment with the ideas presented in this guide; teachers or coordinators may organize study groups, online discussion lists, reflection bulletin boards or critical friends who are willing to give and receive constructive feedback
- keep a reflection log to track and come back to their own development and thinking
- engage in designing an interdisciplinary unit of instruction, beginning with an interdisciplinary unit they already teach and would like to improve or with small-scale expansions of their disciplinary teaching.

Chapter 1 The Middle Years Programme: An interdisciplinary view

Overview

This chapter introduces the core elements of the MYP with an emphasis on interdisciplinary learning. It outlines how the fundamental concepts, areas of interaction and curriculum framework are designed to support interdisciplinary work.

Interdisciplinary learning in the MYP

The MYP is a course of study designed to meet the educational requirements of students aged between 11 and 16 years. The curriculum may be taught as an entity in itself, and is flexible enough to allow the demands of national, regional or local legislation to be met.

Curriculum developers of the MYP share a commitment to prepare young people for the changing demands of life in the 21st century. They understand the competencies required for students to thrive in today's world as well as in tomorrow's, such as the capacity for lifelong learning, expert thinking, problem solving, effective communication and collaborative work in diverse human groups. They also understand the opportunities for growth and challenges that students encounter between ages 11 and 16.

MYP students are at an age when they are making the transition from early puberty to mid-adolescence: this is a crucial period of personal, social, physical and intellectual development, of uncertainty and of questioning. The MYP has been devised to guide students in their search for a sense of belonging in the world around them. It also aims to help students to develop the knowledge, attitudes and skills they need to participate actively and responsibly in a changing and increasingly interrelated world. The programme seeks to support adolescents to become internationally minded people who, recognizing our common humanity and shared guardianship of the planet, help to create a better, more peaceful world.

An important feature of MYP curriculum and pedagogy is its commitment to students' interdisciplinary learning—that is, their ability to make meaningful connections across subjects in order to understand, and act in, the world. By placing students at the centre of the learning process and building on a holistic view of students and knowledge, the MYP seeks to cultivate students' involvement in their own learning. In this chapter, the central components of the MYP are characterized with their relation to interdisciplinary learning outlined.

The IB learner profile

The programme is designed to cultivate internationally minded, independent learners who can make meaningful connections across school subjects and in the world outside the classroom. It seeks to nurture students' capacity to engage in and employ multiple sources of expertise to solve problems, create products, produce explanations and raise new questions about the world in which they live. In this regard, the IB learner profile offers a dynamic portrait of the kind of students and citizens that the IB seeks to develop, and serves as an educational compass for teachers in all programmes. The profile enables teachers to make programme-relevant decisions about the dispositions and habits of mind to be nurtured through disciplinary and interdisciplinary instruction.

IB learner profile	
The aim of all IB programmes is to develop internationally minded people who, recognizing our common humanity and shared guardianship of the planet, help to create a better and more peaceful world. IB learners strive to be:	
Inquirers	They develop their natural curiosity. They acquire the skills necessary to conduct inquiry and research and show independence in learning. They actively enjoy learning and this love of learning will be sustained throughout their lives.
Knowledgeable	They explore concepts, ideas and issues that have local and global significance. In so doing, they acquire in-depth knowledge and develop understanding across a broad and balanced range of disciplines.
Thinkers	They exercise initiative in applying thinking skills critically and creatively to recognize and approach complex problems, and make reasoned, ethical decisions.
Communicators	They understand and express ideas and information confidently and creatively in more than one language and in a variety of modes of communication. They work effectively and willingly in collaboration with others.
Principled	They act with integrity and honesty, with a strong sense of fairness, justice and respect for the dignity of the individual, groups and communities. They take responsibility for their own actions and the consequences that accompany them.
Open-minded	They understand and appreciate their own cultures and personal histories, and are open to the perspectives, values and traditions of other individuals and communities. They are accustomed to seeking and evaluating a range of points of view, and are willing to grow from the experience.
Caring	They show empathy, compassion and respect towards the needs and feelings of others. They have a personal commitment to service, and act to make a positive difference to the lives of others and to the environment.
Risk-takers	They approach unfamiliar situations and uncertainty with courage and forethought, and have the independence of spirit to explore new roles, ideas and strategies. They are brave and articulate in defending their beliefs.
Balanced	They understand the importance of intellectual, physical and emotional balance to achieve personal well-being for themselves and others.
Reflective	They give thoughtful consideration to their own learning and experience. They are able to assess and understand their strengths and limitations in order to support their learning and personal development.

Overview of programme model

To nurture the capacities and dispositions described in the learner profile in students, the MYP has devised a dynamic programme model structured around three fundamental concepts: holistic learning, intercultural awareness and communication. The diagram below represents the programme model. The five areas of interaction connect the development of the individual learner (at the centre) with the educational experience in all subject groups (at the outer points of the octagon). These interactive areas are common to all disciplines, with each subject developing general and specific aspects of the areas. In this way, the subject groups are linked by the areas of interaction, demonstrating the interdisciplinary potential of the MYP. The five areas of interaction have no clear boundaries, but merge to form a context for learning that contributes to the student's experience of the curriculum. They give the MYP its distinctive core. In every year of the programme, students are required to experience and explore approaches to learning (ATL), community and service, health and social education, environments, human ingenuity (formerly *homo faber*). These areas are common to all disciplines and are incorporated into the MYP so that students will become increasingly aware of the connections between subject content and the real world.

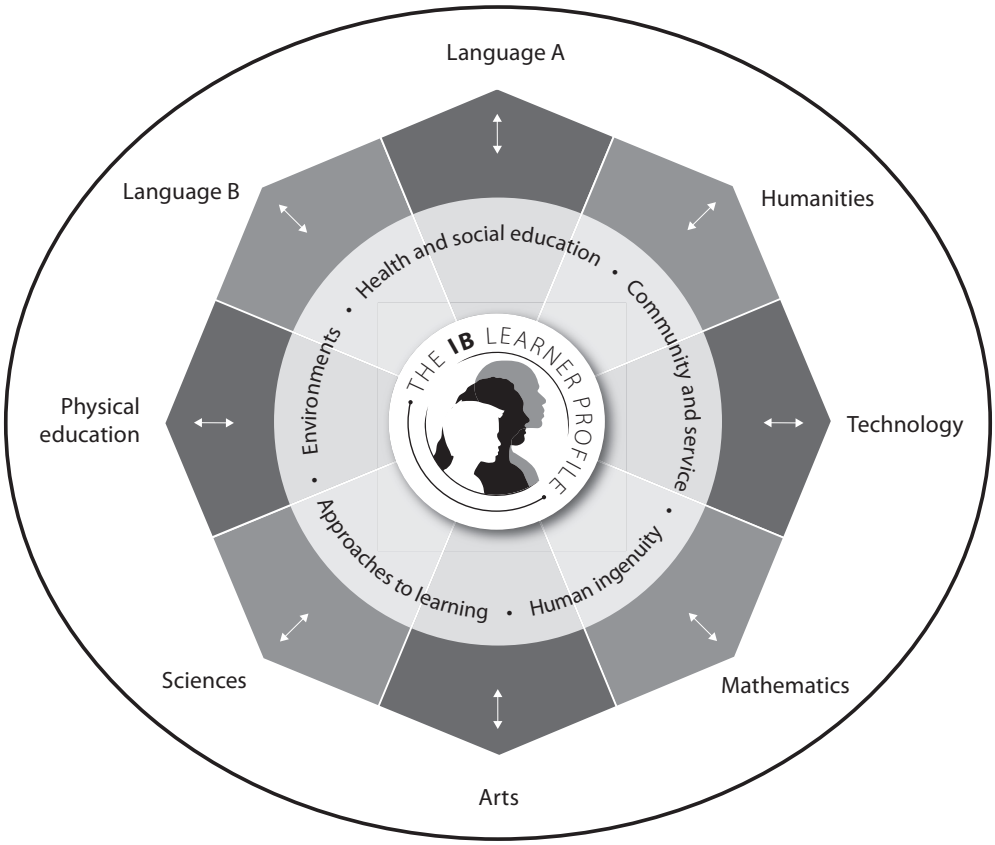


Figure 1

The eight subject groups represented in the MYP programme model provide a broad, traditional foundation of knowledge. Students are encouraged to engage, question and evaluate information in the disciplines embedded in the subject groups. The subject groups offer natural opportunities for students to address relevant topics by bringing together multiple disciplinary perspectives.

In the MYP, the term "discipline" is used to refer to established areas of expertise including academic disciplines such as history, physics or geography; the arts such as music, visual art, or drama; and established fields of knowledge such as technology, design, architecture or medicine. While disciplinary teaching in the subject groups takes place when teachers focus on history, biology, music or graphic design as individual subjects, interdisciplinary teaching occurs when teachers invite students to combine concepts and modes of thinking within and across subject groups. Throughout this guide the term "discipline" will be used interchangeably with "subject."

Interdisciplinary learning in the MYP takes place quite naturally within subject groups. For example, in the sciences students may learn about the local river's ecosystem by exploring and integrating insights in disciplines such as biology, physics and chemistry. In the humanities, they may examine a topic such as migration, employing concepts and modes of thinking in history, economics and psychology.

The MYP also encourages teachers and students to make meaningful connections **across subject groups**. For example, students may be invited to deepen their understanding of the French and American revolutions (humanities) to write a poem (language A) and create a play that captures the visions and world views of the times, inviting contemporary audiences to reflect (arts). Students may complement a study of the ecosystems in the local river (sciences) with an economic analysis that looks at the long-term impact of pollution on health (humanities) as well as the projected costs of environmental cleaning (mathematics).

Fundamental concepts of the MYP

Young people are confronted with a vast and often bewildering array of choices. The MYP is designed to provide students with the values and opportunities that will enable them to develop sound judgment and the capacity to learn and evaluate information critically. Three fundamental concepts give focus to teachers' efforts in the MYP:

- holistic learning
- intercultural awareness
- communication.

These concepts form the basis for the MYP's curriculum framework, which is shared by different types of schools in all parts of the world.

Holistic learning

Holistic learning addresses the interdisciplinary foundations of the MYP directly. It links the subjects to foster a wide scope of understanding—concepts, ideas, and modes of thinking that offer a global view of situations and issues, are relevant to students and society, and can be employed by students in a variety of meaningful contexts.

In the MYP students are expected to become aware of the relevance of their learning, and come to see knowledge as an interrelated whole. They are expected to see the analogies and complementarities among various disciplines or fields of study, but not to the detriment of learning within each of the disciplines, which retain their own objectives and methodology.

As a core principle, holistic learning drives the MYP's emphasis on interdisciplinary teaching and learning. It capitalizes on students' unique intellectual profiles, capacities and interests, and invites students to engage in relevant topics for study, drawing on established forms of expertise. Perhaps most importantly, holistic learning nurtures students' disposition to move beyond learning multiple isolated facts and seek understandings of consequence, conduct critical analysis of complex issues, and synthesize perspectives in quality interdisciplinary work.

Intercultural awareness

Intercultural awareness is concerned with developing students' attitudes, knowledge and skills as they learn about their own and others' cultures. By encouraging students to consider multiple perspectives, intercultural awareness seeks to go beyond fostering tolerance to develop respect and empathy.

The MYP nurtures intercultural awareness by providing students with relevant experiences inside and outside of the formal curriculum. A climate of intercultural respect is expected inside and outside MYP classrooms. In addition, students' intercultural awareness is informed by the systematic study of world history, languages and cultures, as well as topics ranging from the impact of climate change on locations and societies around the globe to the social and individual experiences of migration. Deep understanding of such topics demands an interdisciplinary approach.

Communication

Communication is fundamental to learning, as it supports inquiry and understanding, and allows student reflection and expression. The MYP places particular emphasis on language acquisition and allows students to explore multiple forms of expression.

Throughout their studies, MYP students encounter, learn to recognize and employ the distinctive forms of discourse that characterize subjects such as biology, history or technology. They also explore the expressive power of various symbol systems and art forms. Students' interdisciplinary work prepares them to communicate across areas of subject expertise, as well as to select and integrate forms of communication to achieve their goals and find answers to their inquiries.

The areas of interaction

The programme model of the MYP places the learner and the way the student learns at its centre, as the student's development is the basis of the whole educational process. The areas of interaction surrounding the student in the model are the core elements of the MYP. They provide a framework for learning within and across the subject groups. They allow connections among the subjects themselves, and between the subjects and real-life issues.

Approaches to learning

How do I learn best?
How do I know?
How do I communicate my understanding?

Approaches to learning (ATL) is central to the programme, as it is concerned with developing the intellectual discipline, attitudes, strategies and skills that will result in critical, coherent and independent thought and the capacity for problem solving and decision making. It goes far beyond study skills. It involves students' capacity to "learn how to learn" and develop an awareness of thought processes and their strategic use. This area of interaction recognizes that true learning is more than the acquisition of knowledge: it involves its thoughtful application, as well as critical thinking and problem solving, both individually and collaboratively.

Interdisciplinary learning is uniquely suited to support students in their developing understanding of who they are as learners and how learning takes place for multiple purposes across disciplines and subject areas. Interdisciplinary learning invites a broad range of individual intellectual profiles and working styles that are often associated with particular disciplinary modes of thinking. Furthermore, in interdisciplinary learning students and teachers are asked to clarify the purpose of studying a particular topic; examine how particular disciplines might contribute to a deep understanding of such a topic; and reflect on how various subject areas engage students' individual interests and talents. An important component of quality interdisciplinary learning is the development of a disposition to compare how learning takes place in various subjects and reflect about the very process of learning over time. In so doing, MYP students can begin to prepare for the work that may be expected of them in, for example, the IB Diploma Programme's theory of knowledge course, or indeed in any future educational context.

Community and service

How do we live in relation to each other?
How can I contribute to the community?
How can I help others?

The area of community and service starts in the classroom and extends beyond it, requiring students to participate in the communities in which they live. The emphasis is on developing community awareness and concern, a sense of responsibility, and the skills and attitudes needed to make an effective contribution to society. Students are expected to become actively involved in service activities.

Occasionally, community and service initiatives may develop exclusively as a form of extra-curricular activity, but the most powerful community interventions capitalize on and integrate what students are learning in one or more subject groups. In this respect, interdisciplinary learning nurtures students' disposition towards effective participation, local problem solving and responsible action. It does so by inviting them to draw on multiple sources of expertise to find solutions, create objects or explain phenomena in ways that would have been unlikely without the support of the disciplines or through single disciplinary means. Because real practical problems can rarely be addressed through the context of single disciplines, interdisciplinary approaches present unique opportunities to nurture students' development in this area of interaction.

Human ingenuity

Why and how do we create?
What are the consequences?

Human ingenuity allows students to focus on the evolution, processes and products of human creativity. It considers their impact on society and on the mind. Students learn to appreciate and to put into practice the human capacity to influence, transform, enjoy and improve the quality of life. This area of interaction encourages students to explore the relationships between subjects, aesthetics and ethics. Human ingenuity offers extensive natural opportunities for quality interdisciplinary learning. Whether, for example, by understanding the historical and economic forces that enabled the emergence of the steam engine in England toward the end of the 18th century; by investigating the growth and disappearance of the great civilizations of Angkor or Teotihuacán; by inquiring about the psyche of creators like Picasso and Matisse; or understanding the life and science of Galileo or Newton, students working within this area of interaction are invited to integrate multiple sources of information to explore and engage in human inventiveness. In all cases human ingenuity stems from the purposeful and novel expansion and recombination of available expertise. Aspects of effective human ingenuity study can prepare students effectively for the types of thinking encountered in the IB Diploma Programme's theory of knowledge course as well as for the range of ethical questions raised in a number of IB Diploma Programme's subject courses.

Environments

What are our environments?
What resources do we have or need?
What are my responsibilities?

Environments aims to make students aware of their interdependence with the environment so that they accept their responsibility for maintaining an environment fit for the future. The context provided by this area of interaction considers environments to mean the totality of conditions surrounding us. This area of interaction focuses on the place of human beings within a wide range of environments including natural, built and virtual. In their interactions, students will come to an appreciation and understanding of the effect they have on their natural, built and virtual environments.

An informed engagement with the natural environment and a disposition toward sustainable development demand that students become able to understand aspects of the natural world (for example, atmospheric

change, ecosystems, geological formations) that are typically studied by different branches of science (climate science, biology, geology), as well as human interactions with the environment typically addressed by humanities disciplines (history, economics, anthropology). In their study of the environment students are asked to integrate these insights into coherent accounts of topics such as climate change mitigation, pollution and recovery, species extinction and protection. Not uncommonly, an exploration of the environment and an active commitment to maintaining a healthy environment invites students to capitalize on the power of the arts to express and communicate. In all cases students are best positioned to engage in their roles as young environmental stewards when they integrate learning effectively throughout their courses of study.

The word "environment" can refer to a vast array of complex and often controversial "green" issues. These issues, and the finding of solutions to them, are clearly important in the lives of all people. As students will be increasingly confronted with complex and controversial global environmental issues, this area of interaction provides opportunities for students to see these global issues in the light of local concerns, and vice versa. However, these issues alone do not define this area.

Through this area of interaction students should develop an awareness and understanding of a range of environments and their qualities. Students should also explore the nature of their environment and the interactions between and interdependencies of various environments. As teachers plan to integrate this area with their subject content, they should consider environments in terms of the learning expectations.

Health and social education

How do I think and act?
How am I changing?
How can I look after myself and others?

Health and social education prepares students for a physically and mentally healthy life, to be aware of potential hazards and be able to make informed choices. It develops in students a sense of responsibility for their own well-being and for the physical and social environment. This area encourages students to explore themselves as they develop healthy relationships with others. Health and social education encompasses a range of issues and how these issues affect individuals, human development and interactions. It includes an appreciation of these effects in different cultural settings and at different times. It also provides students with opportunities to inquire into physical, social and emotional health and intelligence, key aspects of human development that can lead to a complete and balanced lifestyle.

Here too, insights stemming from psychology, sociology and biology can inform students about their bodies, relationships and growth. A comprehensive view of who they are as biological and social beings invites students to integrate such perspectives. Also in this area, the arts offer powerful spaces of self-inquiry and expression.

The extent to which young people consider and act on social and health-related issues is influenced by political, social and economic decisions at the community and national level, as well as by the actions and support of schools, families and friends. As schools work to encourage students to make informed and responsible choices, they could involve the whole community, particularly students, in the planning and development of this area of interaction.

Students are increasingly in a position where they have to make choices that require critical thinking. As teachers plan to integrate this area with their subject content, they should consider student learning expectations of health and social education in terms of an awareness and understanding of contemporary and historical social issues; reflection on and having opinions on a range of social issues; and making considered and responsible choices on a range of social and health issues.

While the main defining features of each area of interaction can be outlined, they should in no way be viewed as narrow categories. These broad-based areas of interaction overlap. All subject groups are touched by all

areas of interaction in different and complementary ways. All teachers therefore share the responsibility of integrating skills, ideas, themes and issues related to these areas within the subjects themselves or in special projects. The areas of interaction aim to encourage new links between teachers, opportunities for teachers to tackle topics and foster understandings of wide scope and to learn from one another. A new dynamic is created as teachers work together as a more cohesive team and learn to consider the curriculum from the point of view of the learner.

Connections
Chapter 5 provides a detailed description of how teachers may draw on the areas of interaction to craft teaching topics for productive interdisciplinary exploration.

The subject groups

The MYP offers a curriculum framework that allows school-specific requirements to be met while maintaining the mission and philosophy of the IB. In the programme model, the five areas of interaction surround the learner and connect to eight subject groups. These are: language A, language B, humanities, sciences, mathematics, arts, physical education, and technology. For each subject group the IB prescribes general aims and particular objectives in ways that inform curriculum planning on site, but accommodates many additional requirements of national, regional or school curriculums in schools worldwide. Adding coherence to the programme, subject group **aims** are directly aligned with the learner profile. **Objectives** highlight particular understandings, modes of thinking, skills and attitudes to be developed by students in each subject group.

In the MYP, knowledge, concepts, skills and attitudes in the subject areas are seen as essential tools with which students understand, act and reflect on the world.

The objectives of each subject group embody understandings, modes of thinking and skills that are relevant for students to make sense of the natural, cultural and social worlds they inhabit, and act knowledgeably and responsibly in them. As subject group objectives suggest, quality understanding in a discipline or an established area of expertise involves not only having adequate information about the core concepts, theories, and findings in the domain, but also calls upon students to learn about the methods by which disciplinary knowledge is produced (for example, designing experiments in biology, interpreting sources in history); the purposes and applications for which knowledge is pursued (for example, curing disease or understanding past human experiences); and the typical ways in which information is communicated in the discipline (for example, scientific reports, historical narratives).

Each subject group embodies the perspectives of one, two or more traditional academic disciplines or established areas of expertise. For example, in the humanities, students explore concepts such as time, place and space, through the perspectives of disciplines such as history, geography, economics and psychology. Learning in the sciences typically includes studies in biology, physics and chemistry. Technology may include information technologies as well as new media. Language B often combines the study of communication, literature and culture. The MYP model offers a solid foundation of knowledge in traditional subjects or disciplines, and invites natural cross-fertilization within subject groups in addition to the fruitful exchanges across subject groups.

Throughout the MYP, aims and objectives are broad enough to allow a variety of teaching and learning approaches. Objectives provided by the IB for subjects in the MYP are defined as final objectives. The precise choice and organization of content are left to schools in order to preserve flexibility. While teachers will find it necessary to develop their own interim objectives and assessment practices in years 1–5, the final objectives form the basis for the assessment criteria that are intended for use in the final assessment of

students' work at the end of year 5. Whether or not schools request IB-validated grades for their students, they are all required to organize learning and assessment in a way that is consistent with the prescribed objectives.

Connections
Chapters 5 and 6 provide a detailed description of how teachers may draw on subject group aims and objectives to rigorously ground interdisciplinary learning in disciplinary traditions.

Units of work

In each school, teachers must design units of work. Units of work are the carefully planned sequences of learning experiences that enable students to reach the objectives of each subject or objectives shared across subjects. Units of work may range in length and levels of complexity. Constructivist in spirit, units of work include a sequence of learning experiences or schemes of work that must invite the student to engage with content actively. To learn the topics, concepts, and modes of thinking that are under study, students are encouraged to think with or apply them in new situations. Schemes of work structure students' overall learning experiences over time in a unit of work. Sample schemes of work for all subject groups have been written by practising teachers as a suggested means of achieving this. Teachers may choose to adopt the samples offered, amend them to suit their own requirements, or write an alternative scheme of work.

In interdisciplinary instruction, units of work alternate between offering students opportunities to build deep understandings within a discipline or subject, and supporting students' capacity to make fruitful links across disciplines in a subject group or across subject groups. In quality interdisciplinary instructions, students have ample opportunities to make such connections throughout each unit of work or a course.

Connections
Chapter 7 provides detailed guidelines and examples for the design of effective learning experiences in interdisciplinary units.

Assessment

In the MYP, assessment is criterion-related. Assessment criteria provided by the MYP are directly aligned with the learning objectives in each subject group, thus adding coherence to teachers' educational efforts and students' learning in the programme. The criteria also give teachers, parents and students reliable and valid information on the actual learning that takes place for each student. Teachers must use the assessment criteria to assess students' work internally. All schools must use these criteria for final assessment.

When assessing interdisciplinary work teachers must select and employ criteria from two or more disciplines or subjects and consider them in the larger context of students' integrative work. When deciding on assessment criteria for interdisciplinary work teachers are encouraged to consider four core dimensions of student understanding: clarity of purpose, grounding in subjects or disciplines, productive integration of disciplinary perspectives, and thoughtfulness. Each dimension is captured in question form below and expanded on later in this guide.

- Does the work have a clear purpose that calls for an interdisciplinary approach?
- Is the work well grounded in objectives in two or more subjects?
- Does the work integrate subjects productively?
- Does the student exhibit a reflective stance regarding his or her integrative work?

Connections

Chapter 9 provides a detailed description of effective approaches and criteria to assess interdisciplinary work. Assessed examples of student work illustrate assessment principles.

Reflection point

Consider your experience with interdisciplinary teaching in the MYP. You may draw on your own teaching experience or on the experience of a colleague. In your opinion, what are the elements of the MYP that most clearly support quality interdisciplinary teaching and learning? Explain why exactly you think this is so.

Chapter 2 Defining quality interdisciplinary learning

Overview

Interdisciplinary learning is a central feature of the MYP curriculum and should be visible in teachers' instructional designs, in student work and in the assessment criteria. To support teachers seeking to meet the programme's standards of interdisciplinary teaching and learning, this chapter addresses defined interdisciplinary learning and understanding, offering illustrative examples of MYP students' interdisciplinary work.

What is interdisciplinary learning?

Definition

In the MYP interdisciplinary learning is generally defined as the process by which students come to understand bodies of knowledge and modes of thinking from two or more disciplines or subject groups and integrate them to create a new understanding.

In the MYP, interdisciplinary learning seeks to yield **interdisciplinary understanding**. Students demonstrate interdisciplinary understanding of a particular topic when they can bring together concepts, methods, or forms of communication from two or more disciplines or established areas of expertise to explain a phenomenon, solve a problem, create a product, or raise a new question in ways that would have been unlikely through a single disciplinary means.

Three key qualities of interdisciplinary understanding follow from this definition. Interdisciplinary learning is:

- purposeful
- grounded in the disciplines
- integrative.

These qualities guide the design of interdisciplinary instruction and assessment of student work in the MYP. Each quality of interdisciplinary understanding is defined and illustrated below with an example from a unit entitled "The sound of music" in which students construct and perform with musical instruments.

Background to a unit of work entitled "The sound of music"

On a sunny afternoon, in the first period after lunch, 35 students were gathered in the library practising their lines and tuning (if not fixing) their musical instruments. Teachers, other students, the head of the school and a few parents looked on, hoping that the open rehearsal would work. Unique about this concert was that the music and the African instruments themselves were created by the students. As the show began, a timid strings section alternated with dominating percussion variations, which in turn enlisted the winds in their rhythmic motifs. All the while the budding instrument makers mixed concentration, nervousness and pride in their attentive stares at their conductor and complicit smiles to their peers.

The students portrayed here are in year 2 of the MYP. They were invited by their physics and music teachers to create an orchestra of traditional instruments and compose and perform a rhythmic piece for their school. To do so, they had to study the physics of sound waves, understand how instruments work to make sound and music, and learn to create a compelling musical experience for their audience. The task could not be accomplished by focussing on music or physics alone—integrating these perspectives is of the essence.

Interdisciplinary learning is purposeful

In quality interdisciplinary learning, the integration of disciplinary perspectives or subject areas is **purposeful**. In other words, integrating disciplinary perspectives is not a goal in itself but a means to deepen students' understanding of their world and become more competent in it. Interdisciplinary learning in the MYP seeks to:

- attend to the student learning expectations in the areas of interaction that escape single disciplinary perspectives
- enrich student understanding of topics, objects or problems that they, their teachers, schools and societies find compelling
- respond to a clear aim for which perspectives must be brought together: for example, to solve a problem, create a product, build an explanation
- address a need: where the potential limitations of a single-disciplinary approach to a topic are overcome by drawing on the resources of other disciplines.

Example from the unit of work entitled "The sound of music"

What purpose did teachers pursue? Why did understanding the sound of music matter?

- Understanding how instruments work to create compelling musical experiences serves as a valuable purpose for interdisciplinary inquiry in the MYP.
- It sensitizes students to our human capacity to create compelling artistic experiences with materials in our natural environment (human ingenuity).
- It enables students to appreciate instruments they encounter and the people who make and play them (human ingenuity).
- It invites students to learn about design and problem solving, create future instruments of their own and reflect on approaches to learning available to them.

Clarity regarding the purpose of interdisciplinary learning gives direction and meaning to students' efforts. It points to the problem or issue that students will examine, making its relevance visible. Having a clear purpose for inquiry and work (solving a particular problem, explaining a phenomenon) enables teachers and students to discern between more and less relevant disciplines and connections. When interdisciplinary learning efforts do not have a clearly articulated purpose, contrived connections and fragmented learning are more likely to occur.

Interdisciplinary learning is grounded in the disciplines

A second feature of quality interdisciplinary learning is that it is deeply **grounded in the disciplines** represented in the MYP subject areas such as biology, physics and chemistry in the sciences, or drama, visual arts and music in the arts. Interdisciplinary instruction does not replace disciplinary teaching; rather it builds on it, selecting and reorganizing disciplinary learning goals and objectives in meaningful and connected ways in the areas of interaction. Students exhibit quality interdisciplinary understandings when they:

- know, understand and apply knowledge, concepts, findings, tools, methods of inquiry, or forms of communication in the selected disciplines—that is, as framed in subject group objectives
- employ such concepts and modes of thinking in ways that echo that of experts working in the discipline—avoiding misconceptions or oversimplifications.

Example from the unit of work entitled "The sound of music"

To understand how musical instruments work students had to build the knowledge, understanding, skills and attitudes of a physicist.

They learned:

- what constitutes a sound wave
- how sound changes depending on the wave's longitude and amplitude, how sound travels through different media
- how sound resonates with different materials.

They also learned how inquiry takes place in physics:

- generating hypotheses
- devising small-scale experiments to test them.

Understanding sound waves did not prepare these students to use sound in musically compelling ways. In their music class, these students learned about composition and performance, that is, to think as musicians.

They learned:

- how pitch can be used to create an appealing melody
- how volume creates dynamics and mood
- the role of motifs and variation in composition
- the power of using different kinds of instruments strategically to express intended moods.

In other words, essential to students' interdisciplinary learning in the example of "The sound of music" was the students' adequate mastery of selected concepts and skills in the two disciplines involved.

Disciplinary grounding of student work is an essential feature of the MYP interdisciplinary approach where work across disciplines and subject areas builds on disciplinary learning.

When students fail to ground their work in the knowledge, skills and understandings presented in the subject areas they fail to build quality interdisciplinary understanding—even if they show engagement and motivation. A strong disciplinary grounding in students' work does not mean that students must "fully master" each discipline before integrating views. Rather, students are encouraged to master particular concepts and modes of thinking in two or more disciplines that are relevant to meet the established purpose of their work.

Interdisciplinary learning is integrative

Although mastering selected concepts and skills in two or more disciplines is necessary, it is not sufficient to produce quality interdisciplinary learning. Interdisciplinary learning, as conceived in the MYP, requires that teachers and students **integrate** disciplinary perspectives, and that they do so deliberately and productively. In quality interdisciplinary learning, disciplines are not merely juxtaposed around a "theme", neither are disciplinary connections made haphazardly. Rather, elements of different disciplines (knowledge, understanding and skills) are put into a productive relationship with one another, and connections are considered over time, supporting students to accomplish a new, deeper, more compelling or nuanced understanding of the topic under study. Interdisciplinary learning invites students to:

- deepen their understanding in the areas of interaction by bringing together two or more disciplines or subject areas
- make **good** connections across areas of knowledge—connections that enable a deeper, better understanding of the topic under study
- understand the topics under study in ways that would have been impossible through single disciplinary perspectives.

Example from the unit of work entitled "The sound of music"

In the music example, students integrated their understanding of sound waves and elements of music in two fundamental ways.

1. Physics explains how musical instruments function. Students applied concepts such as wave longitude, amplitude and resonance to explain exactly how percussion, wind and string instruments produce sound. Doing so required them to think flexibly and accurately about sound and to compare and contrast the mechanisms of sound production in different kinds of musical instruments.
2. Music explores the expressive power of new sounds. Because their instruments produced new types of sounds (materials and design gave rise to new timbres) students were asked to reflect on the qualities of such sounds and explore their expressive potential in an aesthetically appealing composition of their own.

Each integration yields a deeper or richer understanding of a topic deemed relevant: how musical instruments produce sound and how sound can be used to create compelling musical experiences.

Integration is at the heart of interdisciplinary work. In multidisciplinary or thematic approaches to learning, students examine a topic through distinct disciplinary perspectives but do not seek to make connections across such perspectives. In the MYP, students are encouraged to bring together knowledge, understanding, skills and attitudes learned in different disciplines or subject groups to deepen and enrich their understanding.

An important source of concern about interdisciplinary teaching is what teachers and students experience as "forced" or "contrived" connections between disciplines. Forced connections take place when integration is considered as a goal in itself rather than a means to further understanding of a relevant topic or problem.

Further examples of interdisciplinary learning

Student interdisciplinary understandings vary greatly in scope and disciplinary combinations. To illustrate the nature of interdisciplinary understanding further, this section introduces a second example of student interdisciplinary work. The section following this includes additional examples, illustrating their connection with the programme model.

Overview of a unit of work entitled "Monsters"

The "Monsters" unit invited students in MYP year 4 to examine two contrasting views of human nature. One view posits that humans are essentially kind, and that contextual and social pressures lead humans to behave in selfish ways. The other view presents humans as primarily evil, waiting for an opportunity to display greed and abuse power. Positions were examined through a close reading of Mary Shelley's *Frankenstein* and William Golding's *Lord of the Flies* in language A and language B classes respectively. In their drama class, students learned about Brechtian theatre and the staging and acting choices that invite audiences to reflect about societal tensions. In history, students learned about the Milgram experiments and the Eugenics movement in the early 20th century. Echoing this approach, science classes took advantage of the focus on human nature to raise ethical dilemmas about our human search for scientific progress and technological development on the one hand and the negative impact of progress on the environment on the other.

In one final project for this unit, students were asked to create and perform a play (Brechtian style) that invited a reflection or presented a position about human nature. Each play was performed for their music classmates and other visitors. One group of students framed their position on human nature in the context of the popular reality shows that mix entertainment with manipulation, humiliation and abuse. What follows is the opening poem for the play and an analysis of one student's interdisciplinary understanding.

Sample of student work—The D.E.M.O.N. Show

We are proud to present to the music class
As well as the honorable visiting team
A vision through the looking glass
At humanity at its densest cream

We wish to expose in your presence
The malicious demons that since the start
Took their eternal residence
In the depths of man's fragile heart

We wish to prove to all you eager faces
That evil does not come in missions
It does not take its place in particular races
But is released when its carrier is exposed to certain conditions

See this man, this malicious mad creature
His lab coat as white as an old goat's nipple
To explore human behaviour such as a teacher
He has locked up and tested a group of young people

What started off as a TV programme for people's leisure
Where every participant's goal was a money prize to be won
Has gradually become a spectacle for the public's evil pleasure
As it witnesses their inner demons in freedom run

And all you present in this vast room
Will you leave or will you stay for more
To watch these subjects' inevitable doom
Or associate yourselves to this evil that lies in our core?

Interdisciplinary understanding examined

How does this compelling poem reveal students' interdisciplinary understanding?

Clear purpose

The poem invites the audience to reflect on the "demons" inhabiting "the depths of man's fragile heart" that are "released when its carrier is exposed to certain conditions". By locating the analysis in a common reality television show, the poem invites the young audience to act: "Will you leave or will you stay for more / To watch these subjects' inevitable doom / Or associate yourselves to this evil that lies in our core?"

Disciplinary grounding

In the play, gesture, narration, and minimalist staging are effectively used in a classical Brechtian tradition to remind the audience that they are witnessing a play and they have rational choices to make. An exaggerated critical reference to science and the Milgram experiment studied in humanities is embedded in the description of the scientist as a "malicious mad creature" prepared to experiment with locked up young people. While the poem is suggestive, additional evidence of disciplinary grounding stems from one student's reflection journal excerpts.

- **Language B:** "William Golding shows, through the example of these schoolboys, how fragile we can be to a change of environment and how easy it is for the evil inside us to be let loose, how easy it is to express, as Ralph thought, the darkness of our human hearts."
- **Humanities:** [explaining the reference to race misconceptions addressed by the poem] "I believe that Hitler's evil did not rise simply from his power, but was always present in his core and all his cruel actions were calculated and taken in patient stages. This is made obvious by his book *Mein Kampf* where he associates the Jews to the Marxists and any other possible reason for Germany to be in its lamentable situation."
- **Brechtian theatre:** "[Brechtian theatre reminds us that] man is in control of his own situation and destiny. Moments of choice are to be pointed out, decisions to be made, all shown throughout the process. Choice is centred on the main character and mainly focuses on actions taken according to social factors. This choice must reflect on social injustices imposed upon the character which is another distinct factor of Brechtian theatre: the suppressor over the suppressed, the creator over the creation and the constructive over the destructive."

Productive integrations

In the poem and the play, the disciplinary insights are "integrated" effectively to create a provocative atmosphere of self-reflection and a critical stance toward sadistic voyeurism. The student intertwines their references to literature, history and science seamlessly without breaking the poetic rhythm and conceptual impetus of the work.

- **Extracting concepts in literature to begin to explain the past:** Reflecting on *Lord of the Flies*, this student explains: "It is a normal habit in society, to create a monster that everyone hates, thus the whole group unites to destroy it. Going back to history, this was the same case for Germany, who used the Jews as the beast to be destroyed."
- **Integrating literature, history and drama to reflect about human nature:** "All these subjects [literature, history, drama] have in common two topic questions:
  - Are monsters man-made?
  - Who is responsible for the monsters we create?

  This unit made us reflect on the monsters that arise in our society and on evil itself."

- "Through *Lord of the Flies* it is understood that evil is inside us all, we are born with it from the start and most of us manage to conceal it inside our core. However, when exposed to certain conditions, those inner demons inside us may be released, leading us to commit the most ghastly atrocities. In the case of *Frankenstein* we get another view on monstrosity: we see that it is how a society mistreats and excludes the creature that drives him to commit his monstrous acts."
- "In the case of history, both questions listed above can be answered. The unfair treatment from the Allies at the end of World War 1 created a bitter resentment in the heart of the Germans, which explains their unfair treatment towards the Jewish. Yet, it is also obvious that a man such as Hitler who took such pleasure in his despicable acts was a natural born monster."

To sum up, the example outlined here offers a vivid picture of students' interdisciplinary understanding and suggest how multiple forms of evidence [poem, play, journals] reveal students' increasingly intricate grasp of a complex and relevant topic.

Reflection point

Answer the following questions using the student's examples.

- What are the qualities of the student's work that grab your attention?
- In your opinion, could a quality poem or play have been created without considering subjects such as humanities, language A, language B and theatre?
- Does this student's work remind you of any learning experience that you have designed (or could design) for your students?

Relating interdisciplinary understanding to the programme model

As the example above suggests, interdisciplinary work in the MYP typically spans subjects and areas of interaction. The MYP model invites a variety of interdisciplinary combinations depending on the purpose of students' (and teachers') efforts. To illustrate this point, a series of snapshots of students' interdisciplinary understanding are considered below in relation to the programme model.

Unit topic: The Age of Enlightenment—when ideologies led to revolutions

Assignment: Students create an original poem that documents national identity and history. They study literature to create an epic poem that is consistent with the literary conventions, personal insights and historical narratives that define epic poetry; and history to understand reasons for, events and outcomes of important revolutions.

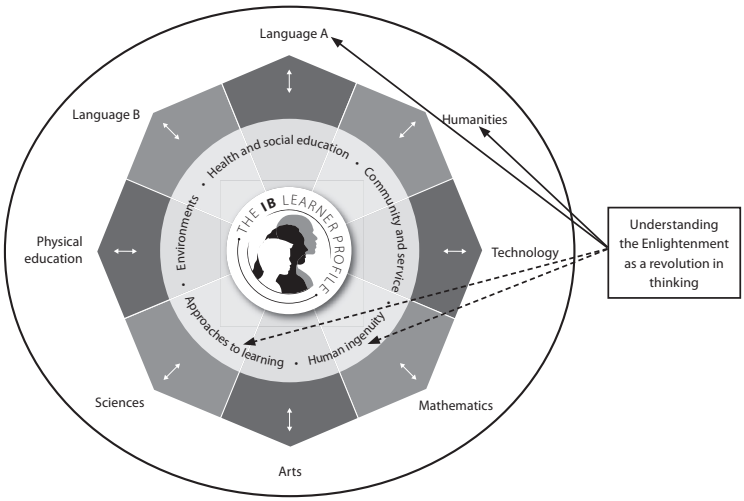


Figure 2

Unit topic: Cultural and environmental conditions that enabled ancient civilizations to survive and thrive

Assignment: Students investigate ancient number systems (Babylonian, Greek, Roman, Incan) and their uses to make hypotheses about why the number systems took the forms they did. They learn elements in mathematics to understand how the ancient number systems worked, comparing them to our current base ten system. They also study social structures, environmental resources, habits of work and number use among different civilizations in humanities classes.

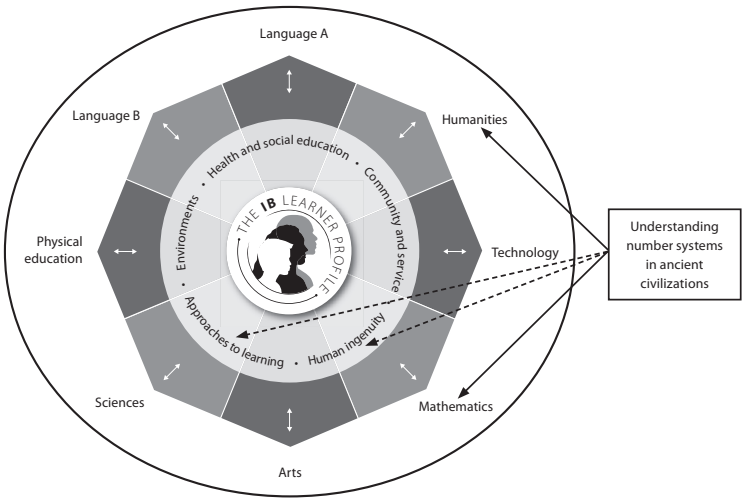


Figure 3

Unit topic: Making Ugandan jewelry to raise funds for a charity home

Assignment: Students create original pieces of jewelry that reflect traditional African aesthetics, Ugandan heritage and identity and contribute to the development of a fundraising event at the school. Students learn about the history and significance of symbols, colours and shapes in Ugandan traditional jewelry. In technology they examine the physical properties and required technologies that make manipulating metals and materials possible; they use visual art to produce distinctly regional designs. Students also begin to develop a business plan for this fundraiser.

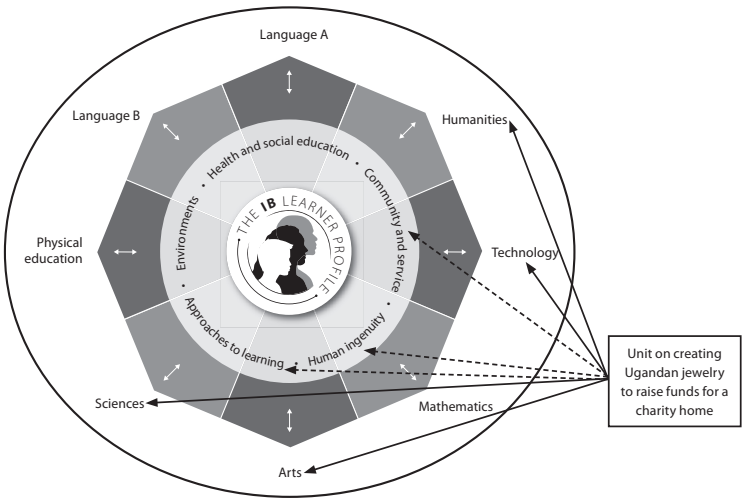


Figure 4

Reflection point

Consider a possible interdisciplinary unit of instruction. What might the unit be about? What might you want students to understand in and across subjects? Explore how you would map the unit on to the MYP framework.

Unit topic:
Assignment:
What students will need to learn:

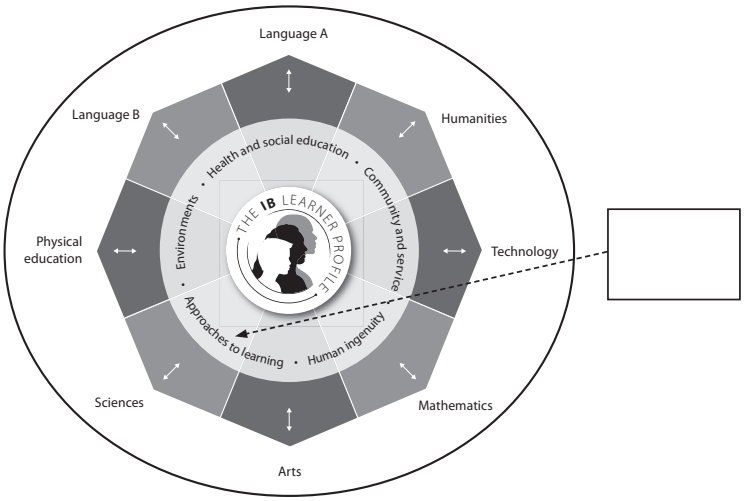


Figure 5

Chapter 3 Why does interdisciplinary learning matter?

Overview

This chapter outlines the reasons that have led the MYP and experienced teachers to favour quality integrative approaches in their teaching. Reasons range from a holistic view of students to genuine opportunities for teachers' professional development.

Reasons for interdisciplinary learning

The MYP values interdisciplinary learning for multiple reasons. Similar reasons are put forth by experienced teachers when they describe why they teach in interdisciplinary ways. These include:

- building on a holistic view of students
- preparing students as lifelong learners and adaptable problem solvers
- highlighting an intellectually rigorous view of knowledge
- preparing students to understand and address global issues
- offering genuine opportunities for teachers' professional development.

Building on a holistic view of students

Interdisciplinary learning recognizes students as individuals with unique interests and diverse intellectual profiles, able to engage with relevant topics and problems as agents in their own learning. For example, "The sound of music" unit shows students engaging with different interests (for example, social, technical, musical, artistic) in a meaningful way. It also calls for distinct human capacities (for example, aesthetic, logical, qualitative, experiential, practical and interpersonal), offering powerful entry points to students with varied intellectual profiles to engage with the topic in depth.

A holistic view of students recognizes diverse interests and talents, some of which might have remained unseen in single disciplinary courses. In the MYP interdisciplinary learning is encouraged to harness such interests and capabilities in order to nurture students' deep understanding of relevant topics. Teachers who embrace interdisciplinary teaching often view their students as whole individuals and members of society, rather than exclusively in their role as aspiring masters of knowledge in a single academic discipline.

> I would hope every student would get turned on to the beauty of mathematical systems, but some students don't, and so I think a lot of students need another avenue into the kind of thinking that I want to get across, and I think that bringing in other disciplines allows that to happen. It turns their attention to some areas where they want to learn about the stuff that they've kind of been having trouble with. So, I get to reach some students that I hadn't been reaching before … with excitement and relevance.
>
> Javier

> I think interdisciplinary [teaching] … encourages different types of learning. Although most of the kids I get are artists, some of them have other areas of study that they do better in, that they're more comfortable with. An interdisciplinary approach gives them the opportunity to delve into things … Some kids are able to write very coherently and other kids are able to show

> understanding of factual information, concepts and issues better … [this class enables them to] integrate that right directly into the artwork … I think that there was more energy put into the work, more enthusiasm, more passion about being able—almost like, it's almost like they were finally allowed to make a statement, you know, about something.
>
> Paul

> What my kids get from [interdisciplinary learning] is they become a community of learners. They see what different people have to offer, and that's always important and always productive. I mean, kids can be really brutal to each other, and so creating that sense of learning together, learning differently, bringing different things to the table, finding different juxtapositions that become catalysts that—while I may be a much stronger reader than the person next to me, it's because of something they saw differently than I did that I can re-evaluate what I think or I can ask a different question and be inspired intellectually by somebody else who thinks very differently from me.
>
> Valerie

Preparing students as lifelong learners and adaptable problem solvers

Teachers point out that in quality MYP classrooms students are not merely expected to record and repeat information given by a teacher; rather they are invited to identify what they know and what they need to know about the topic they are studying, finding new sources of relevant information often outside of the primary discipline, considered with their teachers' support. In so doing, students strengthen their growing role as agents in their own learning and find opportunities to reflect about their own approaches to learning.

When well designed, interdisciplinary instruction helps students understand their strengths and challenges as learners. They gain confidence in their capacity to investigate areas of knowledge about which they know little and develop relevant expertise. In doing so, interdisciplinary teaching strives to nurture students' long-term attitudes toward lifelong learning.

In the example "The sound of music", students can address the failure of their instruments to make sound by enlisting the expertise of the school's physics teachers who can explain, for instance, the role of resonance boxes in augmenting sound. Framing questions or problems, identifying available sources of expertise and ensuring their own understanding prepares students as adaptable actors in our rapidly changing information societies.

> We, as co-teachers were stepping out of the process. We were coaching. We were on the side kind of pushing or moving or adjusting, but they [the students] were basically saying, "What does this mean? How do we figure this out?" One group of kids took it upon themselves to write up on the board, brainstorm, "What do we know and what do we need to figure out? Well, how do we figure that out?" They owned the knowledge, they owned the problem in a way that I don't see kids doing often.
>
> Michael

Highlighting an intellectually rigorous view of knowledge

Interdisciplinary learning invites students to appreciate the nature of knowledge in particular disciplines and see the cohesion and the complementarity of various fields of study. For many teachers, the central motivation for interdisciplinary work is the rigorous teaching of their own discipline. Arts teachers invite students to examine tensions around migration in depth and produce artworks that make a statement in order to inform students' understanding of the arts as a tool for cultural critique. Biology teachers may incorporate a few lessons on still-life drawing in their class in order to help students become more careful

observers of nature during fieldwork. Physics teachers may draw on the history of the Manhattan Project and the creation of the atomic bomb primarily to shed a human light on experimentation but also to look at ethical considerations in scientific research.

In some cases, teachers engage in interdisciplinary work because they expect students to appreciate similarities and differences in the ways particular disciplines shed light on the world, much like theory of knowledge teachers in the Diploma Programme. Teachers motivated by this possibility value students' capacity to reflect about the nature of knowledge in ways that prepare them as knowledge managers. For example, students may compare what constitutes evidence in art, history and biology as a way to enrich their understanding of the nature of evidence. Other teachers may examine the role of symbolism in theatre, music and visual arts seeking to inspire students' original artistic productions.

> You reach a wall in your own discipline, and then you're just kind of grasping, trying to figure—there's so much out there, you know, what's going to help you kind of pull out of your discipline and kind of get that outer view. And I don't even know if I've chosen the best—I've chosen some—history, philosophy of science, things like that, and I think that they did [help my students] to some degree get that more macro, outer view.
>
> Brian

> The arts are in fluctuation now, I mean, in terms of contemporary thinking of arts. And I think that arts education in schools is lagging behind, it is not following contemporary trends [where boundaries across art forms are blurred]. In schools you do skill- or technique-based education. In drama … you do monologues, and playwriting, and scripted plays, you know, Shakespeare … That kind of thinking is completely outmoded. We're teaching students the processes of thinking across theatre, visual arts and music. We're teaching them an appreciation of the creative process … why does a piece of work have the power it has … not just in technique … much more concept and thinking based. These students aren't just taught to do art: they're taught to think why they're doing it, and how they're doing it and where they're doing it.
>
> Matt

Preparing students to understand and address complex global issues

For some teachers, the motivation for interdisciplinary work stems directly from their engagement with a complex and relevant topic—an MYP key commitment. Issues such as the effect of global trade in developing societies, the role of the media in the construction of body images among adolescent girls or the impact of climate change on health cannot be satisfactorily approached through a single disciplinary means. Interdisciplinary instruction becomes a necessary means to address problems of relevance in their full complexity—problems that would have been intractable in disciplinary courses alone.

Complex topics or problems such as the impact of climate change on health are typically multifaceted. Particular dimensions (for example, carbon heat trapping, greenhouse gas emissions, and tropical diseases and prevention) are typically studied by different disciplines (chemistry, atmospheric sciences, and public health). For teachers who seek to support students' comprehensive understanding of the problem, drawing on these various perspectives becomes a necessity.

> [Using an interdisciplinary approach] is partly to dig a little deeper and get much more interesting answers in terms of some of the problems that we're facing, and also it gives me the ability to address real-life problems. So, for example, with the global climate change unit, using only science, I get to address only alternative fuel sources, and a lot of times, those alternative fuel sources are unrealistic without the context of economics or politics. For me, it's about encouraging depth of thinking for the students and also to address real-life problems. That to me was a powerful realization, because I think … students, you know, they have the opportunity to learn some really kind of

> fascinating things, but the way the information is presented is just sort of dry workbook, "here's the information," so I thought that by doing this curriculum, I could instill some emotion and some social relevancy into the curriculum that might sort of challenge students, and maybe even outrage them sometimes, which I think can be good, you know, push the buttons once in a while.
>
> Javier

Offering genuine opportunities for teachers' professional development

Finally, the MYP encourages interdisciplinary exchanges because they offer genuine opportunities for teachers' professional development. Some teachers find interdisciplinary teaching rewarding because it invites them to find novelty and interest in their work and to work creatively using materials from other disciplines. Other teachers value the opportunity to learn about topics of interest and to enrich their own view of their disciplines and of themselves as learners. Still others appreciate the challenge of stretching beyond their comfort zone to increase the richness of what they teach. Finally, teachers value the collaborative nature of interdisciplinary work and the chance to build healthy relationships among adults in their school communities. They also view interdisciplinary teaching as an opportunity to show students how to collaborate effectively, listen intently, challenge arguments and offer meta-disciplinary views.

"The sound of music" project offered an opportunity for each teacher to expand their expertise. The music teacher became intrigued by the science behind the musical arrangements she held dear. The science teacher gained a new appreciation for the complexity of musical instruments. Students themselves witnessed their teachers' determination to learn beyond their disciplines, as teachers consulted with expert musicians and physicists and challenged their own beliefs.

> Well, I certainly have learned a lot, and I've challenged myself more with looking at things from different angles as well. I mean, I teach history and English, and I could have left out the psychology aspect and probably made things easier on the kids but I think it's just a wonderful thing for me, in the area of the humanities especially, to just continue to learn and look at it this way and that way.
>
> Michaela

Ultimately, interdisciplinary teaching in the MYP builds on a serious commitment to teachers' capacity to grow as thinkers, citizens and professionals. For many teachers, this is perhaps the most personally meaningful motivation to teach across disciplinary lines:

> My goal is to transform [the students]; to challenge them to think deeply; to become human beings in the fullest sense of the term. I want them to be weary of simple solutions. I am relentless. I ask them questions to move their thinking one further step. I view ideas in the disciplines as arrows in a quiver, which I use selectively and with precision to transform thoughts at each time. That makes teaching meaningful to me as a person.
>
> Judi

Reflection point

Take time to reflect about your own reasons for teaching in interdisciplinary ways in the MYP. First, you may consider brainstorming multiple reasons that come to mind and then deciding which ones are most relevant for you. Consider discussing these with your peers. It may be useful to use a chart such as the one below.

	Disciplinary teaching	Interdisciplinary teaching
Advantages	• _____ • _____ • _____ • _____ • _____ • _____ • _____ • _____	• _____ • _____ • _____ • _____ • _____ • _____ • _____ • _____
Risks	• _____ • _____ • _____ • _____ • _____ • _____ • _____ • _____	• _____ • _____ • _____ • _____ • _____ • _____ • _____ • _____

Figure 6

Chapter 4 Interdisciplinary teaching in the MYP

Overview

This chapter addresses instructional designs. Specifically, it describes a series of approaches to quality interdisciplinary teaching. Two questions are addressed and illustrated with examples from practice.

1. How might teachers approach interdisciplinary instruction in the MYP?
2. What are the core questions and design principles of quality interdisciplinary teaching in the MYP?

Five teaching principles encouraged by the MYP to nurture quality interdisciplinary understanding among students are outlined.

How might teachers approach interdisciplinary instruction in the MYP?

The MYP recognizes that teachers can devise a broad variety of quality interdisciplinary units of instruction. Teaching designs vary regarding their purpose and content focus, the selection of disciplines involved, grade level taught, as well as scope and forms of teacher collaboration required. Recognizing this diversity is important to enable teachers to find comfortable opportunities for creative and rigorous interdisciplinary explorations with their colleagues and students.

Multiple scopes for interdisciplinary work

MYP teachers are encouraged to find an adequate scope for their work depending on their instructional purpose and level of comfort with interdisciplinary teaching. Interdisciplinary teaching may vary from small-scale disciplinary extensions; to interdisciplinary "threads" in a course; to large scale interdisciplinary units or projects.

Most teachers approach interdisciplinary teaching with a genuine and valuable commitment to teaching their own discipline. Frequently, these teachers find that borrowing knowledge, concepts or skills from a neighbouring discipline can enrich their students' understanding of the discipline they teach. For example, a biology teacher may "borrow" select lessons in still-life drawing to further students' capacity to observe during fieldwork. A mathematics teacher may invite students to create fractal computer art with the intention of building the visual thinking necessary to translate functions into two- and three-dimensional spaces. These examples illustrate how courses that are primarily disciplinary can benefit from quality, modest forays into neighbouring disciplines.

Contrastingly, other teachers may prefer to weave an interdisciplinary thread throughout their disciplinary courses. For instance, a history teacher may revisit the question of how monuments, art works and propaganda use visual symbols to tell a story about society, preparing students to create informed historical monuments of their own by the end of the year. A biology teacher may include selected concepts in ethics or moral philosophy to invite their students to reflect about our human responsibility towards the environment and other species.

Finally, some teachers may dedicate a sizeable unit of work to a topic that demands an interdisciplinary approach. For instance, the study of globalization requires that students learn to think like economists, sociologists and anthropologists simultaneously. A unit on how to mitigate and adapt to climate change demands insights from the natural sciences as well as economics, public health, and political science.

Multiple structures for collaboration

The MYP recognizes that multiple teacher arrangements can suit quality interdisciplinary teaching. In some cases a single teacher finds himself or herself to be prepared to teach interdisciplinary topics either by virtue of their formal training or through their own informal studies. In other cases, a single teacher may lead an interdisciplinary unit alone but only after having worked with a group of peer advisors to address manageable concepts outside their own training. In further instances, teachers engage in collaborative planning and approach teaching either by co-teaching a single group of students or by sensibly linking courses. While in a single teacher arrangement teachers can model integrative thinking for students through their own example, a collaborative teaching approach enables students to witness differences and complementarities between disciplinary perspectives embodied by each teacher.

Among the great variety of fruitful approaches to interdisciplinary teaching three common standards of quality remain unchanged. Quality teaching must yield student work that:

- has a relevant learning or inquiry purpose
- is well grounded in disciplinary expertise in the subject groups
- integrates disciplinary perspectives productively.

What are the core questions and design principles of quality interdisciplinary teaching in the MYP?

Core questions and design principles

Teaching designs (interdisciplinary or not) involve making thoughtful decisions about what to teach, what exactly students should do to learn and how one might assess and support students' progress. *MYP: From principles into practice* (August 2008) offers a series of strategies for instructional design and curriculum coordination that address these questions in practical terms. When teachers seek to foster students' deep interdisciplinary understanding, making these decisions invites particular considerations that will be addressed in the remainder of this chapter.

Teachers planning an interdisciplinary unit or project must ask themselves five fundamental questions. For each question the MYP offers a concrete strategy for quality instructional design. Questions and design principles are first outlined and then introduced below.

1. How do we identify multifaceted unit questions?

   The MYP requires that teachers identify multifaceted unit questions that stem from the areas of interaction and define the problem space to be studied through an interdisciplinary approach.

2. What disciplinary concepts and modes of thinking in the MYP subjects will students need to develop in order to address the question under study?

   In the MYP, teachers draw on the subjects to identify disciplinary understandings (concepts, skills, modes of thinking) that will inform student understanding of the topic or question—and serve as a basis for assessment.

3. How will disciplinary insights be productively integrated to deepen student understanding of the topic at hand?

   In the MYP, teachers articulate the specific connections or integrative understandings across subjects and subject groups that they seek to support among students. These understandings will also be assessed.

4. What will students do to learn?

   In the MYP, teachers are expected to design learning experiences and understanding performances for students that promote purposeful, disciplined and integrative understanding of the topics under study.

5. How will teachers and students know that students are building interdisciplinary understandings?

   In designing interdisciplinary instruction, MYP teachers are encouraged to devise a targeted assessment approach that integrates MYP objectives and criteria to assess clarity of purpose, disciplinary grounding, integration, and reflectiveness in students' interdisciplinary work.

When designing units of work of various scopes, the MYP interdisciplinary teaching model introduced here invites teachers to move among its elements in any way they feel comfortable. We may also emphasize different elements at different moments of a design because, in practice, the framework elements are interrelated and mutually informing. In the end, what matters is that students engage in learning experiences that are **purposeful** (students clearly understand why studying the issue matters and demands an interdisciplinary approach); **disciplined** (understanding that is rigorously informed by two or more disciplines) and **integrative** (an understanding that is enriched by the combination of disciplinary perspectives).

Exploring the five design principles

1. How do we identify multifaceted unit questions?

MYP teachers are encouraged to identify "multifaceted unit questions" as a focus for their interdisciplinary instruction. Multifaceted unit questions are a particular kind of unit question. They address aspects of the world that can be productively studied by two or more disciplines. For example, the unit on sound and music, described earlier in this guide productively addressed the phenomenon of sound from the physics and musical perspectives, involving the understanding of the physical properties of how sound is produced and its musical qualities and expressive possibilities. Multifaceted unit questions invite an integrative understanding and need to be studied beyond single disciplines.

A multifaceted unit question in an interdisciplinary unit defines the problem space for student inquiry and gives it purpose and direction. In the unit "The sound of music", the key question "how do instruments produce sound to create interesting pieces of music?" captures the multidimensional nature of the topic, providing clarity of purpose as the class engages in the unit's investigations. In quality interdisciplinary designs, multifaceted unit questions are relevant, feasible and clearly framed to invite student interdisciplinary inquiry.

Making multifaceted unit questions relevant

A good multifaceted unit question is relevant to students, teachers, and the societies in which we live. Because the MYP places students at the centre of their learning and recognizes the intellectual demands of interdisciplinary work, it is especially important that the questions be meaningful and engaging to students—they must connect with students' prior knowledge, life circumstances, and interests in developmentally appropriate ways. Similarly, powerful questions engage teachers' own expertise, interests and commitments. Perhaps most importantly, the MYP's multifaceted unit questions are vividly relevant to the societies in which we live—capturing important aspects of the world and human experience typically framed in the areas of interaction.

How does the unit on "The sound of music" demonstrate a relevant multifaceted unit question?

In the unit, the topic was relevant to teachers, society and students alike. Rita, the teacher and an accomplished musician in her own right, explained how intriguing she found the question of how exactly her instruments produced sound. Physics, once a distant discipline, became suddenly a very interesting one. She also valued students' appreciation of traditional African instruments especially as rapid globalization threatens to turn ancient cultural heritage into commodities. Astrid, who contributed to teaching music for the unit, explained: "The students wanted to do something that sounds good. I remember the case of this student who really wanted to know how to make a good drum. 'Look, look!', he shouted, 'I have made a drum and there is sound in it and there is even a heart in it'". Rita added: "The nice thing is that they stayed, the bell rang and they stayed, they wanted to ask questions. 'What scale is my voice?' 'Why does my instrument not work?'"

Making multifaceted unit questions feasible

Quality multifaceted unit questions must be feasible with regard to students, context, teacher expertise and resources. Multifaceted unit questions invite multiple connections sometimes beyond teachers' existing expertise and available resources, which is why considerations of feasibility matter in how we define a multifaceted unit question. An important decision in interdisciplinary teaching is deciding what we will **not** include in a unit.

How does the unit on "The sound of music" demonstrate a feasible multifaceted unit question?

The teachers, Marcie and Rita, felt confident that they had the expertise to address the topic, even if later in the unit they realized the limits of their capacity to explain why a particular instrument was not making the expected sound or how to create a graphic model of sound waves travelling inside a resonance box. In both cases, however, they were able to enlist the help of more knowledgeable individuals. First, Rita brought in a professional native musician and instrument maker who eventually joined the group to help students create their rhythmic composition. Marcie then consulted with the high school physics teacher on viable and age-appropriate representations of sound waves for her students.

Framing multifaceted unit questions clearly

Finally, quality multifaceted unit questions are framed in a way that leads students towards purposeful inquiry. A careful framing of the topic for study conveys why students are learning what they are in the unit (for example, developing knowledge needed to create a product, solving a pressing societal problem, explaining a phenomenon). Such a framing goes beyond naming a broad theme being studied such as "musical instruments". Rather, it gives students a sense of what aspects of the theme will be examined, why such examination matters and why an interdisciplinary approach is warranted.

How does the unit on "The sound of music" demonstrate a clearly framed multifaceted unit question?

In the unit, the very description of the topic makes both "sound" and "music" as well as the connection between them clear—"how do instruments produce sound to create interesting pieces of music?"

Connections
Chapter 5 revisits and provides examples, practical tools and strategies to design multifaceted questions in the context of the areas of interaction.

2. What disciplinary concepts and modes of thinking in the MYP subjects will students need to develop in order to address the question under study?

Disciplinary understandings

Because interdisciplinary work is deeply grounded in disciplines or established areas of expertise, "tooling" students to produce quality work requires that we ensure a selective mastery of disciplinary concepts and modes of thinking that are relevant to understanding and addressing the question under study. MYP teachers must identify and select key disciplinary understandings specified in the subject-specific goals and contents.

In the MYP disciplinary understandings are not limited to the knowledge base in a given subject. Rather, students are invited to learn the methods for generating knowledge, how disciplinary knowledge can be employed to help us understand and act in the world, and how knowledge is communicated in the discipline (for example, scientific reports, critical essays). In an MYP unit design, disciplinary understandings must be "robust" and "selective".

Robust disciplinary understandings: In the MYP, teachers are encouraged to align disciplinary understandings with the MYP subject-specific aims and objectives and their school and national subject-specific content. At all times, robust disciplinary understanding should echo the work of experts in each discipline involved. For instance, teachers must recognize and modify students' misconceptions in their discipline. They must also embrace not only information but habits of mind central to the disciplines they teach.

How does the unit on "The sound of music" demonstrate robust disciplinary understandings?
Understanding of sound from a physics perspective implies a close examination of intrinsic elements of sound waves (propagation, medium, amplitude and length), the extrinsic manifestation of the sound wave (rarefaction and compression), and the incidence that a sound wave has on materials and how these materials qualify the sound wave (vibration, resonance, echo).

Selective disciplinary understandings: Disciplinary understandings included in a design must also be strategically selected, both in terms of which disciplines are included in an MYP unit and which specific insights from each discipline are borrowed. In MYP units teachers are encouraged to weigh the particular ways in which disciplines might contribute to student understanding of the multifaceted topic or unit question. Furthermore, teachers must, for feasibility, select which insights—particular concepts, theories, examples, methods or techniques—students will come to master and apply to the problems under study. This selection often requires that teachers rearrange the contents stipulated in the school or national curriculum.

How does the unit on "The sound of music" demonstrate selective disciplinary understandings?

As already explained, to understand how instruments make sound and how to use sound to create aesthetic experiences, students were expected to master a few key selected concepts in physics and in music. Other disciplines and perspectives, such us traditional decorative visual arts or the history of African musical instruments were considered, but not included in this unit to ensure a deep understanding of music and physics within the available time frame.

3. How will disciplinary insights be productively integrated to deepen student understanding of the topic at hand?

Integrative understandings

Integrative understandings are insights that deeply and meaningfully connect elements from different disciplines. That is, a student has an integrative understanding when he or she can act upon, generate, or describe a productive relationship of ideas across disciplines. There are multiple ways in which concepts and modes of thinking in different disciplines connect, and one unit or course may draw on multiple forms of integration.

In quality interdisciplinary designs, integrative understandings are more than superficial links among disciplinary ideas. Rather, they deepen students' understanding. MYP teachers must articulate the connections across disciplines that they seek to nurture, and they must assess students' developing capacity to build fruitful connections over time.

Two considerations must inform teachers' attention to integrative understandings. Integrations must be aligned with the MYP unit question and they must clearly advance understanding.

Aligning understandings with multifaceted unit questions

In quality units, integrative understandings are visibly aligned with the multifaceted unit question that frames a unit of work's inquiry. The multifaceted question in a unit frames teachers' and students' inquiry and learning making some connections more relevant than others.

How does the unit on "The sound of music" demonstrate how to align understandings with multifaceted unit questions?

Teachers expect students to become able to use what they know about the physics of "sound" to produce an informed explanation of how their instruments work. For students, the instrument itself became the point of integration. Conversely, exploring new kinds of sound produced by their instruments could inspire students to push the boundaries of what counts as music in more traditional terms. Both connections are key to the overall purpose of the unit.

Advancing students' understanding

By drawing on two or more disciplines, the MYP units of work seek to do more than alert students to possible connections among disciplines; they seek to nurture deeper understanding of the topics under study. In the MYP units of work, integrative understandings move beyond mere connection making. Rather, they seek to yield an explanation, a work of art, a visual model, a realization, that students would have been unable to produce in the context of single subject approaches.

How does the unit on "The sound of music" demonstrate students advancing their understanding?

The teachers, Rita and Marcie, moved beyond "helping students see connections between physics and music". They framed integrative understandings as follows.

"Students will be able to explain how musical instruments work by understanding the science of sound. Indeed, they will use their understanding of physics to build their own instruments and demonstrate elements of acoustics, resonance, pitch and vibration.

Students will expand, transform, and create 'new' music. Through the use of new (unfamiliar) sounds they will expand their sensibilities about what is possible outside of canonical music."

Connections

Chapters 6 and 7 illustrate how teachers can draw on MYP aims and objectives and school-based curricular content to inform the selection and design of expected disciplinary and integrated understandings in an interdisciplinary unit.

4. What will students do to learn?

Performances of understanding

To the question of how students will learn, the MYP interdisciplinary teaching model responds by engaging in performances of understanding. Performances of understanding are a particular kind of learning experience—one that encourages flexible thinking with knowledge in novel situations. For example, "going on a field trip" or "gathering information about our city" can be engaging learning experiences for students. Yet they become performances of understanding when students are asked to use information deliberately to advance a new understanding. For example, the field trip may be part of a unit on endangered species and students may be asked to identify evidence of predator–prey interactions during their trip to build hypotheses about possible threats to the local ecosystem.

Performances of understanding allow students both to build and demonstrate their understanding in and across subjects. They are based on the theory that understanding is not something we have—like a set of facts we possess—but rather it is something we can do. Note that by using the term "performances", the MYP model does not emphasize "stage performances" such as plays or concerts. Rather, it refers to opportunities to consider something related to the knowledge we already possess, whether such thinking results in a group presentation, an essay, or a mental computation to respond to a question.

Different forms of performances of understanding

In MYP interdisciplinary designs, performances of understanding take different forms depending on where in the unit they are placed (beginning, middle or end) and whether they target disciplinary or integrative understandings. There are three types of integrative understanding, introductory, midway supported synthesis and final synthesis, and one type of disciplinary performance, disciplinary tooling performances. When designing interdisciplinary instruction, MYP teachers must consider all four types of performances of understanding.

Introductory performances: Introductory performances offer an accessible entry to—and preview of—the larger multifaceted unit question and its potential complexity.

What introductory performances could be used in the unit on "The sound of music"?
Students can begin by attending a local concert that employs traditional African instruments. Their task is to identify sounds they enjoy and attempt to explain how such sounds are produced by the instruments they see being performed. During a class discussion afterwards, teachers may introduce the multifaceted unit question that will guide inquiry throughout the unit and identify the areas of expertise that the class will need to explore. Introductory performances offer opportunities for diagnostic assessment, as students make their initial beliefs and knowledge visible. Furthermore, these early performances play a key role in helping students understand the multifaceted nature of their unit question and the purpose and relevance of the work to be accomplished.

Midway supported synthesis performances: Midway syntheses offer students structured support on a manageable integration.

What midway syntheses could be used in the unit on "The sound of music"?
Rita and Marcie supported students in their effort to "translate" physical features of sound into music creating a table similar to the one below.

Science	Music
Wave amplitude	Volume
The elements that determine the speed of sound:	The elements that determine the speed of sound in a music context:
• Elasticity • Density • Temperature of medium.	• (Elasticity) Dryness and softness of the instrument's material • Density of the instrument's material • Temperature of instrument.
Wave longitude (Frequency, for example, 440 vibrations per second)	Pitch (Musical note, for example the central A [la] in the traditional keyboard)

Figure 7

Also, midway in the unit, the students' assignment in the physics class required them to manipulate sound waves to see their impact on sound produced by musical materials and create their own visual models about how sound worked in each case. For example, students placed a tuning fork in water and watched the waves it generated. They also placed dry grains of rice on a drum and watched pattern formations when it vibrated, capturing the relationship between sound and sound waves, rarefaction and compression. Students' preliminary models were revised through class discussions.

Final synthesis performances: These performances allow students to bring disciplines together in a way that shows mastery and greater independence.

What final synthesis performances could be used in the unit on "The sound of music"?
Moving beyond initial analogies and connections Marcie and Rita aspired to prepare students to actually explain how instruments make sound. Visual representations of the sound waves produced by the vibration of a string or a drum skin were of the essence as was an effective performance that would illustrate richness in rhythms and qualities of sound made by various instruments.

Disciplinary tooling performances: Disciplinary tooling performances help students build adequate foundations in the subjects. These performances enable teachers and students to turn their focus toward deepening particular disciplinary understandings.

What disciplinary tooling performances could be used in the unit on "The sound of music"?
In this example, music lessons invite students to apply the concept of variation in composition to create a musical piece of their own. In physics students develop hypotheses about how sound travels through different media and devise small experiments to test them. Naturally, throughout a well-designed unit, students alternate between disciplinary and synthetic performances.

Performances of understanding are carefully sequenced

Performances of understanding are sequenced to advance interdisciplinary understanding of the topic. Whether teachers begin their planning with a very clear articulation of desired interdisciplinary learning outcomes or with a good definition of an area for open exploration, quality interdisciplinary units and courses sequence performances in ways that move toward progressively deeper interdisciplinary understanding, from early intuitive introductions to a problem under study, to guided examinations to more independent work as illustrated above.

Performances of understanding are well-supported

In MYP units, performances are also well-supported by rich experiences and resources. Presentations, films, readings, visits, discussions, and other activities and resources inform students' performances and provide added opportunities for students to advance understanding. In "the sound of music" unit, students had master classes with local musicians, listened carefully to performers, examined a variety of real instruments and used simple materials in their science experiments.

Connections
Chapter 8 offers additional examples and guidelines to craft effective performances of understanding in interdisciplinary MYP units.

5. How will teachers and students know that students are building interdisciplinary understanding?

Targeted assessment

In the MYP teachers are encouraged to employ a variety of assessment strategies, tasks and tools to monitor and further support student learning. For example, teachers are encouraged to employ strategies to gather information about student learning that range from classroom observations to close reading of student journals and joint analysis of their portfolios. In the MYP, teacher-designed performances of understanding may take the form of a composition, a research report, a presentation, or a proposed solution. Such

performances serve two functions: they build student understandings, and they make such understandings visible and amenable for assessment. Teachers can use the information to find out how to support students further (formative assessment) and whether the unit has achieved its goals (summative assessment).

In the MYP assessment is criterion-related. Each subject group offers a series of criteria and descriptors that inform subject-based end-of-programme assessment. Interdisciplinary teaching in the MYP places subject-based criteria in the broader framework of targeted assessment. This assessment approach targets not only students' subject-specific knowledge, understanding, inquiry skills and communication capacity but also their capacity to synthesize and reflect about the process of interdisciplinary learning.

Four elements are highlighted:

- the degree to which student work exhibits clarity of purpose
- the degree to which the work is well grounded in subjects or disciplines (subject-specific criteria enter here)
- the degree to which student work integrates disciplines productively
- the degree to which students show a reflective stance toward their work.

How does the unit on "The sound of music" demonstrate targeted assessment?

Building their instruments and performing their composition gave students a clear sense of purpose for their work. Some students' comments revealed the purpose and opportunities in their inquiry in further detail.

> You can engage with the music better if it is something you made.
>
> When you understand how your instruments make sound you can manipulate your instrument in new ways, you can experiment.

Explaining how instruments produce sound through visual models offered an insight into both a disciplinary grounding as well as an integrative one, revealing acquired understandings as well as misconceptions. For example, a student was able to explain how waves travel through air fluently from a physics perspective. Yet when asked why an African guitar needed a resonance box, one student mistakenly, though understandably, explained "because the box makes an echo and then you hear the music better".

A reflective stance about interdisciplinary work was revealed by another student in the group. He explained that the challenge of the unit was to "hold all the pieces together" in his mind. He went on to describe how, as a musical child, he had always enjoyed listening to music yet understanding how sound is produced adds another layer to that appreciation, "I now enjoy music even more".

The MYP interdisciplinary teaching model explained here offers conceptual tools to guide practical decisions about what and how to teach in an interdisciplinary fashion in the MYP. To enable the necessary flexibility for teachers to adapt design principles to school and national curriculums worldwide, the framework does not prescribe exactly what to teach. Instead it offers recommendations about how to design quality interdisciplinary instruction. The MYP approach to interdisciplinary teaching pays serious attention to subject or disciplinary expertise. At the same time, it recognizes that quality interdisciplinary learning requires more than the mere juxtaposition of subject perspectives on a theme. Students must be supported in their capacity to integrate perspectives in meaningful and productive ways. The model provides a common language to frame topics for study, draw on and integrate robust disciplinary foundations, to organize students' learning experiences and assess and support their progress. Perhaps most interestingly,

the framework offers a common conceptual point of reference for teachers whose interests, expertise and motivations for interdisciplinary teaching is broadly varied—in so doing it sets the foundations for rich learning communities in schools.

A schematic summary of a unit of work

Examples of exemplary interdisciplinary work can be found across schools and regions. Examining them through the perspective of the MYP approach to interdisciplinary teaching offers further illustration of the ways in which the approach can inform and organize practice. A schematic summary of one unit is offered here. The theme of the unit of work was "Exile". In-depth examinations of this and other units appear in chapters 5 to 9.

<table>
<tr><th colspan="3">MULTIFACETED UNIT QUESTION</th></tr>
<tr><td colspan="3">What is exile? Exploring its many forms, experiences and expressions</td></tr>
<tr><th colspan="3">DISCIPLINARY UNDERSTANDINGS</th></tr>
<tr><td>Visual arts

Students will understand how sculptures and installations are used to convey personal and social expressions of exile.</td><td>Theatre

Students will understand the origins and principle of Butoh theatre, its meditational quality and aesthetic, and how it challenges traditional views of theatrical performance.</td><td>Music

Students will understand how musicians have challenged traditional conceptions of music.</td></tr>
<tr><th colspan="3">PERFORMANCES OF UNDERSTANDING (Disciplinary tooling)</th></tr>
<tr><td>Visual arts

• Research lives and work of Do-ho Suh and Kara Walker who have been exiled or who have exiled themselves from society.
• Artist's notebook entry must inform, express and synthesize their findings.
• Critique and expand artists' work.</td><td>Theatre

• Research Butoh theatre tradition and technique as a "dance of darkness" and the search for awareness.
• Artist's notebook entry must inform, express and synthesize their findings.
• Explore and expand performance.</td><td>Music

• Research music of John Cage, Henry Cowell (The Banshee), Steve Reich (clapping music).
• Critique and perform a piece of contemporary music.
• Developmental workbook entry must inform, express and synthesize research.</td></tr>
<tr><th colspan="3">INTEGRATIVE UNDERSTANDINGS</th></tr>
<tr><td colspan="3">Through this unit students will understand the role of symbolism and self-reference in contemporary theatre, music and visual arts.

They will move away from art in the traditional skills-based sense to a more conceptual understanding through the topic of exile.

Students will gain a deeper and more personally meaningful understanding of exile drawing on their own personal experiences and that of others. They will gain nuance in their understanding of exile by re-representing and exploring it in multiple artistic media.</td></tr>
</table>

PERFORMANCES OF UNDERSTANDING (Syntheses)
Introductory performance: Through class discussion students share multiple meanings and expressions of "exile" (individual and social). They examine metaphors of exile and reasons about forces that cause it. **Midway synthesis**: Students create a mood board that visually represents how their findings in visual arts, theatre and music are integrated. They introduce their mood board to the class. **Midway synthesis:** Students develop a draft proposal for their "happening". The "happening" is to include adequate symbol use and make references to the art forms examined. **Final synthesis:** Students develop and perform an original "happening" that expresses what exile means to them.
TARGETED ASSESSMENT
Multiple sources of evidence used: discussion, journal reflections, proposal, mood board, reflection. Criteria focused on students' (a) clarity about the purpose of their "happening" (what they are trying to accomplish and why it matters); (b) ability to place their work in the context of contemporary movements in the three forms of art (subject-specific criteria included); (c) effective integration of art forms to reveal novel interpretations of exile; and (d) their capacity to reflect about the process of creation and the achievements and limitations of their work.

Figure 8

Further examples of resources for planning interdisciplinary teaching

MYP interdisciplinary teaching framework: A teacher's guide

ELEMENTS OF INTERDISCIPLINARY TEACHING FRAMEWORK	GUIDING QUESTIONS
Multifaceted topic/unit question: What topics or issues will this unit address through an interdisciplinary design?	
• Relevant	• Is the topic/question of interest and importance to students, me and society? • Is the topic/question meaningful and engaging to students and me? • Is the topic developmentally appropriate for students?
• Feasible	• Are there teaching resources available? • Is there sufficient time for a deep exploration of the topic? • Is there appropriate expertise available?
• Clearly framed	• Is the topic/question framed so that students understand the nature of our interdisciplinary work in the unit?

Disciplinary understandings: What disciplinary concepts, tools and modes of thinking will students need to understand the topic?	
• Robust	• Does the unit capture important concepts and modes of thinking in two or more disciplines?
• Selective	• Does the unit focus on the most important concepts and modes of thinking in two or more disciplines given the topic under study?
Integrative understandings: What connections across disciplines will students need to make to understand?	
• Tied to the purpose of the unit	• Do the integrative understandings add coherence to the design?
• Clearly described	• Are the integrative understandings described in such a way that students can understand them?
Performances of understanding: What will students do to learn?	
• Foster clarity of purpose, disciplinary grounding, productive integrations and thoughtfulness	• Do the performances help students appreciate the purpose of their inquiry? • Do the performances build disciplinary grounding? • Do the performances develop productive integrations across the disciplines? • Do the performances reflect the learning of the students?
• Progressively advance interdisciplinary understanding of the topic	• Do the *introductory performances*, *disciplinary tooling performances*, *midway syntheses* and *synthetic final performances* move progressively toward deeper interdisciplinary understanding?
• Take advantage of rich experiences and resources	• Does the unit provide a variety of opportunities for students to advance understanding?
Targeted assessment: How will we and students know that they are coming to understand the topic in depth?	
• Draws on a representative selection of student work	• Does the assessment consider all relevant aspects and indicators of student understanding?
• Is formative and summative	• Is the assessment designed to support students and inform instruction along the way?
• Pays attention to clarity of purpose, disciplinary grounding, productive integrations and thoughtfulness	• Does the assessment pay attention to clarity of purpose, disciplinary grounding, productive integrations and thoughtfulness?

Figure 9

The following diagram (figure 10) is a visual representation of the table in figure 8.

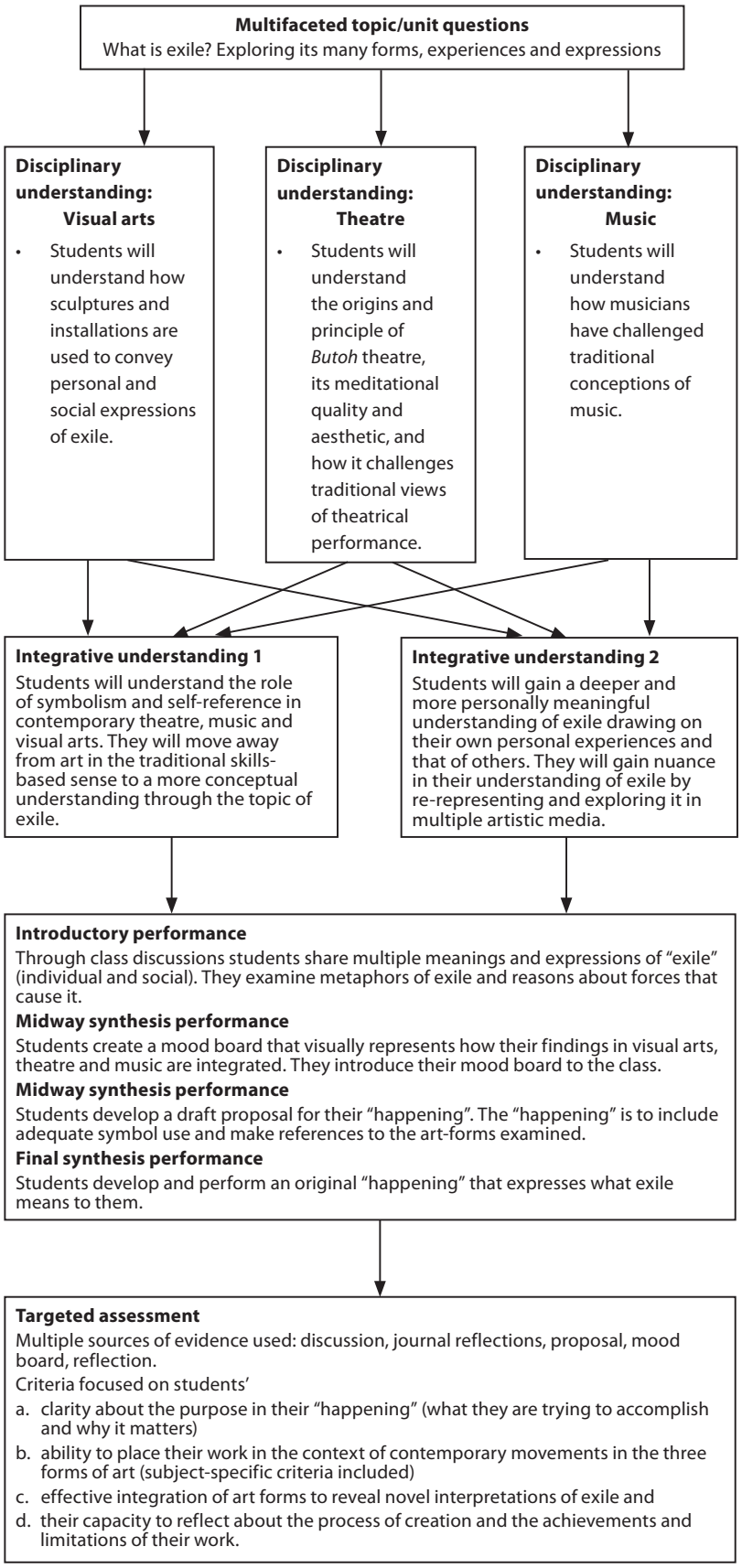


Figure 10

The following checklist may be useful in designing units of work.

CHECKLIST FOR INTERDISCIPLINARY TEACHING

COMMENTS

Is my unit designed with the following **fundamental concepts** in mind?
Select those applicable.

- Holistic learning [ ]
- Intercultural awareness [ ]
- Communication [ ]

Is my unit designed to nurture **interdisciplinary learning** that is

- purposeful [ ]
- disciplined [ ]
- integrative [ ]

Have I designed the unit around a **multifaceted unit question or topic** that is

- relevant [ ]
- feasible [ ]
- clearly framed [ ]

Are the **disciplinary understandings** in my unit

- robust [ ]
- selective [ ]

In my unit, are the **integrative understandings**

- tied to the purpose of the unit [ ]
- clearly described [ ]

In my unit, are the **performances of understanding** designed to

- foster clarity of purpose, disciplinary grounding, productive integrations and thoughtfulness [ ]
- progressively advance interdisciplinary understanding of the topic [ ]
- take advantage of rich experiences and resources [ ]

Have I planned **targeted assessment** that

- draws on a representative selection of student work [ ]
- is formative and summative [ ]
- pays attention to the clarity of purpose, disciplinary grounding, productive integrations and thoughtfulness [ ]

Figure 11

Reflection point

In this chapter you have been introduced to the MYP model for interdisciplinary teaching. Based on this first encounter, what do you view as the promises or the advantages in a model of this kind and what are the puzzles or concerns that the model presents you with so far?

Make a list of each and use your reflection to guide your readings of chapters 5 to 9. Remember that you can read the chapters in any order.

Chapter 5 Crafting multifaceted unit questions in the areas of interaction

Overview

The MYP interdisciplinary teaching approach helps teachers capture the rich opportunities for learning embedded in the subject groups and areas of interaction and turn them into concrete and potent topics for interdisciplinary instruction. Such topics are by nature multifaceted—they visibly address aspects of a problem that are studied by different subjects. A question such as "how can our local community make sustainable use of our river's ecosystem?" requires insights from economics, geography and biology. A question such as "what constitutes an effective health campaign in our school?" will intertwine human biology, language and graphic design. Multifaceted unit questions of this kind guide student learning and inquiry, giving a clear sense of purpose to students' work.

This chapter guides teachers interested in crafting effective topics for interdisciplinary teaching. Specifically, it considers:

- What topics are worth teaching in interdisciplinary ways?
- What makes a multifaceted unit question suitable for interdisciplinary instruction?
- How can teachers design quality interdisciplinary units?

Connections
Chapter 6 introduces the challenges of building disciplinary understanding and offers strategies to do so in interdisciplinary units. Additional guidance for designing learning experiences within each subject group can be found in subject group guides.

What topics are worth teaching in interdisciplinary ways?

Experienced MYP teachers recognize that not all topics are equally suited for quality interdisciplinary examination. Indeed for many topics, (for example, understanding genetic inheritance) a single discipline or subject approach may suffice and often be preferable. A serious treatment of such topics can nurture students' disciplinary capabilities, for example, their ability to generate and test hypotheses, or build complex explanations of historical events. Because such understandings are not easily developed, carefully designed learning experiences are essential to support students' disciplinary growth.

Some topics, however, defy single disciplinary treatment. Understanding them demands that students integrate two or more bodies of expertise. Because these topics address two or more dimensions of a given topic they are called multifaceted. Understanding how the arts embody cultural traditions demands that students learn elements of history, music, visual arts and perhaps anthropology. Understanding how to mitigate climate change demands that students learn both about climate science and about economic incentives or environmental ethics. To examine how teachers might craft multifaceted topics for interdisciplinary teaching consider an example in which students study *sikkus* as cultural artifacts.

An example: *Sikkus* in Latin American culture

Students in MYP year 3 are studying the *sikku*, a musical instrument originally produced by pre-Columbian inhabitants of the Andes in South America. They treat it both as a wind instrument and as a traditional cultural product. "The *sikku* survived over multiple centuries as part of the local folklore", explained Raul, one of the teachers. Today, however, it risks disappearing under the forces of globalization. He went on to describe the purpose of the unit.

> This unit is essentially about Latin American culture. It seeks to help students become aware of, and appreciate their cultural heritage through the arts. In this unit students learn that the arts embody multiple expressions of a community and transcend the community itself reflecting its essential values. The unit's final goal is to create a sustainable development project in low income communities to ensure that children have access to instruments that enable them to continue to play our regional music.
>
> Raul

The unit gathered teachers in disciplines from music, visual arts and technology, to science, geography and history. Learning about sound waves enables students to create *sikkus* out of recyclable materials. Principles of scientific experimentation and technological design help them determine appropriate tube lengths. Learning about pre-Columbian values and aesthetics leads them to decorate their instruments with ancient motifs and perform traditional melodies. Perhaps most importantly, documenting their work enabled them to teach children in a local underserved school to make and play *sikkus* as a way of preserving their ancestral traditions.

This unit effectively focused students' and faculty attention on three multifaceted unit questions for inquiry. Each question addresses a particular aspect of the issue under study and represented itself as an opportunity to integrate disciplinary perspectives. Each question enables teachers to locate their disciplinary contributions on a shared conceptual map of the unit as a whole.

1. How can we create a *sikku* that can be played in a pentatonic scale?

The first question centres on the production of *sikkus* for which knowledge in physics, technology and music are necessary. The question is informed by the aspirations of human ingenuity in exploring the origins and development of *sikkus* over time.

2. In what ways does a *sikku* embody our Latin American cultural traditions?

This question placed the instrument in the larger context of Latin American culture and tradition, drawing on history, geography, visual arts and music to enrich students' understanding of the cultural meanings embodied in the instrument.

3. How can we preserve our cultural traditions in a sustainable way at a time of rapid globalization?

The last question invited students to apply what they have learned to the solution of the practical challenge of preserving Latin American cultural roots in their community. It brought together music, visual arts, technology, history and geography. This question and the one before seek to prepare students for community and service.

Essential to multifaceted unit questions in the MYP interdisciplinary teaching approach is the fact that they embody dimensions that are typically studied by experts in different disciplines or established fields of knowledge. These questions require that students integrate disciplinary perspectives in order to create more complex, thorough and accurate explanations, solutions or products. Most importantly, they establish the learning agenda for a unit or course.

Consider the following examples of multifaceted questions, the subjects they speak to and the area of interaction contexts in which they can be placed:

Examples of multifaceted unit questions

Unit question	Related subjects	Related area of interaction
How have ancient civilizations used their environments and social organizations to develop, thrive and collapse?	Humanities (history, geography, political science); sciences (environmental sciences); arts (visual arts)	Human ingenuity • the processes involved in innovation, creation, development and change • the individual desire to create, develop or change things • how systems or products develop and change over time
Can an awareness campaign addressing the problems of negative body image among teenagers today be effective in our school?	Sciences (biology); humanities (psychology or sociology); language A and language B; arts (graphic design)	Health and social education • ourselves in the wider society—including issues such as freedom, government health policies and globalization • ourselves and others—including issues such as relationships, sex and death
How do the communities living by our local river relate to the river along its course?	Humanities (anthropology, geography, economics, psychology); sciences (biology, chemistry)	Community and service • different communities—including the various forms of community, the needs of different communities, the issues within the communities, organizations within communities

What is the impact of economic globalization on the lives of rural communities in India, China or Mexico?	Humanities (economics, sociology); sciences (environmental sciences); language A and language B (regional literature); arts (film)	Environments • the roles our environments play in the lives and well-being of humankind • the effects of one environment on another • the effects of our actions, attitudes and constructs, such as sustainable development and conservation • physical, social, political, economic and cultural dimensions
What are the expected consequences of climate change on our environment?	Sciences (chemistry, oceanography); humanities (geography, economics)	Environments • the nature and role of local and international organizations responsible for protecting our natural environments • how organizational policies in one environmental dimension can affect other environments • our responsibilities to our environments

Reflection point

Consider the following topics and outline the subject groups, disciplines and areas of interaction in which they may be grounded.

- Why is it important to lower our city's carbon footprint and what can individuals and the city do about it?
- Historical monuments: making art about the past and for the future.

Now revisit your own curriculum and propose a small number of multifaceted unit questions that seem to capture central topics in your teaching, or questions that may enable you to connect with another subject in a fruitful way.

What makes a multifaceted unit question suitable for interdisciplinary instruction?

To select a multifaceted unit question for interdisciplinary instruction teachers must engage in a thoughtful process of considered judgment and deliberation, weighing the learning opportunities offered by candidate topics against one another. For example, in the unit on *sikkus* in Latin American culture, Raul and his colleagues may have considered the benefits of how various traditional instruments work (as Marcie and Rita did in the previous example) versus focusing on one instrument and considering its link to cultural traditions. They may have been influenced by a view of indigenous peoples in the past or in the present.

Teachers begin their crafting of a multifaceted unit question from different starting points. Regardless of where the planning begins, in the MYP interdisciplinary teaching approach, teachers are encouraged to craft multifaceted unit questions that will serve as the focus of their work with students and develop student learning expectations of the areas of interaction. Such multifaceted unit questions provide opportunities for students to develop rich understandings, and they demand that students integrate disciplinary perspectives in order to create more complex, thorough, and accurate explanations, solutions or products.

As mentioned in chapter 4, in the MYP interdisciplinary teaching approach three core criteria determine the quality of a multifaceted unit question: quality questions are relevant, feasible and clearly framed.

Quality questions are relevant

By placing candidate unit topics in the areas of interaction, MYP teachers can explore the potential significance of topics for interdisciplinary study. Gauging the relevance of topics for interdisciplinary instruction in the MYP involves assessing the degree to which a topic can invite students to become better lifelong learners (approaches to learning), better actors in serving society (community and service), better stewards of the environment (environments), better observers of human ingenuity (human ingenuity), better guardians of their own health and that of others (health and social education). To meet these aspirations teachers often must adjust the focus and scope of their multifaceted topics. See illustrations later in this chapter.

Placing the topic of sound waves in the larger context of human ingenuity leads teachers and students to inquire about the ways in which humans have used waves ingeniously to produce powerful musical experiences. Building an instrument and learning to play it in pentatonic scale proved of great interest to students. In turn, placing the construction of an instrument in the larger context of community and service gave a new meaning, urgency and social purpose to the instrument production task: to preserve a cultural heritage at risk of extinction.

Because interdisciplinary units involve a significant learning effort, it is essential that MYP interdisciplinary units of work can engage students' interest and commitment to dedicated work. To do so, teachers are encouraged to select questions that students can come to see as genuinely important to study in depth. Consider how one teacher, Paul, describes a unit about arts and globalization.

> In my arts class students were used to a very traditional way of art-making—focused on basic art concepts, art elements and principles. All of a sudden there's still that, but they are also expected to read economics and anthropology and investigate in these disciplines to inform their art on global inequalities. "Telling global inequalities" was our topic and it meant that students would make artwork about the gap between rich and poor across countries. They had to compare material culture in their communities and that of adolescents in Guatemala or Mexico. We began by talking about jeans and sneakers, their sense of fashion. I had to meet them where they were.
>
> But I also expected them to understand the problem of inequalities well to then make sense of it in our discipline—the arts—to take all that information and then have something to say about that. It was more than they were used to, and I got a lot of comments in the beginning about … how [they felt] stifled.

> Over time as students had a chance to look at their lifestyles and look at other young people like themselves they were more engaged and uncomfortable. They started to understand that art is not only the things that we see in museums, but it's a way to really say, to let people know symbolically about things … you know, a strong piece of artwork can, at the right time and right place, change the way people think about things. They can make societal change.

To sustain their own commitment to teaching interdisciplinary units, teachers are encouraged, whenever possible, to select multifaceted unit questions that capture their own interests and expertise. Teachers explain.

> When I think about what to teach I think "what am I interested in—that I could really dig into, that I can learn and grow from?" I look at our curriculum and national standards with that question in mind; to reframe the concepts and skill there.

> [In selecting a good topic] there is always the obvious aspect of something that moves you, something that you yourself would be willing to take an action step on, do you have a passion for it?

Finally, relevant multifaceted unit questions tend to be relevant towards our societies. Open any newspaper and you can find a multitude of strong choices for multifaceted topics, for example, stem cell research, global warming, global migrations, computer art. When students can see how what they learn in the classroom is an issue that is of importance in wider society, it gives their learning a greater sense of meaning. Using the core question focused through the areas of interaction enables teachers to shed light on the possible relevance of a topic to society. Consider two teachers' perspectives:

> The topic has to be relevant, and it has to be about the future direction of the world. … The question I ask myself as an educator, why should my students learn about this? Will this topic make them feel like an integral member of society, an integral member of the future of the direction that a society is about to take? If the answer is yes then the topic is relevant.

> The topic of "Exile" has massive relevance to all of us as well as to every student in the school. Whether they be from a non-Dutch environment or whether they are Dutch born and bred, this is still alien environments, they are still exiling themselves, socially or culturally exiling themselves from what they know. And we all have a variety of experiences but amazing similarities that we can bring together, and I think that creates energy that can be expressed in multiple art forms.

Quality questions are feasible

Considerations of feasibility play an important role in how teachers select and define a given multifaceted question for instruction. Teachers must ask the following questions.

- Can this topic or question be addressed in the time assigned to the unit in my curriculum?

Teachers are encouraged to consider the time needed to prepare to teach elements from an unfamiliar discipline or to collaborate with others in a well-integrated design.

- Does it build on my expertise and that of available colleagues? Do I have enough material resources (in the library, field trips, videos/DVDs, on the internet, among peers) to teach the topic as framed?

Teachers must craft topics for which they have the necessary sources of expertise and materials (often beyond their own disciplines of training), and topics that are manageable enough to foster deep learning and understanding.

- Can this topic be addressed by my students this year in developmentally appropriate ways?

Teachers must think about who the students are and how much support they will need to understand the topic and the emotional or cognitive complexity of the topic. For instance, exploring the human rights violations associated with the Rwandan genocide might be appropriate for MYP years 4 and 5, but younger students may not be mature enough to handle the intense subject matter.

Selecting a feasible topic also means accounting for what teachers often perceive as "non-negotiable content" in their subject. Given the local curriculum mandates of the school and their genuine commitment to quality disciplinary instruction, teachers are likely to have certain concepts and skills that must be addressed. MYP teachers are encouraged to assess the degree to which this disciplinary content can be naturally integrated into an interdisciplinary unit.

In the *sikku* unit, questions of feasibility emerged throughout the process of planning. Could a good portion of the history course be realistically dedicated to teaching about pre-Columbian civilization? If the response was positive the historical dimension of the project was to be encouraged. Would it be possible to use contacts in a neighbouring school to bring the unit to the classrooms? If so the impact dimension of the topic was to be maintained.

Quality questions are clearly framed

Because multifaceted questions articulate the purposes of learning in a unit of work, their framing must be clear and accessible. Multifaceted unit questions outline the issue students will seek to understand and often preview the connections that teachers expect students to make. In quality units, multifaceted questions or topics point to or take the form of an issue to explore, a problem to solve or a product to be created.

A complex issue may include "how could humans allow the Holocaust and other genocides to happen?" Looking only through a historical perspective cannot fully answer this question. We must also bring to bear psychological findings on obedience (for example, Milgram's experiment) and economic disparities that contributed to social unrest. These perspectives then intertwine to propose a more complex, thorough and accurate explanation as to why these genocides took place.

A problem approach to topic framing involves drawing on multiple disciplines to fully understand a problem and to propose solutions to it, for example, "what can people do to mitigate climate change?" In this case, students come to understand the science of global warming, how human behaviour contributes to global warming through carbon emissions, and how human behaviour can be impacted by economic incentives. Equipped with these understandings, students have the tools to propose realistic solutions to limiting carbon emissions, for example, tax breaks for driving fuel efficient cars.

In a world history class, a historical monuments project is an example of a product approach to framing a topic. The unit is framed as an exploration in "how to grasp and present some of the most troubling aspects of the history of the past 100 years". The culmination of the course involved students in creating a model of a monument, which memorialized an event where human rights were violated (for example, US lynching, Rwandan genocide). Understanding these events called upon students to learn history, psychology and sociology. Presenting them called for an understanding of film, sculpture, architecture and memorials.

How can teachers design quality interdisciplinary units?

Designing multifaceted unit questions with the areas of interaction in mind

The areas of interaction play a key role in inviting teachers to pose important questions about what students are expected to learn. What does this topic suggest about the importance of human creations? How might learning about this topic invite students to develop a closer relationship with their environment?

Multifaceted unit questions play a central role in focusing teachers' and students' attention on optimal topics for interdisciplinary instruction. In the *sikkus* unit above, an emphasis on human ingenuity yielded a multifaceted unit question about the *sikku* as a musical instrument. A community and service context inspired Raul and his colleagues to focus on preserving a local musical tradition. During the implementation of the unit of instruction the areas of interaction continue to orient teachers and students to reflect and adjust the emphasis of their learning and the multifaceted topics maintain the focus and coherence of students' and teachers' inquiries.

An example: Ancient civilizations

Teaching ancient civilizations can be exciting. It has the potential to instill in students an appreciation for history, people and cultures past. It can harness young people's fascination with the very different practices and lifestyles of humans in centuries past. Teachers in an MYP year 1 team recognized that often when learning about ancient civilizations students are asked to amass large quantities of facts from elements of architecture to food, from governance to landscape, from trade to sports and art. They understood that a quality interdisciplinary unit on ancient civilizations required more than inviting students to collect information about these dimensions in a Microsoft Powerpoint™ presentation. They asked why, essentially, should students learn about ancient civilizations at all. They pondered "what is our fundamental educational purpose in this unit"?

An idea map

To design an interdisciplinary unit on ancient civilizations four teachers began by creating an idea map about the topic. After a few minutes of brainstorming they turned their attention to the areas of interaction to examine their map through the contexts provided by each area. What does our map say about the role of the environment in ancient civilizations? What role did human ingenuity play in the development and survival of these peoples? What health-related challenges did these civilizations confront? What opportunities might this topic offer for students to deepen their capacity to learn?

An iterative process of raising questions, discussing options and enriching the map with new possibilities led to several meaningful questions about ancient civilizations. In most cases addressing these questions required combining expertise from at least two subjects.

- How did ancient civilizations organize their governments, communities, spaces, values and actions? (Community and service)
- How can our learning about human inventions and developments in ancient civilizations help us understand today's societies better? (Approaches to learning)
- What role did the natural environments play in the rise of civilizations and how did these societies affect their environment? (Environments)
- What cultural and technological developments led ancient civilizations to survive, thrive and sometimes collapse? (Human ingenuity)

After careful consideration, teachers selected the last two multifaceted questions as the main focus of the unit. Teachers concluded that learning about cultural and technological developments would enable students to come to appreciate past humans' ingenuity, as well as the struggles to survive under various environmental conditions. They also thought that examining human–environment interactions in ancient civilizations would shed light on our relationship with the environment today. Clearly multifaceted, the unit questions required input from history, arts, technology, architecture, engineering and elements of environmental science.

An example of teachers' maps and the possible emphases considered appears below.

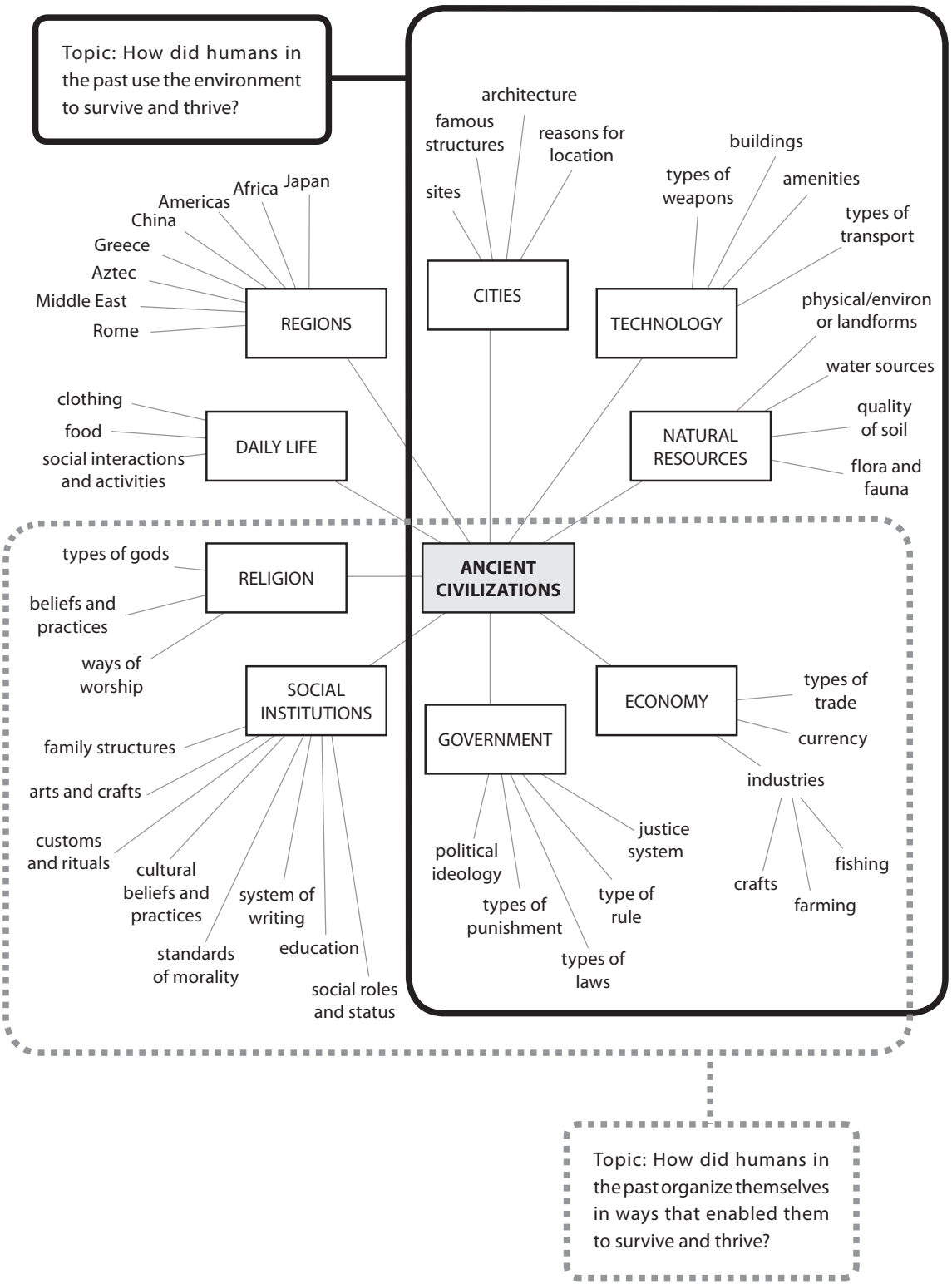


Figure 12

By using the areas of interaction to craft good questions for interdisciplinary inquiry MYP teachers support students in learning the concepts, modes of thinking and attitudes in two or more subject areas and make sense of them in meaningful ways. In this unit, students had a chance to reflect about the roles our environments play in the lives and well-being of humankind (a key outcome in environments). Students also had an opportunity to judge the aesthetic and technological transformations that have led civilizations to unfold and appreciate their intended and unintended consequences (central to human ingenuity).

Once in its implementation phase, areas of interaction and multifaceted unit questions help teachers and students maintain their inquiry focus and make new connections. For example, in the ancient civilizations unit teachers considered how in some cases, such as Mesopotamia, technological development such as ingenious systems for irrigation came with the high cost of soil degradation. Teachers particularly valued the opportunity presented by the last question to learn from the experience of ancient civilizations as we reflect about contemporary climate change. In their technology class students were invited to trace contemporary echoes of ancient inventions (for example, from the Colosseum to the modern stadium), examine the cultural function of these buildings and create a future version of such objects or insights that reflects the values and priorities of today's societies. Several students collaborated in a proposal for a green stadium powered by alternative energy.

To summarize, MYP teachers are encouraged to engage students in the areas of interaction during the early unit planning phase and during the unit implementation in multiple ways. Productive use of the areas of interaction as a conceptual tool for thinking about content should yield an enriched sense of what and how teachers teach and students learn. It should also yield an informed reflection about areas of human development and citizenship captured by the areas of interaction (for example, learning to learn, environmental stewardship, community service). In contrast, a non-productive use of the areas of interaction involves merely linking a given unit to various areas as a rote exercise, without further enrichment of the unit itself or reflection about the larger issues and capacities that the areas of interaction represent.

One important way in which teachers begin to map their curriculum across subjects is around the key questions proposed by the student learning expectations of each area of interaction. When considered in interdisciplinary terms such questions provide a fruitful base from which to generate multifaceted topics or unit questions for inquiry. Consider, for example, the following renditions of the key questions from each area of interaction. While these questions are still too general to guide fruitfully a particular unit of work, they may inform interdisciplinary dialogue among teachers, productively opening a fertile space in which to craft multifaceted topics.

Examples of key questions for areas of interaction

Approaches to learning

How do I learn best from people who have different expertise?
What aspects of a given problem are worth studying and why?
How do I use understandings from different disciplines/subject areas?
How do I communicate my understanding using languages and content from two or more disciplines/subject areas?

Community and service

How do we live in relation to each other as living organisms and cultural beings?
How can I use what I know about the arts, science or humanities to contribute to the community?
How can I draw on multiple sources of expertise to find solutions to help others?

Human ingenuity

How and why do we create, given the social, cultural and economic factors that shape our lives?
What are the ethical, social or political consequences of particular human creations (in science, mathematics, or the arts)?

Environments

What are the physical, biological and cultural worlds like in which we live?
What resources do we have or need and how do our needs for different kinds of resources complement or conflict with one another?
How can I draw on multiple areas of expertise to understand and act on my responsibilities toward the environment?

Health and social education

How do I think and act as a biological, social and cultural being and how do these aspects of myself inform others?
How am I changing in various dimensions of who I am?
How can understanding the historical or environmental context in which I live help me look after myself and others?

The problem with "thematic units"

All too often, interdisciplinary teaching in schools takes the form of "thematic units", whereby a large theme such as "civilizations" or "water" is established and teachers are charged with finding how to connect these. Too broad a topic definition is likely to result in a lack of clarity about what exactly it is that we would like students to understand about the theme in question. As a result, not uncommonly, broad themes can yield superficial or forced connections and fragile understandings.

An example: Egypt

As a schoolwide theme, students aged 11 are studying Egypt. In history they learn about Egyptian lifestyle and theocracy. In art they examine Egyptian paintings and create their own motifs. In geography they study the patterns of flooding in the Nile. In mathematics they learn to estimate the surface and volume of pyramids and other shapes. In theatre students put together a show based on Cleopatra's biography.

The hallway displays in the school suggest a schoolwide effort to provide students with a more integrated learning experience across subjects. However, the substantive integration of content is less than optimal. Why should students learn to estimate the surface of shapes including the pyramid to understand ancient Egypt? What is the significance of the flooding patterns in the Nile? To move beyond superficial links across subjects teachers must clarify their inquiry goals through the articulation of clear multifaceted unit questions. For example, teachers may ask "how do we know that the ancient Egyptians advanced a great civilization and what kind of society did they need to have to reach their peak?"

A question of this kind integrates an analysis of the pyramids and Egyptian art meaningfully. A real-size calculation of the surface of the pyramids may be used to estimate the number of individuals, indeed generations, needed to construct them. Students can then examine the type of social structure and government that would have been necessary to accomplish the task. Similarly, Egyptian drawings would not simply add enjoyment to student learning but serve as sources of evidence to identify markers of social structure and interactions.

A second multifaceted unit question within the same theme might emphasize "how did the Egyptians' natural environment contribute to their great cultural production?" Here the long-studied and predictable patterns of flooding of the banks of the Nile may inform students' further analysis of social structure and accumulated wealth. In these examples, learning in the subjects comes together purposefully to address clearly formulated questions that would not be satisfactorily answered through single disciplinary approaches.

The problem with field trips

Like thematic units, field trips hold the promise of integrative learning. Excursions into cities, parks and mountains genuinely engage students in real-life experiences that can be transformative and present opportunities for deep learning. Teachers capitalize on such opportunities when they structure the trip around key multifaceted unit questions for inquiry. Consider two contrasting examples.

A unit on national parks concludes with a day-long visit to the local park. A group of excited 14-year-old students step off the school bus and prepare to walk from one landmark area to another in the park—the sandy shore, riverside and mangroves. Their task is to listen carefully to the guide and gather as much information as possible about each area. For the first hour some students take notes diligently while others scribble haphazardly onto a page a few names of local species and information on local tourism. As the day unfolds it becomes clear that the main source of excitement for students is the experience of a day out of school.

In a different case (a unit portrayed in the next chapter) students visit a local park with an important purpose in mind. The area has been attracting tourists to the park and students are expected to measure levels of pollution at particular areas. They employ geographic and biological tools to map the three courses of the rivers and the shape of the shore, and to assess the conditions of the environment. Unlike their peers in the previous example, these students approach their fieldwork with multifaceted unit questions in mind. They ask the following.

- How is human activity affecting the mangroves and sandy shores that attract tourism to the region?
- How can an ecotourism initiative support a sustainable and balanced relationship between water and humans?

Reflection point

Consider the following themes commonly used in schools around the world. How might they be transformed into potent multifaceted unit questions?

- My community
- Time
- Water
- The news
- Values
- Ancient civilizations

Think about a field trip for your course. How might the field trip invite interdisciplinary learning and what multifaceted unit question might guide students' inquiry during the trip?

Chapter 6 What disciplinary tools will students need?

Overview

This chapter outlines how successful interdisciplinary teaching in the MYP is informed by teaching in the disciplines. Specifically this chapter examines two questions.

- What constitutes quality learning in a discipline or subject?
- How can teachers select and craft disciplinary understandings?

Quality disciplinary understanding in the MYP is characterized. It indicates how disciplines differ from factual information and explains why disciplinary understanding is often difficult to acquire. Using an interdisciplinary unit on the Pak Sha O river in Hong Kong as an example, this chapter offers an overview of the MYP aims and objectives and points out two criteria that teachers must keep in mind in order to ensure a quality disciplinary grounding of interdisciplinary work.

What constitutes quality learning in a discipline or subject?

Whether they teach history or biology, mathematics or visual arts, MYP teachers strive to nourish students' deep understanding of key ideas, theories, and modes of thinking in their subjects or disciplines. Teachers recognize that understanding a concept in depth is more than merely knowing about it. MYP students are encouraged to use such concepts effectively in new contexts and situations demonstrating deep understanding. Understanding is a capacity. It involves being able to employ concepts, skills and information to produce explanations, offer interpretations, create products, or solve problems in workable ways. Disciplinary understanding, in turn, involves students' ability to employ concepts and modes of thinking developed by experts in domains such as geography, biology, physics, mathematics, language or the visual arts. To nurture it, MYP teachers must understand what disciplinary understanding is and why it is difficult for students to acquire.

All disciplines embody distinct ways of thinking about the world. Scientists hold theories about the natural world that guide their particular observations: they make hypotheses, design experiments to test them, revise their views in light of their findings and make fresh observations. Artists, on the other hand, are less constrained by empirical demands. They seek to shed new light on the object of their attention, depict it with masterful technique, stretch and provoke themselves and their audiences through deliberate ambiguities in their work. Becoming a better artist does not make students better historians, scientists or mathematicians, or vice versa.

Of course, it is unreasonable to expect MYP students aged between 11 and 16 to become expert scientists, historians and artists. Rather, a quality MYP education in the subject areas should ensure that students become deeply acquainted with the fundamental perspectives on the world that each subject group offers. Teachers prepare to nurture disciplinary understandings by reflecting about their disciplines themselves. Why do I teach science, history or the arts? What about these disciplines matters most for my students to learn? Perhaps most importantly, what constitutes deep understanding in my subject or discipline?

Disciplinary understanding defined

A discipline like biology or geography is clearly not a list of items to be "covered" during a given class period three times a week. Instead, disciplines are best described as dynamic networks of concepts, theories and examples, produced through the use of agreed methods and techniques to answer relevant questions about particular aspects of the world. By inviting students to use the perspective of the biologist, the geographer, the historian, the scientist, the artist or the poet to make sense of the world around them, MYP teachers open the door to the most important cognitive achievements of our era—achievements that students may come to share only through dedicated and carefully designed instruction. In the MYP model disciplines are grouped in eight subject groups. The subject aims and objectives offer teachers an overview of important understandings to be nurtured in each subject group.

Building on such aims and objectives experienced teachers seek to nurture four key capacities among young people. They involve understanding:

1. the purpose of disciplinary inquiry
2. an essential knowledge base
3. disciplinary inquiry methods
4. forms of communication.

These capacities are described below and illustrated with examples of aims and objectives in humanities, science and arts.

1. Understanding the purpose of disciplinary inquiry

Commonly, students ask a question that all teachers ought to be able to address genuinely: "Why do we have to learn this?" Responses such as "because it is important that you know this", or "because it is part of the course syllabus, test or state mandates" or even "because you will need it next year" miss the point if what we seek is students' true involvement in disciplinary understanding. Addressing the question of why a particular disciplinary topic is to be learned invites a broader reflection about the nature of disciplinary inquiry. Why do historians, scientists and artists dedicate their lives to their quests? How do our societies use (or dispute) the findings of biology and history or the works of visual arts and dance? Why does disciplinary understanding matter?

Disciplinary knowledge stems from our human need to understand and predict, express a point of view, create products and tools, and/or solve complex problems. Disciplines inform the contexts in which students live. Supply-and-demand principles determine the products that line the shelves of supermarkets. In recent years, a renewed interest in the study of industrial revolution has been sparked by our experience of the digital revolution—the rapid growth of computing and communication capacities transforming the planet. "Biological interdependence" shapes the life of animals and plants at the local park and in the rainforest. Environmental artworks call society's attention to the importance of preserving our ecosystems. Therefore, by inviting students to see how disciplinary knowledge informs human pursuits and everyday life—by nurturing their "disciplined mind"—teachers are preparing them to be more informed and discerning participants in their world.

The MYP aims and objectives highlight this aspect of learning. In the humanities students are expected to develop decision-making skills and inform their actions with knowledge. In science students examine the role of science in society and the purposes that drive us to inquire. Scientific understanding includes our responsibility to the living and non-living environment and the capacity to apply science to solve local and global problems, or discussing how science and its applications interact with social, economic, political, environmental, cultural and ethical factors. In the arts too students are encouraged to appreciate the arts as a form of expression and critique as a means to reflect, comment upon and transform our world.

To reflect on the purpose of disciplinary inquiry with their students, teachers may ask:

- Why does this disciplinary topic, concept or theory matter?
- How can we apply what we learn about this concept, topic or theory?
- Why do individuals dedicate their lives to study in this discipline?

2. Understanding an essential knowledge base

Each discipline embodies innumerable concepts, examples and ideas. Educators are challenged to select those that are most significant for students to learn. An essential knowledge base embodies concepts and relations that are central to the discipline, and applicable in multiple contexts. For example, in a unit on the Industrial Revolution, students must understand social and economic forces that set the stage for industrial advancements in 18th century Britain: widespread Protestant ethics, growing entrepreneurial spirit among artisans and labourers, accumulated capital, largely accessible raw materials and markets, and technological innovation. In a unit on ecosystems, biology students must understand how living organisms relate to their physical environment in a particular place, examine the cycling of nutrients and the factors that enable or disrupt the balance of an ecosystem. Understanding of this kind enables students to link particular incidents of the Industrial Revolution or observation during a field trip with more general interpretations. In other words, a rich knowledge base enables students not only to "know" but also to "make sense" of the information they receive.

An essential knowledge base is central to the MYP aims and objectives in each subject group. In the humanities students are expected to know and use humanities terminology in context and demonstrate understanding of elements of history, geography, economics and sociology in their descriptions and explanations of our social and cultural world. Students are expected to think deeply about matters of time, space, change, systems and the global sphere, moving flexibly between big ideas and relevant examples. In the sciences too, students are challenged to recognize and recall scientific information, explain and apply it to solve problems in familiar and unfamiliar situations. In the arts, students are encouraged to demonstrate knowledge and understanding of the theoretical basis of the art forms studied, as well as a variety of styles, developments and ideas that have shaped the arts across time and cultures.

To reflect on the knowledge base in a discipline with their students teachers may ask the following.

- What are the big ideas, key concepts, or theories that students must learn in this discipline?
- What are examples, cases and findings that illustrate the big ideas in this discipline?
- Are there important connections among ideas in the discipline?

3. Understanding inquiry methods

In contrast to naive beliefs or elementary information, disciplinary knowledge emerges from a careful process of inquiry and vetting of claims. The disciplined mind considers forms of evidence, criteria for validation, and techniques that render trustworthy our knowledge of the past, nature, society or works of art. In the arts students develop habits of visualization, observation, critique, technical mastery and perseverance in the study of a subject. In history students exhibit their understanding of inquiry methods when they compare competing accounts to assess their acceptability, when they are wary of simple explanations, when they consider the sources used, and when they attend to how actors' perspectives are selected and portrayed. In science students learn that experiments require carefully designed controls and that the coexistence of two phenomena does not mean that one is causing the other. By beginning to learn about the ways in which experts do their work, students come to humanize the disciplines.

In the MYP aims and objectives students are strongly encouraged to learn humanistic and scientific inquiry skills. In the humanities students learn to plan, carry out and present investigations; identify key questions and issues; observe, select and record relevant information; evaluate the values and limitations of sources; engage in fieldwork in order to complement an investigation. In science too, they are taught to define a problem or research question to be tested by a scientific investigation; collect and record data using

appropriate units of measurement; organize and transform data into numerical and diagrammatic forms (mathematical calculations, tables, graphs and charts). In the arts students engage in artistic inquiry; they plan and organize effectively to define and set goals, solve problems, experiment and explore through spontaneous and structured activities.

To reflect about the methods of a discipline with their students teachers may ask the following.

- What are the methods that students must learn to understand how knowledge is constructed in a discipline?
- What tools and instruments are helpful to use in the discipline?
- How can we best explain, describe or express our interpretation of an event or phenomenon?
- How can we discern between trustworthy and less trustworthy claims in the discipline?

4. Understanding forms of communication

Finally, disciplines communicate their expertise in preferred forms and genres. Historians see narratives as the best fit for their work while scientists opt for data-heavy research reports. To become proficient communicators, MYP students are encouraged to understand these differences. In science students are encouraged to write (and recognize) a well-crafted scientific report where clear testable hypotheses, methodology, results and discussion are made public for readers to weigh up. They are invited to use a range of scientific languages. In history, they appreciate vivid and well-footnoted narratives as well as well-curated museum exhibits, monuments and documentary films. Humanities students are also expected to organize information in a logically sequenced, clear and concise manner, to use appropriate language, style and visual representation, as well as referencing and a bibliography to clearly document sources of information, using appropriate conventions. In the arts students are invited to use multiple media to explore aesthetic options in depth.

To reflect about the modes of communication of a discipline with their students, teachers may ask the following.

- What are the languages and symbols that we can use to share what we learn in this discipline?
- What are the main genres in which we can communicate what we know in this discipline (essays, scientific reports, poster presentations, videos)?
- How do we take into account our audience and context when we communicate with others about what we know?

In summary, MYP teachers are required to draw on the MYP subject aims and objectives as well as their local school curriculum to select the concepts and modes of thinking that matter most to teach in their subject. By encouraging teachers to do this the MYP model fosters not only students' ability to master particular concepts, theories and examples that are central to these disciplines but also to employ disciplinary methods, apply disciplinary insights and communicate effectively with others. Experienced MYP teachers know that for students disciplinary understanding is not always simple to construct. Often, it involves transforming intuitive or naive views of the world with which students arrive in our classrooms.

The challenge of building disciplinary understanding

Building disciplinary understanding is a challenging task for students. Even the most experienced disciplinary teachers describe their dismay when, by the end of what they thought was an outstanding unit, students' initial beliefs and misconceptions seem to have remained untouched. Why is this so? Psychologists explain that, early in life, students develop intuitive beliefs about the world that are sometimes at odds with disciplinary ideas.

Before entering the elementary school students develop intuitive ideas about how nature works, how people think, what is beautiful and what is not, and how narratives unfold. Many of these ideas, extensively documented by developmental psychologists, are powerful precursors of sophisticated disciplinary

understandings. For example, by the age of 5, children understand that narratives have beginnings, turning points, and ends and that the succession of events in them must "make sense" for the story to work. Historians also organize their accounts of the past in the form of narratives. They must establish when their stories will begin, and when they will end, and select turning points and actors' perspectives that will make their accounts intelligible.

Unfortunately not all initial ideas are equally auspicious. Young children also tend to believe that stories are always about "the good guys versus the bad guys"—a belief that leads to easy stereotyping of historical actors and oversimplifications of their experience. Young students are inclined to believe that events are always the result of intentional actions—especially in the case of leaders. They find it more difficult to understand the unintended consequences of actions in the past. Most strikingly, students often project contemporary values and world views onto the minds of actors in the past, a misconception known as "presentism" that is difficult to correct even with good instruction.

In science, students often hold the belief that experiments are successful when their results match the one in the textbook. Students confuse "theories" with unfounded beliefs (as opposed to well-founded conceptual systems) or believe that hypotheses are claims to be proved right (as opposed to tested). Even after years of schooling, youngsters hold mistaken beliefs about how the solar system works, how electricity functions, how evolutionary changes come about. In mathematics, students are often inclined to detach numbers from their meanings, filling in equations mechanically. In the arts, they find it difficult to understand that a "good" painting does not have to be "beautiful" but could be provocative or suggestive, inviting deep aesthetic exploration. Because the task of addressing and transforming students' early misconceptions may seem daunting, the MYP curriculum design offers a repertoire of clear aims and objectives to guide teaching in the subjects and support even the youngest children to develop more informed understandings.

Reflection point

Consider the following statements produced by teachers in different schools. In what ways do they reflect the concept of "disciplines" similar to the one presented above? Which one seems closer to your own sense of your subject?

> In teaching history, the biggest obstacle is always time. Teaching history itself is not that difficult. I have a list of people and important events that I need to cover. I expect students to know these by the end of the year.
>
> I teach history because I want students to understand how events in the past help us understand who we are and where we come from. I want my students to become able to think about the past and how we come to know it critically. I want them to think about the options that people had then which are different from the ones we have today.

How can teachers select and craft disciplinary understandings?

Clearly, when designing interdisciplinary units of instruction teachers must decide which disciplines will best address the multifaceted topic under study. Quality interdisciplinary learning requires deep disciplinary grounding. Designing interdisciplinary units presents teachers with an important challenge: how much expertise in a discipline will their students need to develop in order to accomplish the unit's overarching goal? Indeed some teachers wonder if it is necessary for students to master the disciplines fully before they can integrate them in any meaningful way. Questions of this kind are important because they reveal teachers' commitment to quality work. Interdisciplinary learning builds on disciplinary expertise—it does not replace it. To illustrate the MYP approach to interdisciplinary teaching, consider the following unit on river studies.

The Pak Sha O river unit

This unit is designed to help MYP year 4 students aged 14–15 understand water centres and examine the balance of the ecosystem of a watershed in order to make reasonable recommendations for its sustainable development. Three multifaceted unit questions guide student inquiry in this project.

- Does the Pak Sha O river's profile of water flow, depth and abiotic factors affect aquatic organisms present in the river along its course?
- How is human activity affecting the mangroves and sandy shores that attract tourism to the region?
- How can an ecotourism initiative support a sustainable and balanced relationship between water and humans?

To address these questions students must master a rich knowledge base in geography including classic river profiles and features such as velocity gradient and channel shape. They must become able to compare the particular features of the Pak Sha O river with the classic profiles typically present in textbooks. In science students will need to understand the significance of estuaries and mangroves in the local ecosystem. They will need to learn how to detect and interpret indicators of environmental stress and pollution. The questions invite students to conduct empirical inquiries that involve hypothesis testing, data collection, graphing, mapping and observation in geography, biology and sociology. Given a rich problem space like this one, how are teachers to decide how to focus their students' attention for deep learning? How can teachers determine what students will need to know in order to address the questions at hand?

The MYP interdisciplinary teaching approach stipulates two core criteria to craft an adequate disciplinary grounding for a unit of work. Firstly, disciplinary understanding must be strategically selected. Teachers must identify which disciplines as well as which particular insights within each discipline will best contribute to students' understanding of the multifaceted topic. Secondly, disciplinary understandings must be robust. That is, they must accurately represent the knowledge base, concepts and modes of thinking in a discipline. Taken together, these criteria enhance the effectiveness and intellectual integrity of students' interdisciplinary learning in the MYP.

Strategically selected disciplinary understandings

In interdisciplinary units teachers must select which disciplines will be included and which will not. To do this they weigh the particular ways in which each discipline may contribute to student understanding of a multifaceted topic. Furthermore, teachers must select which insights from each discipline (particular concepts, theories, examples, methods, or techniques) will be borrowed. The lack of strategic selection often results in an overwhelming number of options and disciplinary combinations and superficial learning. As the previous chapter suggests, a well-chosen multidisciplinary topic often acts as a guidepost to select which disciplines matter most. Essentially it is the substance of a topic that must drive the selection of perspectives that truly matter.

In our rivers unit, teachers focused primarily on geography and biology. In addition they borrowed insights from the growing field of ecotourism, which enabled them to integrate the unit further. Geography was chosen because it enabled students to understand changing natural and urban environments in depth, because it provided necessary inquiry tools to measure changes in the landscape, the river's shape and expected abiotic characteristics. Biology was used by students to assess the conditions of living micro- and macro-organisms. For example, students were able to identify the presence of micro-organisms that vary in their sensitivity to pollution, and they were able to interpret observations in mangroves as adaptations to pollutants. Clearly teachers saw the advantage of using history and economics to enrich students'

understanding: a history of human interactions with the natural environment, as well as economic concepts such as the tragedy of the commons and cooperative action, were considered but excluded from the unit as teachers opted for greater depth in fewer well-established domains of knowledge. Because these were disciplines they knew well they made the unit feasible.

Once the two core disciplines were identified a further selection became necessary. Not all concepts in geography and biology matter to study river sheds. Teachers had to identify the core knowledge, methods, applications and forms of communication that were central to an understanding of the human–environment relations in the Pak Sha O river to ensure that students became able to think flexibly with them. They identified specific disciplinary understandings that would ensure adequate disciplinary grounding of students' work.

Geography

- Students will understand what constitutes a classic river profile and how particular rivers may follow or deviate from the norm (characterizing the upper, middle and lower course of the river; considering features such as gradient, velocity, dominant erosion, valley shape as well as the concentration of abiotic factors in it).
- Students will understand how to use the geographer's tools to study land changes along a river basin (testing hypothesis, gathering data and interpreting evidence, evaluating results).
- Students will understand how to use software to analyse and display quantitative data graphically (bar graphs, distributions, sectional graphs) and communicate their findings in a scientific report.

Biology

- Students will understand that micro-invertebrates living in the water have different levels of tolerance for water pollution and can help us to determine the water quality along the river.
- Students will understand the nature and significance of mangroves and sandy shores in the local ecosystems.
- Students will understand how to conduct and report a naturalistic study of micro- and macro-organisms along the river (advancing and testing hypotheses, gathering, analysing data).

Ecotourism

- Students will understand six core principles of ecotourism as travel to natural destinations that minimizes impact, builds environmental awareness and provides direct financial benefits for local conservation and empowerment for local people.

Robust disciplinary understandings

The second criterion that teachers are encouraged to use to craft the disciplinary foundations of an interdisciplinary unit focuses on the degree to which disciplinary understanding reflects the concepts and modes of thinking of a discipline in an authentic way. For instance, in the Pak Sha O river unit, disciplinary understanding invites students to build a rich and flexible knowledge web about rivers generally and the Pak Sha O river in particular. They learn about geographic inquiry, hypothesis testing, data collection, systematic analysis and presentation. They also learn to observe how organisms like mangroves adapt to a high salinity, low oxygen, low water context. Each concept or mode of inquiry echoes that of experts in the field. In the MYP, teachers are encouraged to ask themselves whether they are inviting students to engage genuinely in historical, geographical or biological inquiry, or to master concepts that are deemed accepted and important in the disciplines that they teach. The MYP subject aims and objectives provide a helpful and broad repertoire of disciplinary understandings from which they can choose.

When designing interdisciplinary units teachers are encouraged to pay close attention to the particular insights they would like students to gain from a discipline beyond their own. For example, in a unit focused on the adaptive differences between imported and native species of plants in the local environment, a

biology teacher discovered that his students did not observe nature in detailed ways. He invited the arts teachers to teach students particular drawing skills. In describing what he expected students to understand in the arts he points out the following.

> Drawing requires attention to the most minute details and as students draw, they need to closely observe how the specimen is formed. A photograph shows form but not all the minutiae an observer may record in a drawing. In these few arts lessons, students became able to draw negative space, perspective, shadowing. Most importantly they learned to stay with a specimen for an extended time. Qualitative information in nature can, therefore, be collected in the form of a drawing, which acts as a vehicle for further observation, interpretation, and discussion.

Understanding that is not robust in the sense portrayed here is often naive or pseudo-disciplinary. For example, experienced MYP teachers realize that when students conduct experiments in the science lab "seeking results that will be just like those presented in the textbook" they are building an erroneous view of how experiments enable scientists to advance new knowledge. They realize that when students "count how many sources" support each of two conflicting historical interpretations, they are learning pseudo-history. When students plug numbers in equations mechanically without a clear sense of what these numbers mean they are not engaging in mathematics but in pseudo-mathematics. In sum, robust disciplinary understanding contrasts with pseudo-disciplinary learning in that it presents students with understandings that reflect expert thinking in a genuine and developmentally appropriate way. MYP teachers are encouraged to nurture students' inquiring mind as well as the skills necessary to investigate the topics under study. Teachers are encouraged to provide a flexible knowledge base that students can apply to make sense of the world and act in their communities with discernment. Teachers seek to prepare students to communicate effectively in multiple modalities. By inviting students to think like historians, biologists, artists in developmentally appropriate ways MYP teachers begin to nurture the disciplined mind.

Reflection point

- Examine the disciplinary understandings considered in this unit. In what ways does each one contribute to advancing students' understanding of the three guiding questions guiding the Pak Sha O river unit?
- Consider the discipline you teach. What would you say are the most important disciplinary understandings that you expect to nurture among your students this year?
- Consider a different subject that might enrich or complement student learning in your own subject (as the biology and art teaching described above). What concepts, inquiry skills, applications or forms of communication in this domain might be interesting to include in your unit?

Chapter 7 How will disciplines come together?

Overview

Successful interdisciplinary learning experiences integrate insights from two or more subjects and yield what we term "integrative understandings" or understandings that bring together concepts and modes of thinking typically studied in different disciplines to explain a phenomenon, make a product or ask questions that would not have been possible from the perspective of one discipline alone.

In this chapter we describe integrative understandings as a key achievement in interdisciplinary learning and we offer guidance as to how to nurture this understanding among students.

Why does attention to integration matter?

In the MYP, interdisciplinary teaching requires that teachers nurture students' capacity to make deep and productive connections across school subjects. Experienced MYP teachers understand that supporting students to build interdisciplinary understandings requires more than merely asking them to "make connections". Rather, it demands that teachers (and their students) are clear about what kinds of connections they would like to pursue and why such connections matter given the topic under study. It is one thing to say that teachers in various subjects are collaborating in an interdisciplinary unit. It is quite another thing to be able to show how participating disciplines are being integrated.

If we just say that disciplines are interacting without an explanation, on some level, about where and how they are interacting (and what specifically students gain from that interaction), we reduce interdisciplinary learning to the proverbial "black box"—something important is going on in there, but we cannot see or talk about it. When teachers do not examine how disciplines will connect, they are less prepared to support students in their efforts to make connections themselves. Because such connections are not always easy to establish, a "black box" approach to interdisciplinary teaching risks becoming superficial. Therefore, supporting students in their capacity to integrate disciplinary insights requires that we open the black box of integration—that we gain a rich sense of how knowledge from one discipline can complement, expand or give new meaning to the insights gained through another one.

An example: Epic revolutions

"Epic revolutions" is a unit on the French and American revolutions designed for students of 14–15 years old. The unit investigates the causes, processes and consequences of revolutionary change in these societies and the role that the ideas of the Enlightenment and an atmosphere of political exaltation played in bringing about such change. This unit integrates history, English, Serbian and the visual arts. Essentially, the unit posed the following question: How do revolutions and their associated mood of political exaltation come about and transform societies?

Working with their history teacher, students developed a rich knowledge base about the circumstances, causes and consequences of these revolutions. They studied the views of Locke, Rousseau, Montesquieu and Voltaire to understand the motivations for both revolutions. They learned about changes in the political, social, and economic systems as well as the new forms of government—federalism and the Napoleonic codes—resulting from them. Students also learned about the post-revolutionary period, to understand the long-lasting effects of difficult transitions.

In Serbian and English, students examined epic poetry. They learned about the history of epic poetry and became acquainted with classic epic poems as well as traditional poems produced by local Serbian writers. They learned to identify and employ poetic devices, such as hyperbole, personification and allusion. They created epic poems of their own in the voice of revolutionary heroes George Washington and Georges Jacques Danton, and performed their poems for the school. As one teacher described, students came to understand "the significance of the oral tradition, and the fact that epics are used to try to explain the inexplicable as well as to entertain, to motivate, and to develop strong feelings of identity either associated with certain personal qualities or with a nationality".

In the visual arts, the class studied artworks by Goya and Delacroix made at the turn of the 19th century. Teachers chose "conflict" and "the birth of new ideas" as topics for visual exploration. Students experimented with expressions of these themes in three-dimensional human figures and collaborated to create a series of tableaux.

Units like the one outlined above are not uncommon among best teaching practices in the MYP. As characterized so far, the unit seems reasonably integrated. Students are expected to encounter the topic of revolutions in multiple contexts. To support students in making meaningful connections, however, a more careful analysis is in order. There are two key questions.

- How exactly do disciplines come together in this unit?
- In what ways does integrating disciplines contribute to a deeper, more nuanced and complex understanding of "Epic revolutions"?

In the "Epic revolutions" example, each subject makes an important contribution. History offers rich, well-documented accounts of the French and American revolutions, including the perspective of particular individuals involved in larger societal changes. Epic poetry (in Serbian and English) invites students to understand revolutionary mood and the personal experiences associated with rapid political change. The visual arts, in turn, provide opportunities to reflect about larger themes such as conflict, national identity and heroism. Disciplines intersect in three distinct forms throughout the unit deepening student understanding of the topic in each case.

- Students understand how epic poems reveal individuals' experiences and the cultural mood of revolutionary times.
- Students make sense of key developments and perspectives on the revolutions by describing them in poetic form.
- Students understand how to capture a significant aspect of the American and French revolutions in a compelling visual metaphor.

We call these connections "integrative understandings". They serve as expected outcomes for the unit.

Students understand how epic poems reveal individuals' experiences and the cultural mood of revolutionary times

How do disciplines come together?

Though historically, epic poetry has its roots in the classical work of Homer, a body of neo-epic writings emerged during and after the French Revolution capturing the mood of the times. As teachers in this unit explain, epic poems characteristically narrate the heroic actions of individuals while capturing the values, mood and uncertainties of the societies in which these individuals lived. Studying epic poems enables students to understand the ways in which past narrators made sense of key experiences. It shows how narrators disseminated their accounts while feeding into a passionate nationalist and revolutionary spirit. Epic writings are historical documents in their own right; they reveal political and aesthetic values of the times.

How does understanding epic poems advance students' understanding of revolutions and vice versa?

A study of epic poetry and writing associated with the French and American revolutions enriches a purely historical view of these periods by opening a window into the more personal experiences and expressions of leading individuals. In turn history prepares students to make sense of the content presented in poetic writing. Without an understanding of history the events narrated in a poem would make little sense.

Students make sense of key developments and perspectives on the revolutions by describing them in poetic form

How do disciplines come together?

Epic poetry is related to the history of revolutions in yet another important way. Epic poems tend to emphasize themes of loyalty, heroism, order and liberty—which are central to an informed reflection about revolutions. In this sense they provide a suitable genre to interpret this particular period in the past. Poems were required to be historically accurate and conform to the epic genre. To create such poems, students had to review accounts of the lives of individuals like Danton and Washington carefully and interpret their perspectives on events surrounding them.

Consider for instance the opening stanzas written by a student in this unit. Marginal annotations are included to illustrate how disciplines are being employed—they are not part of the student work.

The Dawn of France

An epic poem usually begins by directly stating the theme or subject matter of the epic. In this case, the student introduces Danton and his role in French history.

As is the convention in epic poetry, the student starts the narrative in media res, ie in the middle of the action rather than at the beginning, as is usually the case with historical renderings of events.

The subject matter of epic poetry is usually serious, and contains events and deeds that are significant in a culture or country. In the complete original epic poem, the student addressed the overthrow of the French monarchy, the establishment of the French Republic and historical actors like Danton and Robespierre.

THE DAWN OF FRANCE

They call me Georges-Jacques Danton, son of Jacques
And my tale has both sadness and glory
May gods and spirits help me in the task
To tell my story of what I went through
And how I aided the revolution

It was the year seventeen ninety three
And during the month of January
I made the long journey back from Belgium
To vote whether or not to execute
The monarch which has ruled us for so long
"King Louis," I decided, "you must die."
And others, it seemed, viewed it the same way
For when the votes were counted it was clear
For most of my fellows voted to end
The monarchy and the life of the king
As the king walked towards the guillotine
I remember what happened earlier

Historically, Georges-Jacques Danton was a French revolutionary leader, who played a pivotal role in the overthrow of the French monarchy and the establishment of the first French Republic.

Danton had been sent on a mission to Belgium in late 1792, and only returned to France in time for the vote. He voted for the death of the King

On January 15, 1793, Louis XVI's trial in the Convention culminated in a vote for his death without reprieve.

Figure 13

How does creating a poem about the revolution advance students' understanding?

Writing and performing the poem demanded that students revisited their learning in history and identified telling episodes that could be narrated from their particular actor's viewpoint using accurate information at each step. Students had to develop not only literary but also historical habits of mind—they had to assess the significance of particular events and create a meaningful sequence. A narrative poem of this kind invited students to gain ownership over the period by producing their own selections of episodes from the period and articulating them in a story that makes sense. More still, it enabled students to hypothesize about the personal experience of particular actors, bringing their reading of history to life.

Students understand how to capture a significant aspect of the American and French revolutions in a compelling visual metaphor

How do disciplines come together?

History and the visual arts also intertwined productively in this unit, as students were encouraged to revisit their growing understanding of revolutions to distill an essential quality of the period in a visual metaphor. Reflection led some students to appreciate the human cost of societal change—their insights informed their poems and artwork directly. One student's thoughts appear below.

> Analysing the phrase "revolutions devour their own children" I came to the general idea that, from my point of view, revolutions are indeed necessary in order to force a society to function. However this cannot justify the fact that throughout history many innocent people died as a result of shifts in political and social systems. In the French Revolution innocents and ordinary people were hacked to death mainly during Robespierre's reign of terror. In America the victims were the colonists and farmers who did not even revolt in the first place. At the start of the Industrial Revolution the child labourers were most definitely victims of England's unstable political and legal system. These are examples of how sometimes bad systems forced people into either seizing power or, in the cases of the weaker ones, ending their lives. As soon as I saw the connections between systems and revolutions in history I was able to get ready to analyse certain historical points and put them into my work [epic poem and art work].

Students' chosen metaphors of conflict and loss about the period informed the creation of human figure sculptures and tableaux. Some students chose to portray the intimate moment of a mother holding her dying son (see "mother and son" below). The piece refers literally to individuals lost in revolutionary times and metaphorically to the recognition on the part of a symbolic "mother revolution" of the lives lost in her name.

"Mother and her dying son" by Tea, Luka, Stefan, Voja and Stanko

How does this connection advance students' understanding?

Important learning opportunities emerge as students seek to synthesize qualities of these revolutions aesthetically into a memorable work of art. First, like the poems above, the visual arts project invites students to grapple with historical significance—to decide what about this particular period in the past is worth attending to. Typically, in memorializing the past in a work of art, students face the challenge of identifying a metaphor or a concept such as "[revolutionary] mother and son" that clearly captures something important about that portion of the past and will drive their artistic creation. Strong metaphors are informed by students' understanding of the period. When successful, students can point to multiple ways in which the metaphor "works" to capture past experiences and events. Finally, in crafting such metaphors students raise new questions about the past. Why was liberty represented as a female figure? What did it mean to people at the time? Where did the idea of a "mother revolution" come from? In what ways was it a symbol of romantic ideals? Understandably teachers and students may find themselves initially unprepared to address these less predictable questions. Time for further inquiry may or may not be available. And yet, both the overall inquisitive spirit that students demonstrate by raising these questions as well as the very nature of the questions raised suggest that students are beginning to think in highly sophisticated ways. Such ways contrast sharply with rote memorization of causes, dates and actors more commonly associated with factual teaching and learning of history.

To summarize, in MYP classrooms, powerful interdisciplinary learning occurs to the extent that students are able to explain a phenomenon, solve a problem, make a product or raise new questions in ways that would not be achievable by means of a single discipline. In the example above, understanding revolutions and the epic-romantic experiences they embodied required that students gained solid knowledge of key events, circumstances and actors and that they understood these actors' point of view. Most challenging for students was that they were encouraged to think with the acquired information to decide how such actors might have reported their experiences (in the poem) and reflect about the overall lessons of the period as we see it from the present (the sculptures).

Reflection point

Consider your experience with interdisciplinary teaching in the MYP. You may draw on your own teaching experience or on the experience of a colleague of yours to address the following questions.

- In your opinion, how have subject-specific concepts and modes of thinking been brought together in this unit of work?
- In what ways has the integration of disciplinary perspectives contributed to student understanding?
- What recommendations would you make to enhance the clarity of disciplinary connections?
- What learning opportunities emerge in this unit?

Developing integrative understandings

As the example of the "Epic revolutions" unit demonstrates, supporting students to build integrative understandings requires more than claiming that a unit is "interdisciplinary" and alerting students to "find connections". Rather, it requires that teachers have clarity about the kinds of connections they would like students to make and the learning opportunities they embody. To illustrate this point let us consider a less than optimal example. In a unit on genetic inheritance students are invited to create a work of art that is inspired by this natural phenomenon that they have studied. Without a clear image of the learning purpose of the activity, students may resort to copying images of Mendel or make schematic sketches of parents and their offspring. Students may be engaged in the activity. However, without a supported reflection about which aspects of genetic inheritance are worth portraying and why, without a consideration of the best possible visual medium to represent genetic inheritance, the opportunities for deep integrative learning are missed.

Two criteria are key for developing high-quality integrative understandings.

- Integration must advance student understanding of the unit's multifaceted topic.
- Integration must be clearly described.

Integration must advance student understanding of the unit's multifaceted topic

Integrative understanding is most powerful when it clearly addresses the purpose of the interdisciplinary inquiry undertaken. In particular, integration of disciplines should deliver on the aspirations for understanding framed within the chosen multifaceted topic. In the example above, teachers expected students to gain a deep understanding of why and how the French and American revolutions unfolded and the ways they affected their societies. Teachers wanted students to focus particularly on the epic mood that characterizes revolutionary actions in many cases, a mood that explains in part the violence associated with revolutionary changes. Because this unit took place in Serbia, teachers were careful to consider local developments and epic writers which contributed to bringing home the concept of revolutions and their costs. The integrative understanding proposed visibly addresses these learning priorities adding coherence to the unit design.

Integration must be clearly described

In designing an interdisciplinary unit of instruction teachers should seek to identify one, two, or perhaps three core integrative understandings that they will target. In quality interdisciplinary teaching designs, integrative understandings stand next to disciplinary understandings as targeted learning goals. Integrative understandings should be readily communicable to teachers themselves, their colleagues and their students. Multiple strategies for describing the sought-after connections are available.

Describing the overall integrative approach: An interdisciplinary integration can be described in terms of the way we expect that disciplines, at a basic level, will come together in a given teaching design. For example, teachers may introduce the revolutions unit as designed to "help students understand the French and American revolutions in depth, with a particular emphasis on the extraordinary and difficult experiences of actors who took part in the events and the meaning that these revolutions hold for us today". To reach such understanding students will "learn about the history of the period and translate what they learn into a poem and a work of art". Such a description emphasizes the artistic synthesis proposed in the unit.

Describing particular disciplinary roles: A second strategy to make the targeted integrations clear is to share the specific contributions of each discipline to students' overall understanding of the topic. For instance, in "Epic revolutions" teachers may explain that the work students do in the history class will help them understand why and how things happened the way they did in each revolution. In the language A and language B classes in turn epic poems will illuminate the particular experience, values and modes of expression of past actors. The arts class will invite students to step back from what they have learned about revolutions and reflect about the significance of this period for us today. Teachers may also consider discussing with students what would happen if any one discipline were to be absent. For example, lack of historical understanding would render poems ungrounded; excluding the arts would preclude an opportunity to generate a final personal synthesis of what revolutions mean for society.

Showing exemplars: If explaining the "logic" of how disciplines complement one another to advance understanding proves difficult or rather unnatural, teachers may opt for orienting students toward integrative performances on the part of experts (whether they be previous years' students, real-world practitioners, or scholars who produce integrative works). For example, teachers may invite students to

contrast the accounts of the French Revolution offered in their textbook with excerpts from Thomas Carlyle's epic prose. The added value of poetry in understanding the "spirit" of the past will become visible for students in the process. Consider Carlyle's writing on the American Revolution overseas.

> Observe, however, beyond the Atlantic, has not the new day verily dawned!
> Democracy, as we said, is born; storm-grits, is struggling for life and victory.
> A sympathetic France rejoices over the Rights of Man; in all saloons, it is said,
> What a spectacle!!
>
> From Thomas Carlyle, *The French Revolution, A History*. p. 44.

Using integrative concepts as anchors: Finally, one way to think about how to make disciplinary connections clear for students is to examine key complex concepts or phrases that embody the unit's enterprise. We call these *compound concepts* and they intuitively bring together distinct dimensions of an issue that are typically studied by different disciplines. Consider the notion of "epic revolutions" that serves as the title for the unit above. Here "epic" speaks directly to poetry and perhaps the arts, while "revolutions" are best studied in history. "Epic revolutions" suggests, rightfully, that the unit will engage students in a close examination of the epic qualities (experienced and expressed) of revolutionary times. By analysing the title of the unit in depth, and perhaps inviting students to raise questions about each of these dimensions, teachers can create a preliminary map of the content of the unit, the role various disciplines may play, and their overarching inquiry purpose.

To conclude, an important clarification is in order. Occasionally teachers may prefer not to "name" the disciplines involved in an interdisciplinary design. They may consider that naming each discipline and explaining their nature makes the interdisciplinary teaching unnecessarily more complex and might distract students from learning about the topic itself. Among teachers of younger students this position is understandable and acceptable. However, whether or not they opt for naming disciplines explicitly, all MYP teachers should reach clarity for themselves, their colleagues, and their students about the kind of connections they seek to nurture and their relevance towards student understanding of the topics at hand. They may say: "In this unit, you will write epic poems about the French Revolution to help your readers understand what it might have been like for Danton to witness the revolution at the time." When students understand the kinds of connections expected in a unit of work they gain clarity about their learning purpose and can become more active inquirers.

Forms of integration

Among the most striking qualities of interdisciplinary teaching is the sheer variety of ways in which teachers can bring disciplines together meaningfully. As we see in this guide, the term "interdisciplinary" applies legitimately to a unit on musical instruments, a project on environmental preservation, a study of the French and American revolutions or a personal project on film and poverty.

Understanding particular ways in which disciplines can relate to one another has several advantages in planning a unit of instruction. It enables teachers not only to communicate their integrative goals to colleagues and students but also to ensure that the learning opportunities embedded in each kind of integration are not overlooked. Once teachers can distinguish between potential forms of relationship among disciplines, they can also anticipate the kinds of activities or performances of understanding that might best support them. In this section, we explore six distinct ways in which disciplines can relate to each other. They are labelled:

- artistic synthesis
- personal resonance
- crossover tool

- complex explanation
- contextualization
- technological/practical solution.

As their names suggest, each form of synthesis is characterized by a particular understanding purpose.

Artistic synthesis

As our example above illustrates, students engage in an artistic synthesis when they are encouraged to create an aesthetic interpretation of a non-artistic topic or issue, for example, climate change, revolutions, genocide. Artistic synthesis deepens students' understanding because it invites them to grapple with the issues in a new way. Students are asked to translate their knowledge of the topic into a provocative symbolism—into a symbolic work that anticipates how viewers will be invited to make sense of such topics. Successful artistic syntheses must meet aesthetic standards in the medium employed as well as standards of accuracy and relevance towards the topic. In the example above, students may be encouraged to do more than represent "suffering" in a sculpture about the French Revolution. Teachers may challenge them to stay closer to their subject of study—that is, in order to find evidence for, name and portray the particular kind of suffering that took place in that context at the time. The sculpture on the "mother revolution" and her dying son does so effectively. In essence, when the learning opportunities of integration are taken into consideration artistic synthesis is more than asking students to "draw a picture of the French Revolution".

Personal resonance

"Personal resonance" refers to the act of exploring a concept such as "liberty", "respect", "a good life", by examining how it has been interpreted in works stemming from multiple domains. The purpose of a resonance-like integration is not to produce an exact definition of the concept under study but a well informed, nuanced and personally meaningful one.

Consider the following example of a unit integrating multiple art forms. This unit focused on the meanings of "exile". Students explored artists' work alluding to "exile" in theatre, music and the visual arts. They were encouraged to make connections examining how artists' views echoed or contradicted each other and, fundamentally, how these artists' views relate to students' personal experiences. At each turn, the concept of exile, which students had initially associated solely with the experience of individuals leaving their countries of origin, gained new metaphoric and personal meanings. Multiple interpretations emerged: "exile from ourselves"; "exile from our friends"; "chosen exile"; "forced exile"; "exile from the world around us"; "our exile"; "others' exile"; "our role in exiling others". Enriched by multiple possibilities, students built a personal stance on the meaning of "exile", which they represented in writing, in a visual mood board, in music and, eventually, in a "happening" or installation echoing practices in contemporary art.

Essential to resonance is the role of the self as the centre for understanding the meaning of things. Accordingly, resonance is most prominent in the arts and literature, where personal experience and consideration of multiple meanings play a central role.

Crossover tool

Students engage in "crossover tooling" when they learn a skill or concept that can be typically found in two or more disciplines and apply it across subjects. For example, careful observation is central to data collection in biology as well as to life drawing in the arts. Reasoning with evidence is as central to history as it is to physics and mathematics even though the nature of the evidence considered in each case varies. In a science unit on biological drawing, a teacher invites students to learn and apply the observational techniques of the artist to engage in more careful observation of organisms. A series of lessons are offered in the use of artistic techniques to depict negative space and attend to contour. In so doing students begin to apply rigorous approaches from the visual arts to their study of organisms in the biology class.

In this example the techniques of the visual arts are used as tools by the scientist. This crossover use is possible because the approach to close observation of the artist in rendering the world in aesthetically sophisticated ways is similar to that of the natural scientist in producing biologically accurate, visual studies of organisms. In fact, the capacity for close observation crosses a variety of disciplines, and the arts-based techniques of observation are potentially available as tools to study topics in a range of disciplines. Other disciplinary tools, concepts and skills, like statistical modelling, or systems thinking, are likewise available for "lending". Students demonstrate integrative understanding based on crossover tooling when they become able to apply one discipline's tools, concepts or techniques in an appropriately similar context in another discipline.

Complex explanation

Quite often, units of instruction are designed to help students understand why and how a complex event or phenomenon occurs. Teachers and students may ask: Why is the climate changing and what can we do about it? Why did individuals behave the way they did in the past? Why is heart disease more prominent among some human populations than others? Addressing questions of this kind demands that one draws on expertise stemming from more than one subject matter. Such comprehensive accounts illustrate a form of disciplinary integration that is best described as "complex explanation".

Consider for instance students' investigation of the Pak Sha O river basin introduced in the previous chapter. A central goal of this unit was to explain whether human activity was affecting the local ecosystem. As in most environmental studies, a satisfactory account required the coordinated input of biology, chemistry, geography and economics. Biology was needed to characterize the presence of micro-organisms at different stages of the river and assess the health of mangroves on the shore. Chemistry and geography worked together to characterize the shape of the river basin and the abiotic factors affecting living organisms. Elements of economics enabled students to understand the kind of human activity taking place in the area and how such activities might be viably transformed. Ultimately the unit asked students to build a complex web of relationships among factors affecting the ecological balance in the area. Students demonstrate their integrative understanding of the river when they exhibit a capacity to explain how such factors interact. In this approach to integration oversimplified accounts are rejected in favour of those that relate different factors and outcomes arising from the various disciplines considered. Understanding the conditions of the Pak Sha O river basin is no longer a straightforward matter of measuring water quality alone, rather the river is viewed as a complex phenomenon in which natural, biotic and abiotic conditions are affected by human activity. Essentially, when building complex explanations, students take account of topics where multiple factors (typically studied by biologists, economists, geographers and chemists) interact.

Contextualization

In contextualization, students situate a particular concept, issue, or problem arising in one discipline in a larger historical, cultural or philosophical framework that sheds new meaning on the issue at hand. Among experts, contextualization takes place, for example, when historians describe how the contexts in which they lived contributed to Gregor Mendel's discovery of patterns of genetic inheritance or Pablo Picasso's creation of Guernica. Similarly MYP students integrate disciplines in meaningful ways when they examine the historical, cultural or philosophical context of the topic they are studying.

Consider for instance the unit described earlier to help students to become familiar with the pre-Columbian musical instrument, the *sikku*. Teachers in the unit expected that students would not only be able to explain how *sikkus* produce music in a pentatonic scale (much like the unit on "The sound of music" in our introductory chapters) but also how *sikkus* embodied a long-standing world view and tradition in Latin American culture. For example, students analysed the decorative artwork that is typically painted on *sikkus*. The symmetric zoomorphic shapes employed could only be understood when students had a chance to learn about the Incan civilization where these images originated. Students needed to understand these people's relationship to particular species in their natural surroundings.

Essentially, when successful, the integration of two or more subjects enables students to reach an understanding that they would not have achieved through single disciplinary means. Focusing on integration involves being able to identify how, exactly, the concepts, methods, tools and genres of the disciplines are coming together productively. It invites teachers to ask important questions about what they teach. How are history, literature and the arts related to one another in a study of the French and American revolutions? What insights are gained through the combination of perspectives that could not be achieved by considering, for example, history, literature or the arts in isolation? Why does bringing these particular disciplines together in a study of revolutions make sense? When experienced teachers share their views of how disciplines come together in a unit, this enables students themselves to understand the purpose and nature of their learning enterprise.

Technological/practical solution

Techological/practical solution refers to a student's ablity to bring together multiple disciplines with a very concrete and practical goal in mind: to create a product, find a solution, develop an intervention. When working within this approach, students begin with a very clear idea of the outcome in mind and they back fill to seek to reach such outcome. Their success is measured by the degree to which the outcome "worked" in a practical sense. For example, Sofia and her classmates applied their understanding of the relationship between sound wave longitude and tube length in their *sikku* to create an instrument able to play in a given pentatonic scale.

Reflection point

Which of the forms of integration introduced above seem most familiar to you? As a thought experiment consider how each one of the forms of integration above might apply to your own teaching in your subject matter. Specifically, describe how teaching in your subject matter can be expanded, or improved by applying each form of integration above. For example, if you are teaching a unit on genetic inheritance in your biology class, an artistic synthesis may lead you to collaborate with the arts teacher in your school to explore with students how key elements of this phenomenon (for example, the role of chance in genetic inheritance) could be expressed compellingly in a work of art. Decide which form(s) of integration are the best fit for your course.

Chapter 8 What will students do to learn?

Overview

This chapter recommends sequences of experiences or schemes of work to support quality interdisciplinary learning. A constructivist performance-based view of understanding is emphasized.

The preceding three chapters addressed largely the question of what to teach in quality interdisciplinary classrooms.

Focus shifts to the assignments or learning experiences that teachers can design for students to build the desired understandings. Specifically the following questions are asked.

- How do students build deep interdisciplinary understandings?
- How can teachers design quality performances of understanding in interdisciplinary classrooms?

How do students build deep interdisciplinary understanding?

A vignette: Numbers past and present

The classroom breeds excitement and concentration. Sitting in groups, MYP year 1 students are writing multi-decimal numbers and solving operations. Unique about the task is that they are doing so with ancient numerical systems while decoding how each system "works". Two girls discuss where to place knots on an Incan *kippu*. Other students ponder whether beads can "change how much they count for" depending on where they stand in a Chinese abacus. Others discover that the Babylonian numerical system does not allow them to count to 4,000.

As the number system codes are "cracked" students explain their assigned systems to the larger group. Did they use their fingers and toes to count in base 20 systems? One student ventures, did they really need to have very high numbers, like in the millions, if all they were counting was cattle? "The good thing about using *kippus* made with strings is that you can travel with them kind of easily!" Students' exploration is part of a larger unit on ancient civilizations, their cultural achievements and their influences on today's life.

This illustrates the power of deep learning in MYP classrooms. As their teachers put it, the purpose of this activity is to encourage students to understand that (a) number systems are constructed cultural tools; (b) previous systems served particular purposes effectively in their context (for example, in transaction records); and (c) that our number systems today evolved from previous systems. In this experience, students are asked to do more than memorize given principles or solve routine algorithms. They are invited to think with information about each number system to explain how they work, hypothesize about the societies that produced them and apply them in basic operations. For these students, deep learning takes place as they engage in this carefully designed assignment.

"The kids did not have the idea of bases at first," the teacher explains, "but after working through the cases they realized the difference between a base 10 and 20. The big idea is that there is a huge connection between different number systems; they are all logical systems. They also learn that some of these systems would not be effective today but it's not necessarily that they are worse. Rather, the present day system meets our needs."

Imagine trying to learn to use a new computer graphics program solely by reading and recalling operating instructions. Clearly, reading would enhance the information base you have of how the programme is used but it would hardly prepare you to use it effectively to process graphics. Understanding how to use a new computer program requires that that we have multiple opportunities to actually use it, experiment with its options, reflect and try again, aided by the information we obtain and moving toward increasingly open-ended and complex tasks. Understanding is our capacity to think and act flexibly and adequately with knowledge. Understanding how number systems work involves more than having information about them in our minds—it requires that we become able to use information about the number systems, for example, to explain how they work, examine their strength and limitations, apply them in various computational problems.

In the MYP, students' learning is typically nurtured at multiple levels. Students are encouraged to build a rich knowledge base of a given topic, and demonstrate deep understanding and flexible application of concepts and ideas, analyses and syntheses. In this guide we use the term "understanding" generally to refer to the capacity to use concepts, theories, principles, and findings, whether such use involves practical problem solving, analysis, synthesis or critique. Thus understanding ancient Mayan civilization involves more than locating it in what is now Mexico, Honduras, El Salvador and Belize or recalling that it thrived between the 3rd and 9th centuries. Rather, students demonstrate understanding of ancient Mayan civilizations when, for example, they can organize the information they have acquired in light of the fundamental needs that civilizations have in order to thrive and survive. When asked about the reasons why Mayans might have settled in the region they did, these students may spontaneously refer to the Mayans' need for food, drink, shelter and health and point out the fertile river banks along which small-scale self-organized Mayan cities emerged. They may highlight the ease of communication among cities that enabled the exchange of goods and reason that demographic growth may have paralleled material and cultural production. When confronted with the surprising fact that the ancient city of Copan, once a thriving site of Mayan civilization, did not exhibit new monuments or temples built in the 18th century these students demonstrate deep understanding when they hypothesize multiple viable explanations about why the city collapsed despite its wealth: war, overuse of environmental resources, internal political strife.

Much like understanding how to use a new computer program, building understanding of Mayan civilizations requires that students find multiple opportunities to work with the information given. Activities or schemes of work foster deep understanding when they ask students to engage a given content to produce an explanation, design a graph, solve a problem or create a product. In this guide, such understanding-centred activities are called "understanding performances" because they build and demonstrate understanding at once. Two core features distinguish quality understanding performances from more generic activities, schemes of work or student assignments.

- They are visibly aligned with the learning goals of a unit.
- They require that students think with and apply information in new ways.

Our number systems example above illustrates these points clearly: the assignment was designed to enable students to identify defining patterns of ancient number systems—to "figure out how they work" based on a few given clues. They were then to evaluate pros and cons of the number system under study, and to contextualize their thinking by examining the multiple uses that people in antiquity made of computation. In so doing, the performance met two of the stated learning goals for this portion of the unit: to understand the constructed nature of numbers and how previous number systems satisfied contextual needs. The performance is also effective in that it does not limit student learning to the memorization of key given features of number systems, rather it engages students in supported discovery of such features and careful thinking about their implications. Reading about the number systems and memorizing rules may be an activity but it is not an understanding performance, because understanding performances demand that students use the information in novel situations—rather than merely recite it back.

The following chart includes a list of activities and compares them to corresponding understanding performances visibly designed to advance and demonstrate student understanding.

From classroom activities to performances of understanding	
Classroom activities **General student actions for learning**	**Performances of understanding** **Actions that lead students to work through the specific concepts and skills that a unit is designed to teach**
In a unit on environment degradation, students read an article about environmental degradation or watch a film clip to familiarize themselves with the issue.	In a unit on environment degradation, students extract the main indicators of environmental degradation in a given article or film clip and indicate whether such indicators are visible in their local environment.
In a unit on the Holocaust, students read Elie Wiesel's *Night* and then work in groups to dramatize a section that they found interesting.	In a unit on the Holocaust, students read Elie Wiesel's *Night* and then work in groups to closely study an extract from the text. Each group reworks it into a dramatic performance to appeal to a different segment of society who may have a different take on the Holocaust. They then conduct a dialogue with the audience to discuss choices they made in their reworking of the extract.
In a unit on architectural creations, students conduct research on different wonders of the world and present their findings in a Microsoft Powerpoint™ slideshow.	In a unit on architectural creations, students conduct research into how and why a particular wonder of the world was built, and hypothesize on the significance of the wonder on the society that built it. They then plan a "wonder" that they would build in their own country, complete with explanations on why they would build such a creation and how doing so would reflect on and impact their society.
In a unit on ancient Egypt, students find information about the pyramids.	In a unit on the ancient civilization of Egypt, students study the number system used by the ancient Egyptians and hypothesize how they would have used it to calculate the amount of resources required for the pyramids. In doing so, they consider issues such as the geographical region of Egypt (where the stone would come from), the social structure of the society (who the workers were), the beliefs and practices of the society (why would the community support the construction), etc.
In a unit on migration, students read about local migrants.	In a unit on immigration, students research the immigration policies of different countries and the experiences of immigrants in order to create their own policy on immigration for their country.

Figure 14

Reflection point

Select five activities that you often use. Analyse whether these activities are understanding performances or simply activities by gauging the degree to which they satisfy the two criteria above. If they do not meet the understanding performance criteria, how would you transform the activity so that they do?

How can teachers design quality performances of understanding in interdisciplinary classrooms?

Performances of understanding are the essential building blocks of deep learning. Regardless of subject or discipline, designing such learning experiences involves rigorous and creative thinking on the part of teachers. In the MYP teachers design performances of understanding that enable students both to build and demonstrate their growing understanding, which allows teachers to monitor and support their students' learning.

Connections

In the *MYP: From principles into practice* guide, performances of understanding are described as "assessment" tasks. In this guide we examine the task design and their assessment separately. We look at task design in this chapter and criteria for assessment in the next. It is worth, however, keeping in mind that assessment does not require the design of yet another set of activities specially geared for evaluation. Rather, ongoing assessment implies looking at student work, comments, thinking and task performances carefully to gauge their growing understanding. When assessing student work teachers apply evaluation criteria to the understanding performances designed for a unit. Such criteria are addressed in depth in chapter 9.

To design performances of understanding teachers must ask the following.

- What are the particular concepts, skills, ideas that I would like my students to understand through this activity?
- What might I invite students to do with such information so that they grapple with it and give meaning to it?
- Is the activity or task I design truly demanding that students think with the information given in a new way?
- Will the activity make their developing understanding visible, and therefore enable me to offer feedback?

Further explanation of performances of understanding

A defining characteristic of performances of understanding in interdisciplinary units is that they foster interdisciplinary understanding. Thus particular attention must be paid to the design of performances of understanding that will help students to appreciate the purpose of their inquiry and learning, build a robust grounding in the disciplines or subjects involved, develop productive integrations across disciplines, and reflect about their learning.

As seen in chapter 4, in interdisciplinary units or courses, integrative performances of understanding are placed from the beginning of the unit, when introductory performances enable students to preview the topics to be explored, throughout as midway synthesis and final synthesis. This sequence of integrative efforts in a unit is informed along the way by performances designed to help students learn selected concepts and modes of thinking in the disciplines or subject matters involved, that is, disciplinary tooling performances.

Integrative performances

Introductory performances give students a preview of the larger topic in its complexity. Rather than requiring the application of new knowledge, effective introductory performances invite students to apply their initial theories, knowledge or intuitions about a topic, making a diagnostic assessment possible.

Midway synthesis performances are designed to help students see connections among multiple aspects of a topic or problem typically studied by different disciplines. Placed early or mid way in a unit these performances support students to make such connections.

Final synthesis performances enable students to build and demonstrate their most comprehensive understanding of the topic. These performances (a final paper, a presentation, a simulation, a portfolio) are designed to make students' interdisciplinary understanding of the topic visible.

Disciplinary performances

Disciplinary tooling performances focus narrowly on grounding students in the ideas and modes of thinking of a particular discipline. They tool students for the more complex interdisciplinary work by ensuring they understand core selected concepts in the disciplines involved. In such disciplinary performances students examine and apply the targeted concepts, skills or attitudes in a unit, receiving informative feedback from teachers.

Examples of performances of understanding

Selected examples of understanding performances of a unit on ancient civilizations are considered and analysed below.

An example: Teaching ancient civilizations

Teachers in this MYP year 1 course had three goals in mind for their unit on ancient civilizations. The unit seeks to integrate history, geography, language A, arts and mathematics to examine ancient civilizations in Egypt, Mesopotamia, Mesoamerica and Greece and Rome. Three fundamental goals drive this unit. Students studied early civilizations to understand:

- why these civilizations rose, thrived and collapsed
- how factors such as physical geography, social organization, culture, external relationships and the use of natural resources influenced this process
- how we can do research about the lives of people who lived centuries ago.

In this unit, students examined one civilization, Egypt, together in depth in class. Working in groups they were guided to investigate the characteristics, rise and fall of other civilizations as well. Special attention was placed on supporting students in the steps of the research process.

Introductory performance: Raising questions about ancient civilizations

Students begin the unit with a challenge: they are put in the role of Egyptologists who found an engraved stone. Their task is to list possible uses and meanings of the stone. The image they are asked to examine is that of the Rosetta Stone found by French soldiers in 1799, which provided a clue to understanding ancient Egyptian writing. Students brainstorm: "It's about the laws of what's right and what's wrong." "Maybe everybody had one of these in their house—like a prayer or something." "You could also use it as a weapon if someone came to rob you." "I think writing was not very common a long time ago so if they knew how to write these people must have been very advanced for their time." The teacher asks questions to prompt students into further discussion: What would you need to know about the people who lived back then to make sense of the Rosetta Stone? Why are these great civilizations no longer around? Might our civilization also disappear one day, what might be left behind?

Following a video documentary of an excavation, students work in groups to identify what they would like to know about the Egyptians to understand why this civilization emerged, thrived and collapsed. A chart structures students' questions into five areas: "place/environment"; "social organization (class, jobs, government)"; "culture (art, mathematics, sciences and religion)"; "products and commerce"; "neighbouring societies".

Integrative performances

A marker of quality interdisciplinary teaching design is the degree to which it offers students ample opportunities to make meaningful connections across disciplines building toward a final synthesis or project that embodies the ultimate understanding.

Introductory performances: Building preliminary explanations

Introductory performances provide an initial intuitive and synthetic overview of the topic to be studied. They can occasionally be considered preliminary syntheses. Three features characterize quality introductory performances for an interdisciplinary unit. They help students:

- understand the purpose and relevance of their learning
- appreciate the multifaceted nature of the problem under study
- make their intuitive ideas about the topic visible as a diagnostic assessment of students' interests, beliefs and misconceptions.

Understanding purpose and relevance: The initial discussion is designed to help students appreciate that civilizations (past and present) rise and decline and that understanding how this happens matters for our future well-being. "We may not be able to predict the future of our civilization," the teacher explains, "but we can meet it in informed ways if we understand similar human experiences in the past". In addition, the brainstorm helps students identify their own sense of what matters most, and to begin to personalize their inquiry.

Appreciating the multifaceted nature of the topic: By structuring the brainstorm along five core dimensions, students appreciate that understanding civilizations involves considering multiple perspectives and levels of analysis. Such perspectives range from the physical and environmental context to the rituals and traditions that hold a society together. In so doing, the structured brainstorm prepares students for an inquiry in which understanding both local ecosystems and artistic expression will be necessary. The brainstorm opens their minds to the possibility that geography, history and arts as well as other disciplines will be needed offering an introductory invitation to the areas to be studied and their potential connections. Furthermore, the documentary on archaeological work offers a preview of another key aspect of the unit—the nature of research about the past.

Making students' initial beliefs visible: Finally, these introductory performances shed light on students' intuitive beliefs about the topic. The questions do not assume prior knowledge of civilizations and all answers are welcome. Students' responses enable teachers to detect powerful ideas such as the notion that civilizations were marked by their capacity to use symbols and notational systems to convey ideas. They also enable them to detect misconceptions such as students' proclivity to project present values onto the past. Because nurturing deep understanding involves transforming several of these beliefs, identifying them early on matters.

Essentially, good introductory performances offer an overall preview of learning—an intuitive and playful introduction to a multidimensional space where students begin to see "the whole picture" of what they are about to learn even if they do not yet understand it fully. Introductory performances do not assume prior knowledge nor do they expect correct answers. They are exploratory and engaging with the topic and with an interdisciplinary approach.

Midway synthesis performances: Making well-supported connections across domains

Having engaged in introductory performances during the first days of the unit, students are invited and carefully supported to explore and make connections between subjects as the unit progresses.

A relevant component of the ancient civilizations unit involved teaching students to conduct library research about a civilization of their choice. In groups students gathered information about the core characteristics of their civilization along five topics: "physical place/natural environment"; "social organization (class, jobs, government)"; "culture (art, mathematics, sciences and religion)"; "products and commerce"; "neighbouring societies". Students were supported to develop information gathering skills—recognizing that books in different disciplines may offer different perspectives on their civilization; taking careful notes; citing sources; creating a research folder. Each group was asked to draw on their findings to address carefully designed integrative performances of understanding.

Linking environment and societies: Using the information gathered, students work as a group to examine and explain the ways in which the physical environment, flora and fauna of the region contributed to their assigned civilization's rise and/or to its collapse (geography, history).

Linking art and culture to society: Students are asked to select one interesting cultural product of their chosen civilization (pyramids, Colosseum, religious rituals, number systems, artworks, democracy), and to describe the cultural product carefully, explaining how it worked (for example, use of profile figures and story-like compositions in Egyptian art, decimal system in Roman numbers). Students are asked to describe how this cultural product might have contributed to bringing the society together or to creating division and conflict (art/history; mathematics/history).

Creating and sharing larger explanations: A few lessons into the unit on ancient civilizations students are invited to hypothesize why the great civilizations about which they were beginning to read might have arisen and why they were no longer around. What makes civilizations rise and then disappear? In small groups students consider multiple possible causes (war, droughts, conquest) and create a causal map about why civilizations rise and one on why they collapse. As a class students compare multiple maps to generate two whole-class theories on rise and collapse represented on two large posters. As new information emerges from students' research in the unit, students add detail to their maps.

A discussion follows. What aspects of ancient civilizations are most important to understand why ancient civilizations rose and collapsed? Who are the people who know most about these various issues (for example, geographers, historians, medical doctors)? Do you think that all civilizations emerged and collapsed for the same reasons?

Final synthesis performance: Bringing insights from different disciplines together to address the central question of the unit

Final synthesis performances enable students to demonstrate a sense of a clear purpose for learning; they treat the topic in its multiple dimensions, they employ knowledge and modes of thinking in the disciplines accurately and they make relevant and insightful connections.

As a final synthesis for the unit students are asked to write a paper explaining the rise and decline of their researched civilization. Their study of Egypt has enabled them to understand that the physical environment, culture and religion, trade and external relations had an impact on a civilization's early settlements, its growth and collapse. For their final paper students are asked to weigh the impact of each characteristic on the rise of the civilizations they studied, and their eventual decline. In preparation for their final paper each group presents their arguments to the class using Microsoft Powerpoint™ slides.

How do integrative performances work?

Integrative performances are designed to help students make connections across dimensions of a problem typically studied by different disciplines. In quality interdisciplinary units such connections are not placed at the end of the unit but take place throughout with increasing complexity and student autonomy. A few qualities characterize exemplary performances.

Integrative performances help students identify relevant dimensions of the problem and make connections among them: In this example, preliminary disciplinary connections are proposed: for example, the fertile land of the Nile may have contributed to the rise of Egypt because when people were well fed and they had to wait for their crops to ripen they had time to create more sophisticated tools, produce works of art, participate in rituals. It prepares students to construct complex interdisciplinary explanations, the ultimate goal of the unit.

Integrative performances support students in making small- and large-scale connections that yield a new understanding: In this example, students make well-supported connections between geography and history or between art and history as they advance an argument about the role of the environment or a cultural product on a society's life. Students practice making small-scale meaningful connections between history and other disciplines toward an overall explanation of why their civilization developed and collapsed.

Final synthesis performances enable students to build and demonstrate students' comprehensive understanding: In this example, student papers integrate their assessment of a civilization's emergence and collapse considering how the physical environment may have enabled agricultural forms of organization as well as more and less sustainable forms of land use. They also examine the human resources and demands of grand architectural works and their impact on the political organization of the civilization under study.

Disciplinary performances

Quality disciplinary performances in an interdisciplinary unit focus on particular disciplinary concepts, ideas or modes of thinking that are deemed central to understanding the larger topic at hand. Disciplinary performances are placed along the unit introducing specific concepts in isolation and in relation to the overall unit goals as needed. They invite students to do the following.

Apply/think with available information: As in all understanding performances, students are asked to do more than gather and recall information. They are expected to use such information in new contexts, for example, to advance a hypothesis or make an argument about social organization in the Old Kingdom. In quality disciplinary tooling performances, information seeking, library research and note-taking are extended through the use of such information in a new context (for example, analysis and argument building).

Target core concepts and modes of thinking in the discipline: Quality disciplinary performances tend to focus on key disciplinary concepts and modes of thinking. In the examples above, the concept of river basin dynamics and map interpretations are central to the discipline of geography. Conversely concepts like social structure, forms of government and power in past societies, are key to understanding history, as is the interpretation of primary and secondary sources. When students have a chance to build deep understandings of such central disciplinary concepts, they are also more likely to apply them beyond the particular topic under study, for example, in their analysis of other ancient civilizations.

Visibly inform the topic under study: Finally, because interdisciplinary units are informed by selected concepts and skills in each discipline, it matters that students' disciplinary performances contribute directly to student understanding of the topic. In this example, understanding patterns of flooding of the Nile will inform students' understanding of why a civilization emerged in northwest Africa more than 5,000 years ago.

How do disciplinary tooling performances work?

Performances should appear where appropriate in a unit, when teachers turn their focus to deeper understanding of particular discipline-specific learning. Consider the examples below.

Example 1: Grounding understanding in geography—maps and the Nile River Basin

Understanding the rise and fall of ancient Egypt requires an understanding of the Nile as a physical, political and cultural force in Egyptian life. Disciplinary tooling performances focus on each of these dimensions, enabling students to learn key concepts in geography, history and art. For example, to understand the Nile as a part of the physical geography of ancient Egypt students must learn how the river banks evolved over the centuries enlarging the fertile surfaces for agricultural use after 4,500 BC. Students also need to learn about the regular annual flooding of the Nile, which made agricultural production reliable and abundant. How might teachers design learning experiences that enable students to build such understandings?

One teacher explains: "The book didn't have a good tool for us to introduce an area. For example, there is no ancient Mesopotamia or Ancient Egypt map, just maps of the whole world. We wanted the kids to identify where ancient Egypt and Mesopotamia were but we also wanted for them to look at different maps and make connections and arguments using the maps."

In this unit students are asked to do more than collect and record basic information about the Nile. Performances of understanding here include the following.

- Students are invited to use such information to examine the Nile River Basin dynamics—a fundamental concept in geography.
- Some students are asked to create and compare maps of the river at various levels of inundation throughout the year.
- Others are challenged to include flooding management systems developed by the people of the Nile.
- Students are invited to study and discuss how water flows affected fertility of the land and how the Egyptians organized their yearly agricultural activities around the Nile. Flooding increased agricultural yields while drainage and silt accumulation contributed to the expansion of fertile floodplains and delta lands.
- Working in groups students use their images and selected background readings to support their arguments about how the Nile contributed to the rise and success of a fundamentally agricultural Egyptian civilization.

Example 2: Grounding understanding in history—sources and historical imagination

Teachers in this unit seek to help students understand the characteristics of ancient civilizations, the cultural practices, social organizations and cosmologies that held them together or were sources of internal conflict. For example, through a Microsoft Powerpoint™ presentation a teacher introduces the Pyramids of Giza as a monumental expression of ancient Egyptian cosmology, commenting on

how Egyptian society was organized. The teacher asks what it takes for a society to create these magnificent works. What kind of leaders must this society have had? Why and how might people organize their work to create these architectural milestones? If you were the government of this society how would you get enough people to work hard? In an informal discussion students share their opinions, based on the information provided by the teacher.

To examine these questions further students are given a variety of selected resources, references and websites. Their task is to gather information about the Egyptians' social organization, government, religion, education, and art and culture in order to inform a short paper on the characteristics of this ancient civilization that held it together and those that yielded conflict and stress. For instance students reflect on the power of a centralized national bureaucracy during the Old Kingdom and the social costs of slavery.

One teacher explained "to improve the quality of the research writing of students we try first to improve the quality of the information they have, and secondly the way they structure their essays. By using a research organizer, students are creating a clear structure of where to put information on various aspects of the civilization—it becomes clearer to them which piece of information belongs where. They are not then looking at information on religion, if it does not pertain to an aspect they are researching. This is already teaching them the skill of making choices about what information to include, to prevent an overload of information."

Several performances of understanding are designed to support student research and thinking.

- Summary sheets present historical information and guidance as to how to capture main ideas in paragraph and bullet point form.
- Sourcing tasks invite students to identify the source of a document and guide them to assess its reliability.
- A historical imagination task invites students to point out how people in the past might have interpreted expressions and situations differently.
- A classification task leads students to group together characteristics that they think will add to social cohesion and those that might impede it.

Conclusion

Designing understanding performances is the most creative aspect of curriculum and instructional design in the MYP. Research in student learning has shown that when students simply accumulate new information in their minds they may be able to retain it for a test or an exam but be unable to recall such information when a new situation emerges that requires them to bring their knowledge to bear. To nurture deep understanding MYP teachers are asked to engage students' prior knowledge about the topics that they teach and have students work with the new concepts and skills being taught in multiple ways, for example, considering analogies, using them in building explanations, supporting a personal position.

Crafting performances of understanding demands that teachers are clear about what exactly we would like students to come to understand and that they weigh multiple competing options of what students might be asked to do to build such understandings. Developing performances of understanding in an interdisciplinary unit also requires that teachers think carefully about which performances will work best as introductions to a unit, which ones as disciplinary grounding, which as integrative.

The design below aims to support teachers in this creative task.

Aligning AOIs, understanding goals and understanding performances

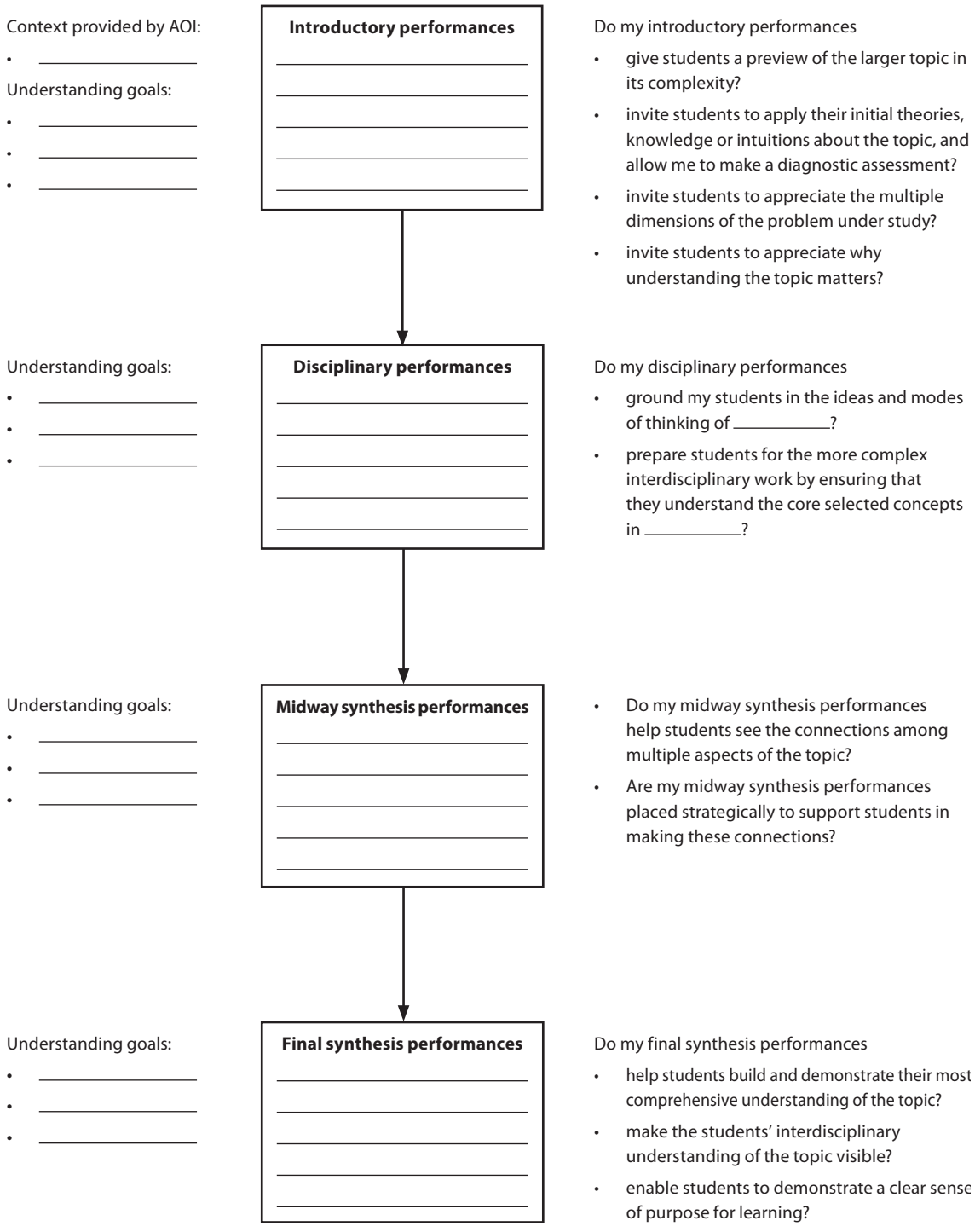


Figure 15

Chapter 9 Assessing interdisciplinary learning

Overview

This chapter introduces core principles and practical guidelines to assess student interdisciplinary work in the MYP. Three questions are examined.

- What are the qualities of good assessment practices in the MYP?
- What constitutes adequate evidence of students' interdisciplinary understanding?
- What challenges do teachers confront when assessing interdisciplinary work?

What are the qualities of good assessment practices in the MYP?

Crafting quality assessments requires careful attention to the strategies through which information about student learning is to be gathered, the criteria by which progress will be measured and the kind of feedback that will best advance student understanding. A few key practical guidelines can prove of great help to teachers interested in rigorous assessment of their students' learning.

Assessment is carefully planned: In planning a course or unit of work teachers develop an assessment strategy that is inseparable from their teaching strategy. For example, they define a final project, decide which activities to include, or how to sequence them over time, keeping in mind how such activities will advance and demonstrate student understanding.

Assessment is formative and summative: In addition to the final assessment that typically follows a unit of work, teachers begin to assess on day one and continue to assess over time. For example, early in a unit teachers may invite students to solve a problem or brainstorm ideas about the unit's topic in ways that make students' initial understandings visible. Throughout the unit activities are designed to develop these early understandings and demonstrate growth.

Assessment is aligned with MYP aims and objectives and areas of interaction: In planning and conducting their units, teachers use MYP aims, objectives and areas of interaction as guideposts. These inform not only the selection of what to teach but also the criteria by which related assessment can be conducted ensuring coherence to the teaching design.

Assessment is based on evidence of student work: In the MYP assessment builds on close analysis of student work. Teachers select relevant pieces of student work for assessment and are able to point out students' accomplishments or misunderstandings in their products or performances.

Assessment offers informative feedback: Viewed as an opportunity to support further learning, assessment does not seek to expose students in their mistakes but to help students recognize, and have evidence of, their accomplishments and misconceptions as well as strategies to improve their work.

What constitutes adequate evidence of students' interdisciplinary understanding?

The general guidelines above address primarily how teachers can assess student work. These guidelines apply to subject-specific and interdisciplinary assessment alike. When students engage in interdisciplinary learning they have an opportunity to draw on multiple subject areas and to integrate their perspectives. As a result, when teachers wonder how exactly interdisciplinary work is to be assessed, they ponder about key qualities that distinguish exemplary from less accomplished interdisciplinary work.

Consider these two examples of student work.

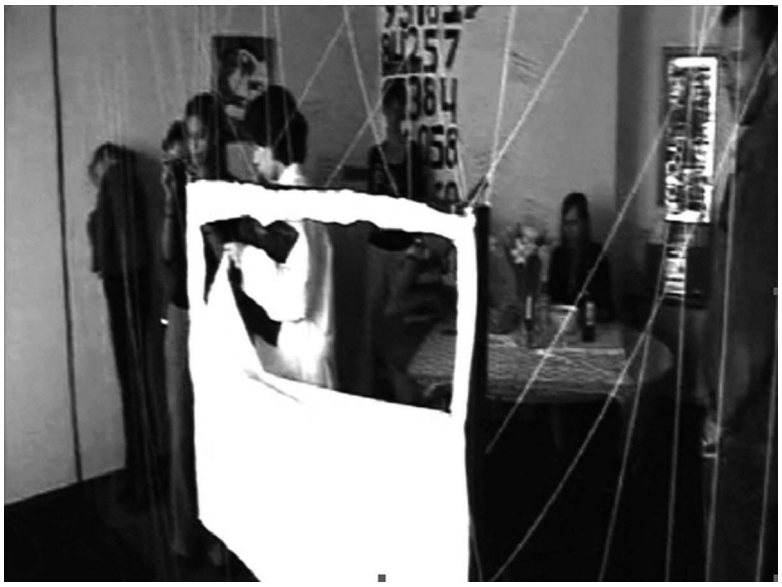
The multiple faces of "exile"

Students in MYP year 5 were required to work across drama, music and the visual arts to create a "happening" in the school on the theme of "exile". The unit was developed collaboratively by teachers in the arts department. Students worked in groups that consisted of members from each discipline. The project lasted 12 weeks with time divided to allow students to conduct research on art forms and artists in the three areas, to advance an interpretation of "exile" and to develop their "happening". The final project consisted of a series of public "happenings" involving image, sound and performance.

The "happening" created by Celestine, Devon, Ella and Mariella is entitled "Exiling ourselves from the world through the media". Invitees to the "happening" walk quietly into the room curious about the experiences that students in theatre, music and visual arts have prepared for them. The room is dimly lit. Two clearly defined spaces are separated by strings tied from floor to ceiling. Dominating this virtual wall is a large TV screen made out of paper. One side of this transparent wall features a warm dining room scene where two students are enjoying a lively conversation surrounded by the soothing Brazilian bossa nova sound of Vinicius de Moraes. The conversation flows naturally from pasta recipes, to comments about last weekend's outing and an old friend's personal life.

Actors are oblivious to the audience moving in their space—a detached and stale environment makes the audience feel separated from the "happening" itself. On one wall a column of large numbers appears in red: 27,000; 800 in three months, 6 million.

A warm dining room scene where two students are enjoying a lively conversation, ignoring the column of large numbers in red on the wall behind them.



In the morgue, a blue-coloured body, covered by a white sheet with printed red words, lays stiff on the examination table.

The forensic specialist prepares her instruments for the autopsy. Behind her, the two spaces of the performance are shown in jarring juxtaposition.

A glance to the other side of the virtual wall reveals the scene of a morgue. A blue-coloured body covered by a white sheet with printed red words lays stiff on the examination table while a forensic specialist wearing a white lab coat is getting her instruments ready for the posthumous exam. Attached to the body's toe is a label with a number. Slowly the audience moves to the morgue side of the room, as if through the television screen, through a hole cut by the forensic specialist in the paper TV. Once behind the media screen the audience walks quietly around the body and watches with stupor while, in the background, Vinicius de Moraes' enchantment with the girl from Ipanema becomes physically unsettling.

A doorbell rings in the dining room. A message is delivered to the host, "the autopsy will now begin", the specialist clarifies, "I must request that you leave". Unsettled, puzzled, challenged to put it all together in their minds; the audience leaves the "happening" and moves into the school hallway where they remain moved and silent for a while.

Understanding *sikkus* and ourselves

Concluding an MYP year 3 unit on Andean cultures, Sofia's final report offers an extensive account of her exploration of Andean musical and cultural heritage and the importance of preserving it in our rapidly globalizing times. Sofia outlines the dual problem that drives the work of her class as follows: "School #33 (a neighbouring school of limited resources) has no musical instruments. At the same time, Andean cultural artifacts and traditions are increasingly lost in contemporary societies."

To address these problems, Sofia reports, she and her class built a series of *sikkus* (a traditional Andean flute) with recycled materials. The *sikkus* were carefully designed with an understanding of sound waves and pitch intervals; they were made of recycled materials and illustrated with traditional Andean art motifs. Sophia views this initiative as a low-cost small-scale sustainable development

programme that will at once help children and preserve the Andean cultural tradition. Most compellingly, Sofia examines the roots of musical instruments like the *sikku* and the *charango* in ancient Andean civilizations, showing how the traditional religious meaning attributed to such instruments in the past has given way to the sometimes misguided, profit-driven meanings of our century.

Drawing on her research for this unit, Sofia concludes that it is only recently that "autochthonous music has been socially accepted as a form of cultural expression in our city. This is a new phase in a process that goes from discrimination, racism and intolerance to acceptance, admiration, respect and inclusion of all inhabitants in our cities, their practices and cultural expressions."

Performances and reports like the ones described above illustrate the multiple ways in which students bring together what they have learned in two or more courses in a given unit and how they are making sense of the information and skills acquired. The exile unit integrates student learning in subjects or disciplines within a subject group, the arts. The *sikkus* unit integrates understanding across multiple subject groups: sciences (physics), humanities (history and geography) and arts (music and visual arts).

Teachers in charge of assessing and supporting student learning must look at these productions carefully, seeking evidence of understanding and opportunities for further growth. Important questions are raised by teachers when they begin to do so. Is student interdisciplinary work to be assessed in the same way as their subject-specific work? Are there additional challenges to learning across disciplines that we should attend to? How can we assess students' capacity to produce work in which the whole is visibly more than "the sum of its disciplinary parts"?

To address the specific demands associated with assessing interdisciplinary work we introduce here an assessment approach that teachers are encouraged to use to inform their practice. Grounded in the definition of interdisciplinary learning introduced in previous chapters, this approach guides teachers' attention to four dimensions of the work embodied in the following questions.

- **Purpose:** What is the purpose of this work? How clear, interdisciplinary, and focused through the areas of interaction is it?
- **Grounding:** Is the student drawing on the subjects' knowledge and modes of thinking (concepts, skills, attitudes) accurately and appropriately?
- **Integration:** Are the subjects in this work integrated in ways that deepen students' understanding?
- **Thoughtfulness:** Is the student thoughtful about his or her work and the challenges and opportunities of making connections across subjects?

The recommended assessment approach builds on the subject criteria stipulated by the MYP and expands beyond them by inviting teachers to examine interdisciplinary student work holistically in a systematic way. Each dimension is examined below illustrating how it illuminates the' "happening" on exile and Sofia's report above.

Purpose: What is the purpose of this work, and how clear, interdisciplinary, and focused through the areas of interaction is it?

This is the suggested starting point for assessing students' interdisciplinary work. MYP teachers will find it helpful to begin their assessment by identifying the purpose of a piece of work or interdisciplinary exploration. Student interdisciplinary work varies greatly in purpose. Some aim to describe or explain a phenomenon or event in their full complexity. Others seek to solve a complex problem. Others aim to offer new interpretations, expressing thoughts aesthetically. Still others seek to create products or call for action and change. Understanding the purpose of a student's work matters because such purpose drives the crafting of the work and sets standards for its assessment. When teachers and students have clarity about the purpose of their learning and inquiry they can more readily determine what disciplines can be used to meet their goals, which disciplines should dominate, how disciplines could be best combined and how to decide when the work is "done" and its purpose accomplished.

Three core steps are in order as teachers examine the purpose of a student's interdisciplinary work.

- **Describe:** What is the purpose of the work?
- **Assess:** Is the purpose of the work clear (whether explicit or implicit)?
  - Does the purpose invite/require an interdisciplinary approach?
  - Is the work clearly focused through an MYP area of interaction?
- **Guide:** How can we support the student to gain clarity about the purpose of his or her interdisciplinary work and its relationship with the areas of interaction?

For example, the unit on Andean cultures invited students to create musical instruments and understand their historical and cultural context in order to preserve the Andean cultural heritage. The purpose was clear and multifaceted and could not be successfully achieved through the perspective of music, history or physics alone. Rather, multiple perspectives were necessarily combined. Sofia's statement about the two problems her work seeks to address provides evidence of her clear goals. Sofia's project speaks directly to human ingenuity as an area of interaction, enabling her to appreciate human ingenuity and our longstanding search for means of expression from ancient civilizations until today. Her work also speaks to community and service in her attempt to act to preserve the Andean tradition among disadvantaged children. Sofia explains.

> Children in school #33 lack musical instruments and native cultural traditions are being lost with globalization. To address this problem I will create a *sikku* out of recycled materials and teach children in a neighbouring school how to make one and play it as well, in order to preserve traditional Andean culture in our society today.

In the particular case of "exile and the media" students sought to call their audience's attention to the ways in which frequent news about numbers of deaths around the globe has rendered us apathetic to the reality of human suffering associated with each death. In their work they employ multiple art forms as a means to ensure a rich exploration, not as an end in itself. In other words, students do not describe their work as an effort to integrate theatre, music and the visual arts. Rather, they see themselves drawing on these art forms to pursue a larger purpose: to examine how the saturation of media in post-industrial societies is leading to a new form of exile and disconnection and to invite their audiences to reflect about that as well. Most commonly the general purpose of students' work—for example, "to explore multiple meanings of exile"—is determined by the teacher. In many cases, including this exile unit, teachers also give students sufficient latitude to define or refine for themselves the particular purpose of the work. Consider how students themselves characterize the aims of their "happening". Consider how effectively students' aims align with an understanding of human ingenuity and their role of raising awareness about human rights violations in their communities.

> We wanted to talk about modern tragedy that's happening all over the world, so not necessarily in the Middle East or just anywhere. We want somehow to demonstrate how it wasn't real to us. We thought that … how the idea of statistics was a barrier, the fact that we hear "30 people have died today in Baghdad" means so little to us nowadays. We'll hear it every day and go back to eating dinner and just turn the TV off. It's not really real to us. And when you walk through the TV and you actually see what's really happening, I think that's the impact that hits you a lot even though his face is covered. Also, at the end when she adds the one number on the door, it like shows you that story behind that one person, and so you think when you see here like 30 people dead, you know there's a story behind every one of them.
>
> We were aiming to create something where people would walk in and see what we're doing—bringing together elements from all over the place—and walk out different, with this image implanted in their mind.

Exploring media-induced forms of "exile", students judged, was a worthy enterprise—one that required that they draw on multiple art forms, to give dense layers of meaning to their "happening". In doing so, they borrowed broadly from the courses they had taken.

> We studied a number of different artists like John Cage and Bruce Nauman. Bruce Nauman had many ideas like us. He was saying like he was inspired by the irritation of how people can just ignore what they don't like. So the effect that we wanted to give people was that they couldn't just run away. So it was in their face—that was like being in the morgue. It was like actually being in reality but covered up.
>
> The different artists showed us different ideas of what we could go into and so we already knew what was out there. So we could combine their ideas, which made us think of our own. It seemed as if our idea was original but actually it was all synthesized. We borrowed from a variety of places.

In its final production, the purpose of the students' "happening" seemed clear, requiring no additional revisions or further guidance. Throughout the process of developing their interpretation of "exile", students considered various focuses for their work and found that the task of reinterpreting exile was challenging. Committed to doing "something that related to home life and to mass violations of human rights", students struggled to name the form of exile that the distance between these two worlds represented. They were able to define the purpose of their work when they realized that phrases such as "exiled by media overload", "numbed by the death tolls on TV" became an adequate framing for their work.

Appreciating the purpose of student interdisciplinary work is sometimes counterintuitive for teachers. Firstly, because most typically they, not their students, are establishing the purpose of students' investigations. Secondly, because such purposes are often presented in terms of learning goals rather than in terms of the kinds of knowledge-based pursuits in which human beings engage in authentic contexts: explaining a phenomenon, creating an instrument, solving a social problem, developing a personal position about a complex social or environmental issue. In schools student work is typically (and rightfully) framed in terms such as, "students will understand core features defining contemporary art"; "students will demonstrate their understanding of the creative cycle". Appreciating the purpose of interdisciplinary pieces of work like the ones presented above involves gaining a sense of how students themselves give meaning and direction to their efforts—how they link what they do in school with the world in which they live, adding authentic meaning to their learning.

Reflection point

Think of an interdisciplinary unit that you or a colleague has taught previously. Reflect on the following questions.

- What learning goals were established for the unit, and how can they be transformed into authentic purposes for inquiry? In reflecting about this ask yourself why young people should develop such understanding in our contemporary societies.
- Who established the learning goals or purpose of the project? If you did, how would you then encourage students to develop compelling shared purposes for their inquiry? If your students were the ones who established the learning purposes, how would you help them to articulate, clarify and pursue these purposes?

Disciplinary grounding: Are students drawing on the subjects' knowledge and modes of thinking (concepts, skills, attitudes) accurately and appropriately?

This criterion is concerned with how accurately and effectively students have drawn from relevant subjects or disciplines involved in their work. Teachers may ask: does the work exhibit evidence of students' developing mastery of the core concepts, skills, attitudes outlined in the subjects? Are there misconceptions, oversimplifications, or major oversights?

Here too, three core steps and guiding questions are in order.

- **Describe:** Which disciplines inform this work in general?
- **Assess:** Are subjects or disciplines selected in ways that fit the purpose of the piece or are they included in a forced manner? Is there evidence of the student developing mastery of key objectives in the subjects selected—that is, are knowledge, skills, methods, languages, values, used in accurate, rich and effective ways?
- **Guide:** How can we further support students in their efforts to improve their understanding of core relevant knowledge, skills and attitudes in the chosen subjects?

Assessing the disciplinary grounding of students' work requires teachers to focus on the particular subjects involved in their units of work. For example, in examining the exile happening teachers may ask: Are students employing the knowledge base and modes of thinking that they learned in their visual arts, drama and music classes? Drawing on the arts subject criteria teachers may ask the following.

- Do students demonstrate knowledge and understanding of the art form studied in relation to the societal, cultural, historical and personal contexts? (Criterion A)
- Do they demonstrate knowledge and understanding of the elements of the art form studied? (Criterion A)
- Can they develop an idea, theme or personal interpretation to a point of realization, expressing and communicating their artistic intentions, applying skills, techniques and processes? (Criterion B)

Because not one but three distinct art forms are included in this unit, teachers do well in examining students' work from a theatrical, visual and musical perspective. Consider for example how a music teacher describes the *sikku* unit's musical goals.

> During the project, we did a lot of this investigation of materials, so they know what are instruments and what are things that aren't instruments and to get them to expand their notion of what can be an instrument. We investigate silence, or non event, phasing and the way a lot of contemporary artists have used phasing to mean different things. And we also investigated the connection

> between the music, musicians and expressing political or social ideas. And that's the sort of thing that joins us all, the type of artists we use, why those artists, operating on the edge, or redrawing the lines around.

Evidence of disciplinary grounding abounds in the students' exile "happening". For instance, students explored the tension between "home" and distant realities elsewhere inspired by Do-Ho Suh's work where the co-existence of multiple realities in the confines of the familiar home is explored. Do-Ho Suh's sculptures continually question the identity of the individual in today's increasingly transnational, global society. They call our attention to the connections between "here" and "there"—a connection (and disconnection) that students explored successfully in this piece. They examined Bruce Nauman's use of numbers to represent dehumanization. In describing her initial visual design for the scene one student explains.

> This is Bruce Nauman, and everything instead of being linear, everything is coming from different directions. There's upside down, right side up, everything's highlighted in different colors and set up differently. Instead of having key lines just written normally, it's in huge colors, and in your face, which is exactly what Bruce Nauman does. He gets right in your face with things that you don't normally see. Just by looking at these, you already have an idea, without reading it, you get the mood, the feeling of it and that teaches you more than anything.

The performance was also visibly informed by students' learning of drama. They exhibited clear stage presence and focus of the mind "on here and now" typical of the Butoh theatre approach examined in this unit. Butoh theatre teaches students the importance of "being in the moment and not thinking about the audience". This is a powerful way to get students to think about performance space, quite contrary to more "traditional" drama classes where students learn to act out a play on stage for an audience. Butoh finds beauty in the grotesque, emphasizing the distortions and contortions of the body and mind in the search for a state of being, of presence. Students viewed the use of a blue dead body as building on such tradition—combining minimalist and meditative states of mind with the grotesque numbering and impending autopsy of the body. Butoh explores the beauty of our existential struggles and celebrates the painful yet essential journey towards awareness. In this sense students came to view the theme of personal and social exile as essential to this work. One student explains.

> We learnt a lot from Butoh theatre. Every group had a list of artists that they could choose, and nearly everyone chose Butoh to look at because it's so different and can teach you so much about what a happening is, like you're not doing it for other people, you're doing it for yourself. You have to explore boundaries and go beyond what is expected. And it can be beautiful or it can be disturbing, happy or sad. It can be everything, all at the same time. A large part of Butoh is also playing with time, perspective and space. And that was key in our happening, because we wanted to twist around the audience, where they were standing, how they were, what kind of time period. Everything. We all played with that.

Finally, the performance made intelligent use of music. In this unit, students explored the work of musicians and composers who challenged traditional definitions of music such as John Cage ("4' 33""), Henry Cowell ("The Banshee") and Steve Reich (clapping music). Borrowing on this inclination, students made a provocative use of Vinicius de Moraes' bucolic "Girl from Ipanema" by juxtaposing it with the drama of a human body (numbered 3358) ready for autopsy.

> With the music workshop, she (the teacher) talked about how people could play music not for other people, so it doesn't have to sound pretty to be music … We had two pieces [of music]: one was very relaxed, it was "Girl from Ipanema". It was at first really nice here in the living room but then obviously when you cross over it's still playing and you have that music but you're looking at death. It's eerie. And then it was a really eerie song where the lyrics are really important [for the next part]. It's very slow, saying "welcome to the soldier's side, there's no one here but me, people all grow up to die, there's no one here but me". It's really eerie.

In assessing the disciplinary grounding of students' interdisciplinary work MYP teachers refer to the criteria detailed for each subject. When multiple disciplines within a subject group are being integrated in an interdisciplinary study like the one portrayed here, teachers may find themselves employing the same criteria to slightly different domains. For example, understanding the work of contemporary visual artists like Kara Walker or Do-Ho Su demands that students learn to place these artists in the broader framework of contemporary visual arts, appreciating their techniques and aesthetics. In turn, understanding the work of Butoh theatre performers involves understanding the actor's relationship to his or her body and mind. Despite differences in content, however, teachers in this unit identified important commonalities across these art forms that served as productive bridges for integration—the third criterion by which these students' work is to be assessed.

Like these students' "happenings", Sofia's final report required a collaborative assessment on the part of her multiple teachers for this unit. However, in this case, collaborating teachers brought perspectives from multiple subject groups. For example, criteria A and D in the arts shed light on Sofia's accurate understanding of musical language, as well as her high level of interest and personal commitment to her work. Sofia takes initiative. She explains flexibly what constitutes a musical scale and places her instruments in the larger context of the Andean tradition. Sofia's analysis and experimentation with pre-Columbian art motifs and meanings also merited a high level with regards to knowledge and understanding and application of artistic skills, including the zoomorphic images that were characteristic of that time.

Sofia's physics teacher considered the adequacy of her understanding of sound waves as well as the ways in which she designed experiments to test the sound made by tubes of particular lengths.

Assessing Sofia's work collaboratively enabled these teachers to learn about each other's subjects and begin to find productive connections across their fields.

Reflection point

Using the same interdisciplinary unit you considered before, discuss the following questions

- Are there other disciplines that could have been integrated in the unit? What made you decide to integrate the ones selected? What were the knowledge and modes of thinking that you wanted your students to master in the course of the unit?
- By what means, both formal and informal, did you help students to develop mastery of the key objectives of the unit? If you felt that they were not meeting your expectations, how could you use assessment to guide them towards more productive inquiry?

Integration: Are the disciplines or subjects in this work integrated in ways that enhance students' understanding?

As described in previous chapters, a hallmark of quality interdisciplinary understanding is the students' capacity not only to employ multiple disciplines but to integrate them in ways that yield a deeper, more nuanced and informed understanding of the problem they are studying. Quality assessment of interdisciplinary work requires that teachers pay close attention to the integrative nature of students' understanding. To do so they must describe how they view disciplines coming together in a body of student work, assess the degree to which such integration is productively advancing students' understanding and guide students' work further as the work requires. As before, three questions are in order.

- **Describe:** What are the key points of integration proposed in the work—that is, where are disciplinary perspectives clearly brought together in a phrase, metaphor, interpretation, or explanation?
- **Assess:** Are the integrations enabling students to advance their understanding effectively—for example, to produce more comprehensive descriptions, richer explanations, more creative and new interpretations, deeper explorations or effective solutions that benefit from the combination of perspectives?
- **Guide:** How can we further support students in their efforts to integrate available disciplinary insights to advance their understanding (if applicable)?

In chapter 7 we outlined a variety of ways in which disciplinary perspectives can be combined to deepen student understanding. The "Happenings" unit enables students to develop a personal interpretation of the notion of exile that is informed by multiple art forms. Students also showed a growing ability to understand commonalities and differences in the ways in which aesthetic symbols are used across the arts in provocative and creative ways.

Personal resonance

Personal resonance refers to the process by which students advance an increasingly nuanced and personally meaningful understanding of a topic such as exile, by placing the topic in the context of multiple disciplinary traditions. For example, students placed their comfortable images of "home" against the work of Do-Ho Suh, which revealed the comfort as a form of immoral detachment from the larger world. They then examined this contradiction in the context of musical transgressions such as John Cage's playing of silence. Students' nuanced understanding of exile was reached through a virtual dialogue among perspectives that they have experienced in the unit. As one teacher explained, the arts were chosen in order to personalize students' experiences and understanding and to create a powerful piece in which students will not forget the "monuments of the happenings". Matt, the theatre teacher, talks about the "power of the arts" to enable self expression.

> The thing that we really want to focus on in this project is the whole cycle, the whole creative cycle, the phases of the process. … Maybe deeper than the processes, they find that they need the arts to express what they want to express, and they find they've got the access.

Crossover tool

Through this unit students were invited to move away from art in the traditional sense and look at contemporary trends in art. In doing so, students transformed their intuitive skills-based understanding of the disciplines to a more conceptual understanding through the topic of exile. Students were asked to explore symbolism in the arts. They learned that music does not have to be the sound a piano makes when one plays it. The teachers noted that this was a difficult concept for students and teachers as both are used to a more skills-based learning environment. However, it is an important tool for students to have because once they are able to understand what it means to be symbolic they will be able to transfer this knowledge to other domains of their life.

> Ours looked a little bit more segmented but they are all connected. We had a camera that was for Diane Arbus and had pictures, examples of her work throughout it, and it kind of melded into a score, a musical score. We actually took and cut out the treble cleft from the page because it was John Cage and he does all this work where the audience actually creates the music. He literally sits at the piano for four minutes like this [shows fingers poised above the keys] and just sits there! And the noise of the audience is his piece. So the audience becomes the artist. And the poster looks different every time it's moved, because of what's behind it.

> A lot of them [the students] start thinking, "Oh! But I gave up drama! Oh, I gave up music!" But seeing their productions, they've all linked up the arts and their productions wouldn't be right if they were missing one of it. It's not like, "Oh, I'll stick some music in here because I'm good at music". They recognized the commonalities in each field.

> I think the complementarities arise when they're really comfortable with the arts that they're working with. For them to start looking at complementarities, they really have to understand the differences ... We talked a lot during our meetings about what it is really that makes our disciplines different, and it was difficult! It wasn't easy … And the segments of like drama you do, monologues, and you do playwriting, and you do scripted plays, you know, Shakespeare … That kind of thinking is completely outmoded. That kind of thinking is like a skill-based education in the arts, like we're going to teach students skills instead

> of processes of thinking, like we're going to teach a student how to do a scale in music, as opposed to teaching them an appreciation of the creative process. Why it makes the noise it makes, why does a piece of work have the power it has, not just in technique … a much more concept, thinking based.

Technological/practical solution

Techological/practical solution refers to our capacity to integrate information from multiple subjects to fashion a new technology, instrument, product or practical intervention. When working within this approach, integrations are assessed by whether or not they "worked" in a practical sense. For example, to produce a *sikku* that works and honours Andean cultural heritage demanded that Sofia and her classmates understood how the longitude of sound waves is shaped by the length of a recycled paper tube, which in turn determines the pitch of her instrument. They had to understand how to manipulate tube length experimentally to produce an instrument that played in a pentatonic scale.

In teaching students in school #33 how to design *sikkus* of their own Sofia and her peers also engage in a practical solution. They integrated their understanding of *sikkus* and how to build them with their growing understanding of development aid options (learned in their geography class). This enabled them to design an intervention that would be viable (employing recyclable materials) and effective in preserving Andean tradition in contemporary local populations. Both understanding of music and physics as well as understanding of forms of aid were essential for a successful delivery of this project. Sofia explains.

> Ours is a sustainable project, one that builds on adequate technology to provide long term technical aid. We will teach the children how to make a *sikku* and our objective is that this skill will be passed from generation to generation of students in the school. Our project is also low cost and seeks to have impact on the local community—specifically on school #33.

Contextualization

Sofia and her friends had an opportunity to contextualize their understanding of *sikkus*. Their understanding of the music played with these instruments was enriched by understanding the historical and cultural contexts and the perspective of historical actors who imbued their instruments with divine powers in the past, ambivalence in the more recent past and a renewed appreciation in the present. Sofia explains.

> The term *"sikku"* has its origins in Aymara language and means a tube that produces sound. *Sikkus* are important in today's cultures because they commemorate our past. *Sikku* music can be heard today as folk bands play *sikkus* quite regularly. However, they do not do so to worship gods or lead rituals as our ancestors did, but for enjoyment in carnivals and for tourism.

Assessing students' capacity to integrate what they learn is perhaps the most challenging step in assessing interdisciplinary work. This is in part because teachers are not used to looking closely at how perspectives connect. Often, in looking for integrations like the ones characterized above, teachers may realize that they have conceived their units as multidisciplinary ones—where students learn about particular topics through multiple perspectives but no serious attempts are made at meaningfully connecting these views. Missing evidence of integration calls upon teachers to revise their designs so that they can foster and support students to integrate. As the examples above suggest, developing the habit of assessing how students integrate subjects in their work involves becoming used to examining how exactly disciplines come together as well as how the combination enriches students' understanding.

Reflection point

Consider your subject group with regards to the following questions.

- What are the common big ideas, skills or habits of mind that are shared by multiple disciplines (for example, sciences, social sciences, art forms) in your subject group? How are these ideas and skills similar or different across disciplines in your subject group? What advantages and disadvantages do you see in teaching these ideas and disciplines together?
- Create a visual map of the subject groups in your school placing your own subject at the centre. What might students learn (if anything) in each neighbouring subject group that would help them deepen their understanding of your subject in meaningful—not forced—ways?

Thoughtfulness: Is the student thoughtful about his or her work and the challenges and opportunities of making connections across subjects?

Interdisciplinary performances of understanding invite students to engage thoughtfully with their topics of study and to consider different ways of approaching problems and issues. When assessing student work teachers are encouraged to consider the degree to which students are reflective about their accomplishments and the limitations of their work, whether they understand the learning challenges and possibilities of bringing disciplinary insights together to meet their purposes. As before, teachers must ask three questions.

- **Describe:** Does the work indicate that the student has reflected about the learning challenges and possibilities of bringing disciplinary insights together to address his or her purposes?
- **Assess:** Do the student's reflections about the process and outcome of the work reveal understanding of key aspects of doing interdisciplinary work—for example, the possibilities opened by integrative work, the insights gained along the way, the challenges of bringing disciplines together, the tension of satisfying conflicting standards?
- **Guide:** How can we further support the student to understand the demands of interdisciplinary work (if applicable)?

In the MYP teachers are encouraged to invite students to reflect about their own learning on a regular basis. Interdisciplinary projects provide important opportunities for them to do so. Students can reflect about how their problems or topics of study are framed, about the relevance of learning what they are asked to learn, about their own struggles to make a connection. Developing such metacognitive approaches to learning prepares students for the type of lifelong learning that is increasingly necessary in contemporary life. In the examples considered in this chapter, students demonstrate their thoughtfulness in multiple ways.

Sofia evaluated her community project highlighting some of the learning challenges that presented themselves and showing a healthy appreciation and skepticism about the success, immediate and long term, of her class's intervention.

> This was no doubt an exciting project. I learned a lot about Andean cultures and their art and music. I even learned how to estimate the length of the *sikku* tubes. I made my own *sikku* and it worked.
>
> Perhaps the most challenging aspect was to visit school # 33. I was uncomfortable at first, feeling that the children were not motivated and didn't care about the instrument we were about to show them. Later as we explained the ideas further, they seemed more engaged. Finding out if our project will work is a matter of time.

In the "happening" project on the other hand, students reflect on the personal meaning of their learning, how they changed their minds about the nature of exile and their own roles as citizens in a visibly violent world.

> I think I learnt a lot about myself, like I must admit that I sometimes do watch television and then the news comes on and I turn it off because I don't want to watch it, you know, and I feel like I'm hearing the same thing again and again. But now I do watch. I watch more of the news and you know like if you hear "dozen dead, car bomb" then you know that there's a story behind every single one of these people, and that's what we tried to convey, that there's a family, that that's just one of the people, and there are thousands of people who died in Iraq, for example. And now I think I know more about my own personal exile from the media, and I know how I can overcome that.

Reflection point

Thinking back on the interdisciplinary units that you have taught in the past, consider the following.

- What kind of reflection pieces have you set for your students? What are the questions that you have asked to encourage them to reflect on their learning?
- How would you move students from a superficial reflection on their work to a more metacognitive approach to the key aspects of doing interdisciplinary work?

What challenges do teachers confront when assessing interdisciplinary learning?

A productive use of targeted assessment demands careful adaptation of the four proposed elements to the particular courses and disciplinary combinations involved. MYP teachers are encouraged to develop a more detailed characterization of the qualities of interdisciplinary work that they seek to foster. What exactly will the purpose of student inquiry be? What specifically are the disciplinary insights to be developed? In what ways should understanding be advanced? What insights will students gain about the process of doing interdisciplinary work?

Teachers may vary in how specific they prefer to be in their assessment of interdisciplinary work. Some opt for precision. They ask: "Where is there evidence of disciplinary integration?" and "Is there evidence that the student has understood the purpose of the work?" They then identify corresponding quality indicators in interdisciplinary work and focus on them when assessing work. Others prefer to use the criteria more holistically to get an overall sense of the quality of a student performance. Whether precise or more holistic, the assessment of student work must be grounded in samples of work that offer evidence of interdisciplinary understanding. It must be ongoing and informative to students. Whenever possible, interdisciplinary assessment should be collaborative as well as using multiple teachers' expertise on a particular student's work. These practical challenges are illustrated below with examples from the "exile" unit above.

Drawing on a representative selection of student work

It is difficult for a single piece of work to embody all three of the criteria; in most cases teachers found it necessary to assess a range of performances (see the previous chapter). Interdisciplinary work is shaped by the genre in which it is created; the genre also affects which qualities are made more visible in a particular context, for example, an academic paper invites explicit thoughtfulness or critical awareness but a short story does not, and works of art that invite multiple interpretations do not lend themselves well to explanations of disciplinary foundations and how and why different disciplines have been brought together. Teachers are encouraged to consider which aspects of student understanding they wish to focus on in a particular performance for instruction and feedback, and what range of performances they are going to require of students, for instance, artistic pieces were accompanied by a reflective statement that unpacked the influences that went into the work of art.

In our example, the arts department described the "exile" unit as a learning process for the students, which began on the first day of the unit. From the very beginning, students were given a journal and asked to make at least one journal entry on the unit every day. This record of the students' learning process became an invaluable piece for assessing students' learning about the disciplines. During student interviews, students discussed their learning process by examining their journals and noting the difference between their entries at the start of the unit compared to their entries closer to the end.

Students' understanding of integrating disciplines was assessed and challenged in student–teacher interviews. These interviews were an intrinsic part of formalizing the process of understanding. For example, students were interviewed about the mood boards they had created and described how the disciplines blended together to create their mood board. These interviews allowed teachers to home in on students' ideas and thoughts and challenge their thinking on integration. Furthermore, students' reflection interviews after their "happening" were important to evaluate whether students had a clear purpose, whether their purpose was well grounded in the disciplines, whether they were able to bring these disciplines together and whether they were reflective about the unit.

Ongoing and informative assessment

As in all good teaching, the assessment of student work does not just happen at the end of a course; students are given ongoing feedback about how their understanding is developing and constructive advice about how to develop their understanding further. In other words, this approach to assessment is not just about evaluating students' understanding; it is also about supporting and promoting it.

Experienced teachers find various opportunities to give students feedback during the course of their interdisciplinary units. Some of this feedback is formal and planned, for example, written comments on papers or project proposals, evaluations of class presentations, and art critique sessions in which students give structured feedback to their peers about their work. At other times, feedback is informal, occurring spontaneously during class discussion or one-on-one interactions with students. Feedback is not just given by the teacher to the students; there are also opportunities for students to assess each other's work as well as to reflect on their own work, sometimes in the form of journals or reflective pieces.

Depending on the disciplines involved and the structure of the unit, some teachers find it appropriate to assess their students' disciplinary understanding before engaging them in integrative performances.

Among experienced teachers, assessment is clearly outlined for the students. Teachers develop task-specific clarifications for student work and students are able to check levels of performance against these rubrics in order to improve achievement. Furthermore, there are many opportunities for informal formative assessment. In the case of the unit on exile students were required to give two group presentations on their work. Artist logs ensured students' thinking and development were clearly charted. Furthermore, students were interviewed by the arts teachers about their happening as it unfolded. Interviews provided a good profile of how each individual contributed to the group and how the group was functioning as a whole. Workbooks were handed in at key intervals so that teachers could assess student progress over time.

Assessment revealed not only students' accomplishments but also their learning challenges. By working across the arts students experienced difficulties operating outside of the areas of art in which they felt confident. Each student had elected only one art subject to study in MYP year 4 therefore some found it challenging to be working in the other art disciplines. For example, visual artists expressed a discomfort with stage-, performance-based activities. To support students, teachers chose introductory pieces for their workshops that would help students ease back into the discipline. For example, Matt chose Butoh theatre, which introduced students to thinking about being in the moment and about the performance space. This was a good beginning point in order to get visual artists more comfortable with the space around them:

> These students aren't just taught to do it, they're taught to think why they're doing it, and how they're doing it and where they're doing it. You know, the whole idea of moving an artwork … moving an artwork from one room to another completely changes the context … When you move a performance, whether it be music or drama, outside, it becomes something completely different. When you move it into a hole in the ground, it becomes completely different. It's not the same piece of drama. It's about the context. The students here are incredibly confident in their ideas, and how they present their ideas because they're encouraged and given the tools to see outside the box. There's no confining space for what we do; the space changes, the skills are transferable. They can take them back to their arts individually, or they can be connected.

Furthermore, by creating groups of students from different disciplinary backgrounds, each student was able to take the lead for his/her discipline and supported others in the group who did not feel as confident. By the end of the unit, students were more confident in other disciplines. For example, Devon, a drama student, talks about the transformation in his journal from pages of writing at the beginning to changing the layout to reflect different artists' work.

> This project was really good because there were so many connections between art and drama, and music, of course. Sometimes when you're just doing drama, you feel that you need to do some art things in order to express all of your ideas. … So I think that here it's really good that we're able to mix it all together so that then we're able to get all ideas out and it doesn't matter which way. I'm a drama student, and if you see my work in the beginning of the year, I do writing, I do pages and pages of writing and that's all. But this is contrary to what I've done in previous years and now what I did with this exile happenings, I took time into looking at how the layout should reflect their art, and how it needs to be set up in different ways.

Another issue that arose was one within the students' own department. Students' definitions of their own disciplines were stretched throughout the unit. They needed to be encouraged to explore and delve into areas that were unknown. Given that a strong emphasis was placed on this process within the unit, students were supported in taking risks in their own disciplines and experimented with concepts that otherwise might be left outside of their field.

> The last two classes have challenged us and our challenge is to continue by challenging ourselves. What we want to accomplish with our performance requires us to reach into ourselves and stretch beyond what we think we can do. We want to show how we are not stuck in the box of simple, typical and ordinary.

Collaborative assessment

Finally, while interdisciplinary teaching can be done by a single teacher, most typically it is a collaborative effort. In terms of assessment the collaboration matters because it enables teachers to draw on their particular areas of expertise and their specific subject goals to assess student work. To move from a multidisciplinary assessment in which teachers only consider the perspective of their subject to an interdisciplinary one, teachers are encouraged to engage in collaborative assessments of student work. Analysing purposes, disciplinary grounding and thoughtfulness together based on several students' work entails an important professional development opportunity for teachers who begin to see how exactly their subject areas interact, overlap or complement one another. Clarity about such disciplinary connections also enriches assessment and instruction. To support collaborative assessment of interdisciplinary student work teachers are encouraged to consider the following assessment protocol.

A collaborative assessment protocol for interdisciplinary student work

In this protocol you will become acquainted with a student's work and gather general impressions; you will assess the piece(s) in terms of its interdisciplinary qualities; and reflect about the protocol itself. Once a person has briefly introduced the student's work avoiding evaluation (for example, grade, course) please allow the question to guide and focus your collective analysis of the work.

i. Getting acquainted with the work (10 minutes approx)

Describe:	What qualities of the work(s) call your attention? Please describe qualities of the work avoiding evaluative language.
Appreciate:	Overall, what are the qualities of the work that you appreciate?
Evidence:	What makes you say so?
Note concerns:	What questions or concerns does this work raise for you?
Evidence:	What triggers your concern?

ii. Assessing **purpose**: How clear, interdisciplinary, and aligned with the areas of interactions is the purpose of this work?

Describe	What is the purpose of the work under analysis? (for example, to explain a phenomenon, to create a product or work of art, to develop a programme, to change people's minds, to solve a problem)
Assess	Is the purpose of the work clear (whether explicit or implicit)? Does it speak to one or more areas of interaction? Does the purpose invite/require an interdisciplinary approach?
Guide	How can we support the student to gain clarity about her purpose and frame it in a way that invites her use and integrate the subjects taught in the areas of interaction (if applicable)?

iii. Assessing **disciplinary grounding**: Is the student drawing on the subjects' knowledge and modes of thinking accurately and appropriately?

Describe	Which main subjects or disciplines inform this work?
Assess	Consider one discipline at a time: How does this work reveal student understanding of the aims and objectives of each subject? Are the subjects' knowledge, skills, understandings, attitudes being used effectively given the overall purpose of the work?
Guide	What knowledge, skills, attitudes, understandings does the student need to work on (if applicable)?

iv. Assessing **integration**: How well integrated are the subjects in this work?

Describe	What are the key points of integration in the work, that is, where disciplinary perspectives are clearly brought together in a phrase, metaphor, interpretation, or explanation?
Assess	Does integrating perspectives help students advance their understanding (for example, can they produce richer descriptions, multi-causal explanations, novel interpretations, or deeper explorations that benefit from the combination of perspectives)?
Guide	How can we further support the student in her efforts to integrate available disciplinary insights to advance her understanding (if applicable)?

v. Assessing **thoughtfulness**: How reflective is the student about his learning and interdisciplinary work?

Describe	Does the work indicate that the student has reflected about his learning (for example, why the topic matters, how it can be addressed in interdisciplinary ways, the challenges of interdisciplinary work)?
Assess	Do the student's reflections about the process and outcome of the work reveal understanding of key aspects of doing interdisciplinary work?
Guide	How can we further support this student's appreciation of the opportunities and demands of interdisciplinary work (if applicable)?

vi. Revisiting **the protocol**: How did the conversation help us assess student work?

Revisit	In your opinion, how well did this protocol enable us to understand and assess student interdisciplinary work?
Adjust	What changes in the protocol do we need to make next?

Figure 16

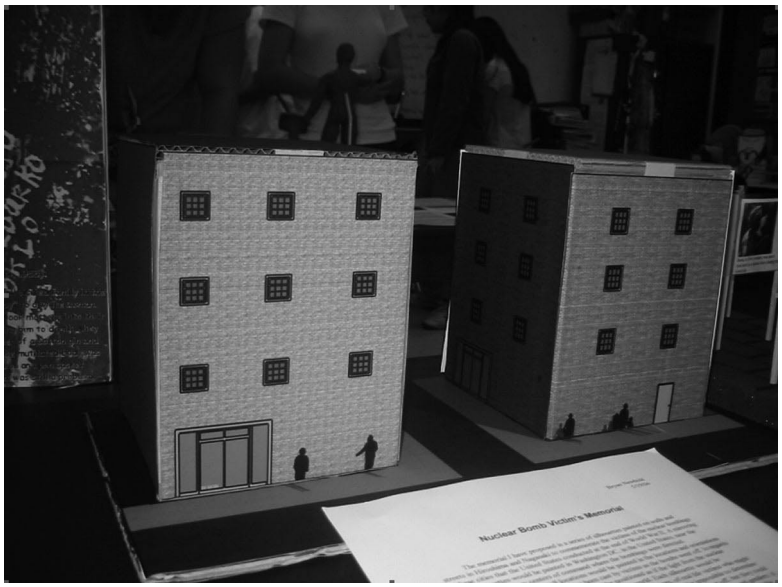
Assessment protocol

The purpose of this protocol is to enable a structured conversation or individual reflection about a particular piece (or pieces) of student work. The protocol is designed to structure a small group of teachers' conversation about a particular student's work in order to reveal its strength and growth opportunities. It provides a set of steps through which the group moves, guided by a facilitator. These steps include reminding the group of the questions to explore, looking at the evidence, describing the evidence, asking questions. Of course, adjustments to the protocol can be made to accommodate varying purposes as well as aspects such as time constraints. After becoming familiar with the protocol, groups may want to reflect on how the protocol might be more effective and then experiment with change. For teachers who are interested in practising with the protocol the case study at the end of this chapter includes a sample of an exemplary student's work.

Reflection point

Have you ever been involved in a collaborative assessment in the past? If so please reflect on: (a) the strengths of such collaborative assessment, (b) the difficulties or puzzles that arose in the course of the collaborative assessment and (c) the ways by which your team either resolved or tried to overcome these difficulties.

Case study



Excerpt from student work

Nuclear bomb victims' memorial

The memorial I have proposed is a series of silhouettes painted on walls and streets in Hiroshima and Nagasaki to commemorate the victims of the nuclear bombings in these cities that the United States conducted at the end of World War II. A mirroring set of silhouettes would be painted in Washington DC, in the United States, near the political and military centers of command where the bombings were directed.

The silhouettes in all locations would be painted in the locations and orientations where actual shadows would have been cast by victims as the bombs went off. In regards to Washington DC, the shadows would be positioned as if the light from the nuclear explosions had traveled all the way around the world. Each silhouette would be accompanied by a small plaque listing the name, or names, of real life victims who might have cast a shadow just like the painted silhouettes. It would be impossible to determine the exact locations and positions of real victims when the bombs went off, but they could be approximated, and real names matched with corresponding body types and genders. A central information kiosk with a map, further names, and basic information about the bombings in many languages would exist near by any grouping of silhouettes.

The intended audience of this memorial is two-fold. In one regards, it is a monument to the lives of victims, and is targeted at descendents and survivors of the blasts, to recognize the potential that was lost and the emotional gap that people have to live with. In another regard, the target is government leaders and policy makers, both of the past and the present. Past leaders would be haunted by the ghosts of the innocent civilians who died at their discretion, and present leaders would feel the pressure of lives lost in the past weigh upon the decisions they must make in the present.

This memorial does not take a side and say whether the bombings were a good or bad decision, a horrible mistake or a difficult step that had to be taken. Instead, it recognizes the huge loss of life that resulted, and stands as a reminder that victims are functioning members of society, not just numbers.

This exhibit is intended to be similar to one in Berlin, which has signposts describing Nazi laws persecuting Jews sprinkled through a neighborhood. The silhouettes would not directly intrude upon people's lives, cause inconvenience, or attract large numbers of tourists. However, they would stand as a constant reminder of the empty holes in our society by the use of nuclear weaponry, and the impact that military decisions made from across the globe can have on real human lives. The purpose is to integrate the memorial into people's lives, and to make the remembrance of victims an everyday part of life, as opposed to a once-in-a-while, optional visit to a remote or isolated monument.

Brian N., Boston Latin School

Interview with student (excerpts)

Let's start with the monument you did.

The [task's] goal was to make … a small model of a monument … memorializing or recognizing a person or group of people from the course in general. The way she teaches the course is, it goes from bystanders, upstanders, victims and perpetrators … you could either kind of villainize perpetrators in your monument or you could recognize upstanders or victims … or kind of get people to speak out on bystanders.

How did you come up with the idea of what you would do?

When we visited Berlin there was this one neighborhood where throughout the entire neighborhood there are signposts there's a little, kind of like a street sign but a big sign, and on one side is a symbol and on the other side is the wording of a Nazi law that would persecute Jews that was passed in the 1940's. So the way the monument worked really well … It was just part of the daily life and then it was explained to us that the whole purpose is … connecting the history. I really liked that and I wanted to kinda do that in my monument and that it would be there and people would see it and they could understand it but it wouldn't interfere with their lives … it would just be like a daily reminder, I guess. So, um, I thought of the shadows of the bombs. I didn't really like it at first. I thought it was kind of simplistic.

And you like it now?

Yeah, I like it now. I decided to have it in D.C. too … In Nagasaki and Hiroshima it's almost like a tombstone … there's a person here and they're not here anymore and it's something to be sad about and recognize and so they won't be forgotten. It's not like, "those damn Americans got us". It's just recognizing a tragedy …

I was thinking about the nuclear bombs and the power in this one blast that just kind of in one instant, like you know it's in a lot of movies there's it's just this light shockwave and people cast a shadow and then they just like vaporize and they're gone.

How did you come to think about the shadows?

If there's a bomb that goes off in Hiroshima it'll pass shadows in a certain way but then at the same time in Nagasaki it'll be shadows in a different direction … so each city will have the shadows from that individual explosion and I was thinking how you could spread it out all the way around the world … where there's a nuclear explosion and there's like the, um, shockwave around the world is kind of the image I like. And then we are almost the other side of the hemisphere so I was thinking, what's an exact opposite? I tried to visualize it. You could do something there.

The idea of having parallel shadows in D.C. definitely works. And then it doesn't have to just be Hiroshima and Nagasaki. Because D.C. and the Pentagon was where the orders went out to drop the bomb so that that was the best place. In D.C., the monument … it's like being haunted by these ghosts of people … and I could romantically imagine a lawmaker getting out of congress and walking down and seeing this and thinking, you know, "what's the impact of my decision?" like real people are not here, like you can't, I can't even hear their cries cause they're gone, like they've just been eliminated so much …

Did you specify the colors that you would use for the shadows?

Black, yeah, just like a regular shadow would be cast … and then there'd be a little plaque with … who the person was … If you know someone is … a mechanic you can put it on a gas station trying to connect the life lost with the reality that continues.

What kind of research went into creating this monument?

Most of what I learned came from … well, earlier in the year we went and saw *The Fog of War* which is about… [Robert] McNamara and that was a great film about … the decision to drop the bombs. So I've been kind of thinking about it since then, and there's been talk in Iraq about using tactical nuclear warheads.

In class this year we covered Hiroshima and Nagasaki towards the end. We went over first hand accounts of victims who were seared and had burns … and the effect of waking up after being knocked unconscious and seeing people walking around with horrible wounds. There's this one of a child in a classroom; they see there's a shockwave and the teacher goes over to the window to look out and then there's like this flash of light and she just saw like the shadow cast against the blackboard through the room and then the teacher dies and almost all the other students die. So that image was one I had been thinking about too.

[Our teacher] She's careful in class to not say like the bombings were bad or right … like we had a post and an online discussion … of the bombings whether it was the right decision or not. I kind of waffled on it and said that it was probably the right decision but it wasn't done in a correct manner.

What did you think?

Well … it's easy to look now and say all these people died but you wouldn't have known where the war would have gone. Obviously it was a horrible thing … but there was no easy way to just end the war that I could see. Maybe more diplomatic like a blockade or something … but with what we know today I couldn't see an easier way out. And I don't really buy into much of the "we were just trying to show the Soviets we had the technology" because there are easier ways to do that. We did the Manhattan Project; they knew. There's still victims, you know, but it's not much different than if we'd invaded and killed that many people. It was a true tragedy using a nuclear bomb. But firebombing Tokyo I think is almost an … equal tragedy. There's isn't as much public outcry over that; it's just like this fear of nuclear technology. But there is that one moment—that's kind of what I memorialized—there's just one blast and then people are gone, these holes in the society.

Did you think about this project as an artist?

I knew the significance of the event and how many people died, from reading the first person narratives and reports—but then you have to make a real monument in the real world. Um—when you have to try to memorialize it, it makes it very personal. You have this responsibility to these people … you can't just, like I'd feel bad just having a statue with a little plaque on it. Building the memorial definitely engaged me 'cause it makes like the history interactive. It's like you're taking part in it; it's like here's my contribution to history. Like, these people died and I did something about it instead of just knowing it and absorbing it for myself. I took part, you know; took action. I used art to make a point. Um, and that makes history much more, you know, alive.

It also brings it down to a personal scale when you realize, okay, you know, you can't have a hundred thousand shadows in the city you can only have a hundred … it's a concrete and practical problem that you face as an artist—how do I work with this scale? But then you wonder … Wait: there's that many *people*? Like you could walk around the entire city and cover every building with shadows and it still wouldn't be enough. It really brings home the scale of it. You realize how much of a tragedy it was.

Do you think that creating the monument changed your understanding of the event?

I had the history pretty well and this really captured the personal aspect of it for me. And this gave me a connection with it. In history you normally can't add anything you know, it's all said and done, like you can't go to the revolutionary war and grab a rifle or something … but this made it possible for me to have a personal connection. The process of making it and coming up with the ideas and rendering it and stuff that's something that if in the future I think back, you know, what does Hiroshima and Nagasaki mean to me, well here's this thing … I did that's … I have like physical memory of working on it that will make me remember more than just scribbling out some notes or taking a test.

So what exactly did creating the monument mean for you?

I had to visualize in my mind exactly what it was like at that moment and what those people were doing at that very moment. Especially because it's one single instant ... that it all takes place in. Like the monument just kinda captured that moment for me. … the moment the whole earth stood still. People make a big deal about the revolutionary war and the shot heard round the world; this is really the explosions heard round the world. Everybody knew about them and it, you know, this whole nuclear era kicked off. This was an incredibly important moment. And it really captured for me the intellectual view of it, but then I captured a bit of what it was actually like for these people on the ground. They were there, they died, were they mutilated, or they got cancer, or their families did … So it brought together that. And then obviously in the monument I am at the same time trying to represent people's reactions and my own.

Chapter 10 The personal project: Supporting student interdisciplinary research

Overview

The personal project is a significant body of work that students produce over an extended period of time. It is a product of the student's own initiative and should reflect his/her experience of the MYP. The personal project holds a very important place in the programme. It provides an excellent opportunity for students to produce a truly creative piece of work of their choice and to demonstrate the skills they have developed in approaches to learning. Because the personal project builds on a strong MYP learning foundation it is completed during year 5 of the student's participation in the programme. The IB places great importance on the expression of the student's personality and understanding as measured by means of the personal project. The personal project is a requirement for all MYP schools, whether or not they request grades validated by the IB.

The areas of interaction are central to the experience of the personal project. Intended to be the culmination of the student's involvement with the five areas of interaction the personal project allows students to investigate and focus on a theme of their choice and report on their investigation.

This chapter focuses on interdisciplinary personal projects—projects that integrate the perspectives of two or more disciplines, subjects or areas of expertise. The following questions are asked.

- What constitutes a high quality interdisciplinary personal project?
- How should interdisciplinary personal projects be assessed?

What constitutes a high quality interdisciplinary personal project?

To support students' interdisciplinary personal projects we must understand the opportunities and challenges that such projects present for meaningful and rigorous independent learning. In this section we begin with two exemplary cases of student work and illustrate the ways in which they represent quality interdisciplinary learning.

The two examples of outstanding projects that follow illustrate the level of personal and intellectual engagement and higher order thinking that personal projects may aspire to embody.

17th-century Realism through the eyes of a camera obscura

Sascha is intrigued by the ways in which new technologies have influenced the work of artists over time. For her personal project she examined how 17th-century painter Johannes Vermeer created his masterpieces using elements of optics. In her research into the painter, Sascha concluded that to understand the development of Realism as the dominant style at the time, she would have to create a camera obscura, "a portable box that incorporated lenses and mirrors, so that real-life images were reflected onto a viewing surface that was visible outside the box where it could be traced or painted". Contemporary optical tools are commercially available today but Sascha refused to use these. She opted to use the materials and technologies available to 17th-century artists. Sascha's goal was to reproduce the conditions under which Vermeer created pieces like "The Milkmaid" to judge the contribution of optics to the development of 17th-century Realist art. Sascha's paper brought together learning in science, visual art and technology, addressing fundamental questions about human ingenuity.

Giving a lift to the Bunyandiko and Buwatha villages

As a young child, Carly spent some time with her family in the villages of Bunyandiko and Buwatha, Uganda. Her personal project gave Carly an opportunity to reconnect with the women in the villages that she held dear and support their development through a small sustainable social entrepreneurship initiative. Carly gathered information about the women's lifestyles as well as economic and health needs. She created a scheme to donate donkeys to several households in the village. Women benefited from this initiative doubly: first the donkeys produced milk that could be sold. Secondly the donkeys helped the women to carry heavy market loads and water barrels. In so doing women would no longer carry this weight on their heads—a practice that impacts their hip bones and heightens risks at childbirth. Her personal project involved raising funds, purchasing two donkeys, creating a system by which the donkey's offspring was passed to another family to benefit multiple families, and previewing the need for a veterinarian to ensure the health of the donkeys over time. To advance this powerful community service initiative, Carly needed to understand how to survey and interpret villagers' needs, advance a financially viable scheme, and communicate through verbal and non-verbal means.

In what ways do these personal projects illustrate quality interdisciplinary research at the middle school level? The examples above represent exemplary cases of personal projects. In these projects students delve into their topics of choice with passion, intellectual rigour, exemplary work habits and professional teacher support. Key characteristics of quality personal projects are outlined below.

Reflection point

Consider a few examples of successful personal projects in your school. What made them work? List seven qualities that you associate with successful personal projects. If possible, collect a similar list from experienced students.

Further ways in which personal projects support interdisciplinary learning

Personal projects may take many forms

As the examples above suggest, interdisciplinary personal projects may vary greatly in goals, genre and execution. Sascha's project illustrates an art history research project where science and technology inform students' understanding of past artwork. Carly's embodies the development of a social entrepreneurship initiative informed by the data-gathering tools of social scientists and the executive plans of business.

Like their disciplinary counterparts, interdisciplinary personal projects can vary. Across MYP schools students may be working on:

- original works of art (visual, dramatic, or performance-based depicting a topic typically studied in biology, history, physical education or mathematics)
- written pieces of work on a special topic such as Sascha's analysis of Vermeer's work
- pieces of literary fiction (creative writing informed by insights in history, psychology, geography or environmental sciences)
- original science experiments (combining biology and technology to test the impact of humans on local environments)

- inventions or a specially designed object or system (such as a public campaign against anorexia where graphic design conveys accurate medical information)
- presentations of a developed business, management, or organizational plan (that is, for an entrepreneurial business or project), a special event, or the development of a new student or community organization.

Personal projects engage the areas of interaction

The areas of interaction embody the aspirations of the MYP and should be the foundation of personal projects. Quality personal projects are designed to nurture students' capacity for lifelong learning (approaches to learning), to instill an appreciation for human ingenuity over the centuries; to invite them to care for their well-being and that of others around them (health and social education), to render students able contributors to local and global communities (community and service) and to become informed environmental stewards (environments). The personal project provides a unique opportunity to nurture these capacities among students, building on a topic that they feel close to their hearts.

In our examples, Sascha's goal is to understand the conditions that enabled Vermeer to paint as he did, to capture the ingenuity with which he embraced a new style. Her focus on the process by which humans advance new ideas or products places Sascha's project in the context of human ingenuity. Carly's personal project, on the other hand, offers a formidable example of learning in community and service. Drawing on her own experience, she is aware of community needs and is ready to participate in an informed and responsible way.

While embodying the learning opportunities of human ingenuity and community and service, these two projects are especially geared to helping students understand multiple "approaches to learning". All personal projects invite students to ask question such as:

- how do I learn best?
- how can I guide myself to learn?
- how do I know?
- how do I communicate my understanding?

As a result, approaches to learning plays a key role in all personal projects. Personal projects embody a significant body of independent inquiry on the part of the students. Successful projects capitalize on the competencies for learning that students have built in MYP years 1–4. They provide students with an opportunity to revisit and deepen such competencies in their last year of MYP studies. Sascha' s rigorous reconstruction of the camera obscura with original tools and materials and subsequent analysis of Vermeer's work gave her an opportunity to revisit principles of design, concepts and experiments in optics, and perspective-taking in history. Carly's project represents and illustrates action-driven learning. In all cases students are invited to practise the skills that will enable them to become successful learners—effective study skills; critical, coherent and independent thought; and the capacity for solving problems and making decisions.

Interdisciplinary personal projects invite students to reflect about the very nature and challenges of interdisciplinary learning. Students must think about the kinds of expertise that best advance their goals, how to identify reliable sources in multiple disciplines, how to integrate their perspectives to create a product or solve a problem, how to evaluate the success of their interdisciplinary inquiries.

Connections
To understand how personal projects can focus through the areas of interaction see the MYP *Personal project guide*. For each area of interaction, the guide offers key questions as well as examples of possible topics for study. Most topics can be productively examined in interdisciplinary ways.

Personal projects build and demonstrate interdisciplinary understanding

Interdisciplinary personal projects place great emphasis on the process of learning while also attending to its results. Quality personal projects invite students to engage in a reflective process of learning. Students begin with early beliefs about their chosen topics. New findings, theories, connections or tools enable them to revise or enrich such initial views. Students' steps in building understanding are captured in research logs, project-related informal questions, analytical memos, pilot schemes, draft object designs. Making their understanding visible enables students to receive informative feedback from teachers, experts and peers and in turn deepen their understanding. Through such an iterative process, building and demonstrating understanding take place at once.

Through an iterative process of making understanding visible, receiving new input and revising understanding, quality interdisciplinary personal projects seek to move beyond uninformed opinion or commonsensical claims. Students' inquiry approaches and their resulting insights must be informed by the subject matters offered in school or by domains that are typically not addressed in school but that students have a good chance to understand. Examples of school subjects include: biology, physics, visual arts or history. Examples of extra-curricular disciplines or areas of expertise may include computer programming, sailing, photography or interior design. Whether students borrow from school-based subjects or from outside experts, their work needs to demonstrate more than their initial opinions on the topic.

Personal projects address multifaceted topics in a purposeful way

Choosing and defining a problem for interdisciplinary research is challenging for students. Quality interdisciplinary projects focus on problems or topics that clearly call for more than one source of expertise. The following features can be seen in exemplary projects:

Topics are personally relevant to students. They invite students to reflect about the issues that matter to them the most and about which they are curious. Projects may be inspired by family histories, personal identity, the places where students live, people or contributions they admire, problems they seek to solve, products they seek to develop.

Research questions or project goals set a clear purpose for the work. By doing this, students can maintain focus throughout their inquiry. Purposes vary from raising awareness in the school about cosmetic testing to explaining the differences between creationism and evolution.

Topics are multifaceted calling for different disciplinary perspectives. Students can map the topic to identify its parts or central dimensions. They can then identify the kinds of expertise that they will need to meet their goals.

Research questions are focused through an area of interaction. A visible and meaningful connection is made through learning how to learn, becoming a better steward of the environment, participating in the community through service, understanding and protecting health, or understanding human ingenuity.

Research goals are viable. Students propose to carry out a scope of work that is appropriate for their age and context and for which they have adequate resources (reading materials, expert mentors, interviewees) available within their school, family and community networks.

Sascha and Carly illustrate purposeful approaches to multifaceted topics. Sascha frames her topic and inquiry purpose with great precision.

> My goal in this project is to build a camera obscura box in order to personally judge the efficiency of optics during the 17th century, thus gaining a better understanding of 17th-century Realism.

Her project clearly calls for an interdisciplinary approach. It involves creating a device (using knowledge of technology and science) to understand how the nature of art (in the visual arts) was transformed into a new form called Realism (history of art). Materials and mentors are available to her at school.

Sascha explains.

> Throughout my project, my main focus was to develop opportunities for me to appreciate the capacity of artists during the 17th century to invent, create, transform, enjoy and improve the quality of artistic instruments during their time. This was focussed by human ingenuity as it encouraged me to see the relationships between science, aesthetics and technology. In other words, I looked at the technological and scientific aspects (optics and reflection) of a period in time and used them to gain a better understanding of art from that period.

Carly's topic is also multidimensional, relevant and feasible. She seeks literally to provide a physical lift for the women in their daily carrying of heavy loads, and figuratively to lift the women out of their current poverty. The issue is relevant to the villages of Bundyandiko and Buwatha. The project is feasible in that Carly's father has initiated a similar and successful project in a neighbouring community, albeit with goats. She had seen her father work and he was ready to help her as well. The project demanded integrating multiple forms of expertise: understanding the culture and economic structure of the villages; how to create a sustainable budget; how to structure and run a fundraising campaign and communicate accomplishments.

Carly explains.

> My goal is to support and develop an existing women's group by creating a small microfinance program to help a women's group in the village be able to generate their own money … This being my final year in Uganda, I wanted to leave something behind. My first year in Uganda was spent in Kasese, near the foothills of the Rwenzori Mountains, this is where the villages of my project are. Since I lived in that community, attended a local school, I wanted to give something back, I wanted to help them … Because I feel so close to this town, encourages me to carry on with this project a lot. Simply talking to the women, and seeing in what positions they are in, and how much help they truly need, inspired me a lot. It really made me want to make a difference, and even obligated to. The fact that this project will not have an ending, will only continue to grow and will help families, even after my personal project is finished, motivates me the most.

Another student developing a campaign against animal testing in her school explained.

> I was inspired to carry out this project when I was exposed to commercials on cosmetic animal testing by the PETA organization. Their commercials were very persuasive and included devastating photography which really touched my heart. As I researched more, I became aware of many new perspectives. I discovered that I had been contributing to the cruelty by buying cosmetics from companies that do tests on animals. This boosted my interest and determination because I realized that there are so many people out there who were ignorant, just like me. So then I saw this project as a mission to save the animals. I chose cosmetic animal testing because we relate to this in our everyday life. We all use cosmetics, whether it is lipstick or hairspray. But is it really necessary? Is looking beautiful worth the millions of animals killed?

Personal projects are well grounded in subject matter knowledge and modes of thinking

To be interdisciplinary a personal project must draw on two or more areas of expertise. In some cases such areas represent school subjects. In others they are embodied in the professional work of lawyers, community organizers, businesspeople, or designers outside school. To conduct quality work students must identify relevant forms of expertise in general and specific terms. With the help of their teachers students must identify which disciplines will be most helpful and in each case which sources, concepts, tools or methods they may want to employ.

Sascha's project demonstrates understanding of art, history and technology. For example, she explains that the subject of 17th-century paintings were usually outdoor scenes, objects close to a strong light source often depicted in misleading proportions. Close analysis of particular works of art illustrates her explanation of the emergence of Realism. She also demonstrates her capacity for historical reasoning as she sifts through primary sources to determine the exact materials used to create the camera obscura. She sought to "verify that all my findings were accurate, thus guaranteeing that my camera would closely resemble one from the 17th century". Finally she advances her understandings of science and technology not only in her choice of materials to construct the camera obscura but also in her capacity to determine how the focal length of lenses affected the size of the box.

Carly also drew on multiple disciplines or areas of expertise. She employed focus group interviews and observation techniques borrowed from the social sciences to discover that the women were usually carrying loads to the market and back and were responsible for lugging heavy water containers from the wells to their homes for household use. She learned that these women were suffering physically from carrying the loads as the weight forced their pelvic bones closer together, consequently narrowing the birth canal and causing difficult pregnancies. She heard their concern over the education of their children. Carly borrowed from microeconomics to work out a budget, determine the costs of a donkey as well as the salaries for those running the project. She learned how to present a budget to prospective donors. She attended to the sustainability of her scheme by ensuring that the donkeys bred and that offspring were distributed among villagers. She also planned for each household with a donkey to contribute 10% of their earnings from the donkey's milk towards the provision of children's healthcare and education.

One student developing a school campaign against animal testing explained her process in detail—especially interesting is the healthy skepticism with which she approaches multiple sources of information.

> I did lots of research using a variety of different sources. I thought of what information I need which would suit my goal. I decided to gather information on: (1) cosmetic testing statistics to prove the extremity of the issue, (2) specific alternatives to animal testing, which will back up my arguments and stress the fact that there is no reason for cosmetic animal testing to continue, (3) the testing procedures to expose how cruel and disgusting it is, (4) contacts of animal rights organizations for direct information or raw material like video footages because such footage speaks louder than words, (5) information for getting active … to inform my audience about how they can actually solve the issue … and (6) I need information to prove that products not tested in animals are safe … As a part of my research, I also interviewed a Science teacher … because I wanted to find out how I can prove that products not tested on animals are scientifically reliable.

Personal projects integrate disciplinary perspectives

Projects clearly integrate information and perspectives into a complex explanation, a new artistic interpretation, a conceptual model, a fictional narrative, a project. The integration of perspectives yields a better, deeper, more comprehensive understanding of the topic under study. In quality projects the initially stated purpose of the work guides students in their efforts to integrate.

For example, in Sascha's account an understanding of optics in the camera obscura informed a deeper explanation of the visible features of Realism. Sascha learned that the camera only portrayed images in very strong light, and that objects had to be focused individually when tracing them: "I have become aware of the 'defects' and imperfection of optics used during this period of time". The technical limitations of the camera obscura led her to understand how salient features of Realism—the daylight and indoor scenes with strong light sources, the varied proportions of the objects portrayed—were the result of the limitations of the optic devices used. According to Sascha, "its use led to the depiction of distorted or unfocused images. It also limited painting to daylight scenes and indoor scenes with strong light sources. In addition, objects in dim light were often erroneous and misleading due to their focus or proportion in comparison to other objects in the same painting". The project enabled her to "find evidence of these defects (arising from the use of optics) in Realist paintings from the 17th century".

Carly, too, integrated multiple forms of expertise in her project, yielding a more effective intervention. Collected data from women's focus groups (a technique often used in the social sciences) helped set the priorities for her project and determine the desirable level of funding. Her fundraising campaign and fundraising strategies in turn yielded a social intervention that can only be assessed by gathering information from women again. Intertwining social science and business enabled Carly to have greater impact.

Personal projects invite reflection and meta-cognition

Projects invite students to reflect about their own learning in multiple ways: Firstly, projects invite them to reflect about the sources of expertise informing their work (qualities, contributions, trust). Secondly, they invite students to reflect about disciplinary similarities and differences, and the challenge of combining different perspectives. Third, they may address the contributions as well as the limitations and possible next steps of their work.

Sascha's paper displays a constant willingness to reflect on her assumptions, findings and conclusions. She explains.

> Consulting 'experts' seriously influenced my practical work in a positive way. This is because they helped me make decisions regarding things that I was very unfamiliar with in such a way that I learned and understood the information they had to offer me.

Her physics teacher, a carpenter and a design technology specialist offered advice on the building of the camera obscura. Conflicting primary sources about the camera yielded an understanding of how to weight the trustworthiness of sources at times when information is broadly available.

Working on the project revealed unanticipated insights. She explains.

> What started off as a problem (when the lenses on her camera could not focus properly) turned into an investigation of a valuable aspect of 17th-century optics: the limitation of 17th-century optical devices to portray only daylight scenes and images … However there were times when factors beyond my control influenced my project in a negative way … Materials and information availability sometimes limited me on the production stage … Nonetheless, this taught me to be improvisatory in finding solutions, and to look at more sources of information when one source was limited. If I were to repeat my project, I would research and consult modern-day artists who incorporate optics in their work. By doing this I could compare modern-day optics to those of the 17th century, thus gaining a better understanding of the progression undertaken throughout the Realist movement and the exact importance of the camera obscura for modern society.

Carly also exhibited thoughtfulness. She pondered about the ambitious nature of her project, a common challenge of interdisciplinary research.

> I was scared at the beginning of this project that it wouldn't work out, that I was thinking too high for this project, and I was afraid I would disappoint the women. That is why I spent so much time researching, to make sure that everything I have would be foolproof.

She examined the relative advantage of multiple courses of action. For example, when considering making a poster to raise awareness about the situation of women, she concluded: "I found it did not enhance my project, or add anything new, which wasn't already in it."

Other students' comments illustrate the thoughtfulness here outlined.

Connections
Information about how the school can optimally organize the personal project experience for students can be found in the MYP *Personal project guide*.

Advice on interdisciplinary inquiry

Even when age-appropriate, interdisciplinary inquiry is challenging for students. Students cannot be expected to produce high quality work without guidance and support. The features of a quality interdisciplinary project outlined above set the foundation for student support. Building on such features, personal project supervisors are encouraged to:

- explore with students the multiple forms that their project might take (for example, written paper, a product, a work of art). In doing so supervisors will bear in mind that the genre in which a project is produced will greatly inform the type of disciplinary expertise needed to complete the project successfully. For example, a work of art will necessarily prioritize expertise in the arts. A literary work will demand high performance in languages.
- ensure that student projects clearly reflect the educational intention of an area of interaction. All projects will enable students to apply approaches to learning skills, but they will vary in the areas they embrace.
- discuss the inquiry process and expected standards of any interdisciplinary understanding with students. Explain, for example, how the iterative process of sharing work in progress, receiving feedback and revising can support and deepen students' understanding of their chosen topic over time.
- discuss students' chosen topic attending to the degree to which the topic is personally relevant to students, related to an area of interaction, multifaceted and perhaps inviting of an interdisciplinary approach, and viable. Supervisors may recommend a conceptual mapping of the topic along these criteria, and through this discussion they can help students clarify their specific purpose or goals.
- guide students in the task of identifying the potential disciplinary forms of expertise necessary for a successful completion of the personal project and offer feedback and suggestions about expert sources to consult or possible informants to contact. Supervisors may invite students to map the key dimensions of the topic and brainstorm the kinds of experts that will be necessary to include for each part of the problem. When necessary, consult with colleagues on the selection of particular insights, big ideas, techniques and approaches in the relevant disciplines to ensure that students' understanding is rigorous in developmentally appropriate ways. Supervisors may also arrange a consultation meeting with the school's theory of knowledge teachers to inquire about what particular disciplines may contribute.
- support students in their effort to integrate disciplines or subjects. Supervisors may explore with students how each chosen discipline contributes to an understanding of the whole, how some disciplines are limited in themselves to help students understand the problem they study and can be complemented by other disciplines. For example, supervisors may inquire what would happen to the project if we took away a given discipline—for example, history or the arts?
- ensure that the project is reflective and metacognitive. Supervisors may listen carefully as students talk about their learning process, the achievements and limitations of their work, and the work habits with which they organize their production. Supervisors may comment on a student's research plan and progress toward achieving stated goals. They may invite students to assess their own work for its merits and possible improvements, and comment on the unique challenges of interdisciplinary research.

How should interdisciplinary personal projects be assessed?

Like other forms of student interdisciplinary work the personal project should be assessed along four fundamental principles: clarity of purpose, disciplinary grounding, integration and reflective strength. These principles inform the application of a series of concrete criteria embodied in the personal project's aims, objectives and assessment criteria that can be found in the *Personal project guide* on the online curriculum centre (OCC).

Examples of development of interdisciplinary personal projects

Required structure	Essay	Mural	Fundraising
Title page	Poverty in my City: How Can it Be Explained?	Creating a Mural about Poverty in my City	Fighting Poverty in my City
Table of contents	Titles of sections and sub-sections of the project	Titles of sections and sub-sections of the project	Titles of sections and sub-sections of the project
Introduction • What is the area of interaction through which you are focusing the topic? • What do you want to find out about the topic, and why does it matter to you? • How are you conducting the investigation of the topic?	Area of interaction: health and social education Goal: understanding the causes and effects of poverty in my city Outline: general review of poverty through local statistics; main aspects of poverty and its causes or consequences in terms of health, education and local environment	Area of interaction: community and service Goal: sensitization of people in my school to the conditions of poverty in my city Outline: general review of poverty in my city; consideration of ways of conveying a feeling and a message; drawing my way of perceiving it; seeking feedback from others; completion of the mural	Area of interaction: human ingenuity Goal: finding ways in which different groups of people can take action to fight poverty in my city Outline: general review of poverty in my city; finding out about people and organizations fighting poverty; evaluating ways of contributing; deciding on processes and procedures, beneficiaries; organizing the fund drive
Description of the process and analysis 1. Gathering from expertise and different sources • Who do you need to talk to? • What kind of expertise is necessary? • How would you go about gathering this expertise?	Research through reading various documents, statistics; interviewing of social workers, sociologist, psychologist, poor people in different parts of the city, police; analysis of data and information	Investigation of different sources (about art and the topic at hand); choice of aspects of poverty to be reflected in the mural; choice of techniques, sketches; feedback on stages of completion and final product	Investigation into poverty in the city and organizations that already work with poor people; interviewing and gathering data about needs and possible action; choice of strategy to organize and publicize the fund drive; organizing and completing the activity; follow-up with beneficiaries

Required structure	Essay	Mural	Fundraising
2. Putting expertise together • How does learning from different sources help you advance your project? • What would you do to put it all together?	Showing the contrast between what different sources say about the main causes and consequences of poverty in the city; analysis of how the consequences of poverty affect health and education of the poor people of the city; analysis of how poverty affects the environment where people live (may be related to housing, pollution and other factors); review of the process in terms of difficulties encountered and ways in which the student solved them	Showing how the symbols of poverty are used and explaining how to produce the impact you want to create in the community; justifying the use of different techniques and colours in the mural; showing the contrast between own interpretation of symbols, techniques and colours used, with the feedback received by others; evaluating the changes introduced into the mural; analysis of the characteristics of the audience; analysis of the best location for the mural to create the greatest social awareness	Short analytical description of the different ways in which institutions are working to raise money to fight poverty and how their actions have made a difference; analysis of the way in which the fundraising will be carried out to make it appealing and effective; review of the process in terms of difficulties encountered and how these were overcome
Conclusions and reflections	Identification of the main causes and consequences of poverty in the city that affect health, education and environment, according to the findings of the research. A new approach to the question could be to consider how changes in the surrounding environment improve the quality of life of poor people	Evaluation of whether the mural has been able to reflect the environmental problems linked to poverty in the city; reflecting on the impact the mural has had on the community; reflecting on the impact the mural has had on the student's own perception; formulating a new question that could arise in the mind of the student: is a mural a good way to sensitize people about a specific problem? or what other means could have been used?	Reflection on human ingenuity through the impact that this type of activity may have on the ones who benefit from fundraising; assessment of the impact of the project on people who benefited from the fundraising; review of the outcome (money raised versus expectations), involvement of others, responses; indication of other ways to help to fight poverty in terms of community and service; overall perspective on how the project changed the student
Bibliography	Books, newspapers, magazines, interviews, internet sites	Books, newspapers, magazines, interviews, internet sites	Books, newspapers, magazines, interviews, internet sites
Appendices, where appropriate	Statistics, graphics, histograms, questionnaire used for interviews, other material	Pictures, photos, list of artists, art movements that inspired the student	Questionnaire used for the interviews, and supporting statistics

Framework for planning a personal project

The table below can be used when planning a personal project.

Area of Interaction		

What is my topic? Why do I want to investigate it?

What are the main parts of the problem/project that I need to understand?

1.	2.	3.

What sources or individuals will help me gather the expertise I need?

Sources	Questions

What are the important ideas, concepts and skills that I'm expecting to learn *OR* what have I learnt after completing this research?

1.	2.	3.

How do these ideas, concepts and skills help me address my topic?

Have I gained the expertise I need to complete the project? Who else or what other resources might I consult?

What are the main components of my research project that I need to develop and for which I can get feedback?

1.	2.	3.

What have I learnt and how does it help me advance my question?

Figure 17

Chapter 11 Professional development and teacher support

Overview

Throughout this guide, we have paid particular attention to student learning. We have addressed the challenges and opportunities interdisciplinary work presents for students, and how learning can be supported and assessed. Yet interdisciplinary teaching also involves important opportunities for teachers' learning. A mathematics teacher meets with arts colleagues with excitement about the possibility of a fractal art project. Geography teachers collaborate with biology teachers on a unit on the impact of water scarcity on global health. A language A teacher consults with the technology teacher as he or she supports a student's personal project on an e-advertisement campaign. In all these cases teachers are learning from and teaching one another, expanding both their expertise and their professional relationships. How do teachers learn to teach in interdisciplinary ways: what barriers do they find and what kinds of supports will they benefit from?

How do teachers learn to teach in interdisciplinary ways?

Points of departure

Learning to teach in interdisciplinary ways can be an exciting and challenging task. The excitement is clear: Interdisciplinary teaching invites new collaborations with colleagues and friends in a school; it allows teachers to tackle topics that they deem important, even if slightly outside of the areas of expertise. It enables teachers to engage their students' multiple talents in projects that matter to them; it enables teachers to learn about topics that are intrinsically interesting to them.

In a sense, learning to teach in interdisciplinary ways is similar to other forms of professional development. Learning works best when teachers have an opportunity to experiment in their practice, considering a few elements of a new framework, putting them to use in their designs, and reflecting about the results they obtained and how their practice could be further developed. Teachers may find multiple points of departure and preferred structures on their way to becoming better interdisciplinary teachers.

Small expansion

Teachers revisit a disciplinary unit that they teach and consider a small-scale expansion. For example, a biology teacher attends art classes to see how lessons in three-dimensional drawing in the arts can help biology students become better observers of nature.

Course thread

Some teachers prefer to incorporate a question that is posed throughout their course—a question that invites meaningful connections beyond their discipline. For instance, in a course on modern history a teacher may add "how does art reflect the changes in lifestyles and ideas at different periods in time?" Addressing this question will require learning to analyse a painting and understanding markers of artistic style, placing them in historical context.

Improving a successful unit

Often, teachers choose to begin with a close analysis of an interdisciplinary unit that they teach well. They feel comfortable formalizing the elements of the framework of a unit for which they feel well prepared. These teachers find a framework productive in improving particular dimensions of their unit.

Exploring a topic of deep personal interest

Occasionally teachers view creating interdisciplinary designs as an opportunity to teach about topics that matter both to them and to students. Feeling familiar with the topic, they begin with small-scale experimental units allowing multiple opportunities for reflection.

Many other points of departure exist, such as collaborating with a particular colleague or following student interests. What matters in all cases is that teachers build on their strengths. Teachers who are beginning to work across areas are not encouraged to embark on learning many new subjects at the same time. Rather, they must build on the areas in which they have a strong foundation and ensure that they have sufficient understanding (or peer support) in a neighbouring discipline's insight to incorporate it in class. Of course, this does not mean that a degree in multiple disciplines is needed. But a solid understanding of the particular concepts, techniques or modes of thinking of neighbouring disciplines matters a great deal.

As in most effective professional development processes, teachers improve their interdisciplinary teaching capacity by engaging in a cyclical process that includes:

- becoming familiar with new concepts (for example, analysis of components of the framework presented here)
- applying concepts to practice (for example, MYP in curriculum planning and teaching)
- reflecting (through close analysis of student work or discussions with peers)
- adjusting designs as well as their interpretation of what concepts mean.

Teacher meetings and regular curriculum development structures in the school can be used to advance teacher mastery in this way.

How teachers change their minds

Learning involves changing our minds. When teachers engage in productive efforts to deepen their ability to teach in interdisciplinary ways, they expand their understanding of their own teaching, their subjects, and the possibilities and limitations of interdisciplinary education. A few conceptual changes that can be observed are described below.

- From interdisciplinary teaching as a form of motivation, to interdisciplinary teaching geared to deep and broad understanding.
- From interdisciplinary teaching as a goal in itself, to interdisciplinary teaching as a means to deepen and broaden understanding.
- From disciplines as information fixed in textbooks, to disciplines as dynamic perspectives onto the world.
- From interdisciplinary teaching as teaching "themes" with or without genuine connections across disciplines, to close attention to meaningful connections that yield deeper understanding.
- From thinking that all disciplines must be involved to produce a good unit in the school, to understanding that topic and purpose drive disciplinary selection.
- From striving for equal time assigned to each discipline in a unit design, to allowing the purpose of the work to dictate the relative dominance of one or another discipline in the design.
- From emphasizing activities that may or may not promote deep understanding, to designing performances of understanding that do.
- From integrating disciplines at the end of a unit, to supporting students' synthesis throughout a unit.
- From leaving assessment for the end of a unit, to ongoing assessment attending to students' views of the purpose of their work, understanding of disciplinary insights and integrative understanding.
- From viewing collaborations as an opportunity to exchange readings, to viewing them also as a chance to teach each other how to think in a different discipline.

Reflection point

Revisit the ways in which teachers are likely to change their minds when embarking on professional development and design groups focused on interdisciplinary teaching in their schools. Which shifts make most sense to you or describe a change of mind that you can see yourself making or having made in the recent past? Which ones make less sense to you? If possible, discuss these with two or three colleagues in your school.

Barriers to interdisciplinary teaching

Teaching in interdisciplinary ways can also meet important obstacles. Interdisciplinary teaching is demanding in intellectual, social and institutional ways. Recognizing potential barriers will enable teachers and administrators to prepare solutions and supports that are productive for all.

Intellectual demands

Interdisciplinary teaching confronts teachers with the limits of their expertise. It also shows them the limitations of their own disciplines to address the topics that they seek to teach. Often, teachers find themselves having to learn selective content in another domain or depending on their colleagues for the success of their work. This too may present difficulties to teachers used to working in their subject and who are in full control of the content they teach. Learning to navigate foreign subjects is a challenging task. For example, a science teacher may ask: What are the big ideas in geography? How do I know which ones will help my students best?

For many teachers, interdisciplinary instruction appears as a threat to the integrity of teaching in their own discipline. A careful weighing up of the pros and cons of interdisciplinary designs is in order, one that helps teachers view the comparative advantage of each approach.

Occasionally, teachers engage in an effort to map the school curriculum in order to find points in which their teaching might connect across disciplines but find difficulties in identifying genuine connections across subjects. In some cases, what seemed like logical connections while discussing possibilities prove difficult to translate into quality teaching practice. In all cases close attention to what is being taught and why is important, as is a careful consideration of the viability of emerging ideas.

The intellectual demands of interdisciplinary teaching suggest that teachers need space, support and a trusting environment to experiment. A collaborative climate in which teachers can resort to the human resources in the school for guidance will enable teachers to consult with librarians, and peers such as the Diploma Programme's theory of knowledge teachers if available. At the same time, a climate of informed experimentation in the school will encourage teachers to try new units and small-scale, safe innovations.

Social demands

Teaching across subjects often invites collaboration. Collaborative work is engaging for teachers in schools. Sometimes, however, teachers must overcome the hurdles of interpersonal dynamics. Collaborators may not agree on the preferred purpose of the work; they may feel the need to have their disciplines more fully represented in a unit design. Collaborators may agree on substance but have different and incompatible working styles, making working together more difficult than expected. A careful consideration of the purpose, realistic expectations and preferred approach to collaboration is necessary as a faculty. Collaborations sometimes require coordination across school areas or departments. Occasionally, teachers working across departments must bridge not only content but values, educational priorities and working styles.

Working across disciplinary or subject lines demands a very special kind of perspective-taking capacity. It demands that teachers pay attention to the ways in which their colleagues think about knowing, teaching and learning. What questions matter to them? What types of problems or issues do they prefer? What approaches do they prioritize? Quite interestingly, interdisciplinary collaborations among teachers seem more mature when teachers do not only share readings that they identify for each other, but when they stand ready to teach and learn from each other about issues such as how to perform a close reading of a literary text, use statistical correlations, or interpret historical sources well. Collaborating in this way requires that teachers practise curiosity, humility, tolerance for ambiguity, and generosity of mind. These intellectual dispositions are therefore modelled for students in class.

Institutional demands

The first institutional barrier that teachers mention is, predictably, lack of time. Teachers need time to coordinate collaborations, plan a curriculum, learn new content and reflect on practice. Interdisciplinary teaching takes time.

In many cases teachers work in coordinated or linked courses or they co-teach particular units for a given class. The coordination of teachers' instruction may prove logistically challenging and financially burdensome for the school; careful and strategic planning is required.

Most interestingly, it is sometimes the students and parents themselves who resist interdisciplinary instruction. Because interdisciplinary units sometimes challenge their expectation of what particular teachers are expected to teach, special attention is needed to explain to parents and students why, for example, a mathematics teacher will spend time teaching the science of climate change before applying statistical analysis techniques to help students understand future projections.

Occasionally, the culture of collaboration and interactivity that characterizes interdisciplinary teaching stands in conflict with a more individual-based culture of the school.

Supporting interdisciplinary teaching

Being aware of the demands of interdisciplinary teaching prepares teachers and administrators for the road ahead. Interdisciplinary teaching is rewarding but also challenging. It requires an entrepreneurial mind on the part of teachers and support on the part of administrators. Multiple strategies may prove informative. Particularly productive ones are listed below.

Creating sustainable structures for professional development

In addition to professional development courses, school field trips and external consultations that are focused on interdisciplinary teaching and learning, teachers in a school will benefit from forming local study groups where they focus alternatively on interdisciplinary teaching principles, collective analysis of student and expert work, and sharing and reviewing unit designs. Occasionally such teams may include teachers in the same subject area who specialize in different disciplines such as the theatre, music and visual arts teachers in the arts department or the physics, biology and chemistry teachers in science. On other occasions study groups may be formed around areas of interest such as human and natural environments or health, drawing on teachers from various subject areas.

Analysing examples to deepen understanding

Conversations about interdisciplinary education can easily become abstract or aspirational and lose practical meaning or generate misunderstandings. Teachers benefit from close analysis of exemplary work—work done by experts on topics of their interest (for example, environmental artists, the Intergovernmental Panel on Climate Change, the World Health Organization). Looking closely at how disciplines inform these exemplars and how they are combined to yield deeper or better understandings of the problems under study is productive, especially when expert work is not presented in an intimidating way. Again in this case, book clubs and study groups provide an ideal collaborative context. In a similar vein collaborative analysis of student interdisciplinary work enables teachers to sharpen their own sense of what counts as quality work and how to support it.

Supporting meaningful work, bottom-up and top-down

To engage in this highly professional type of work teachers need to be genuinely engaged. They must view their own learning as meaningful, building on their own interest and desires for improvement. They must also find the time and encouragement in their institutions to advance this work. Setting sustainable structures for growth needs a bottom-up and a top-down approach. Teachers can advance a professional development agenda that meets their needs and those of their students. School administrators can encourage these by opening spaces for genuine reflection. Providing time and structure without a professional development agenda in place will yield meagre results. Initiating a professional development movement without a structure that encourages exchange may cause frustration. A workable balance is to be reached, even if such balance varies from school to school.

The role of teacher leaders

School environments conducive to quality interdisciplinary teaching are often shaped by teachers or administrators who take collaborative leadership positions. These are individuals who are committed to interdisciplinary work and serve as champions for initiatives in the school. These individuals are typically widely read, humble collaborators and secure in their own disciplinary and professional ability. Ultimately these leaders seek to establish a community of learners in the school, one where teachers can articulate their own and others' ways of knowing with clarity.

Reflection point

After considering the recommendations above, design a preliminary plan for professional development in your school. What structures would you create? Who should participate? What activities may the group engage in?

You may also want to reflect on an earlier attempt at interdisciplinary teaching: what went particularly well and why was it so? What were some challenges that you encountered, and how would you do it differently the next time round?

Chapter 12 Conclusion

At the dawn of the 21st century the quality of a curriculum framework is to be judged not only by the professionalism of its instruction and the deep understanding it instills in its students but, quite importantly, by the relevance of what students learn. To meet the demands of contemporary societies wisely, young people of today must become able to navigate growing international interdependence, participate actively in the local and global sphere, understand the environment and its sustainability, care for mind, body and well-being, and become reflective learners in dynamic knowledge societies. Responding to these demands the MYP curriculum model articulates a much needed bridge between what is typically learned in schools and the most pressing questions that concern our societies. Attentive to adolescents' development, the programme emphasizes rigorous learning in the disciplines and interdisciplinary synergy, inviting students to tackle relevant issues, from climate change to globalization, thus preparing them for the work of the next generation.

Appendices: Appendix 1—Acknowledgments

Many individuals contributed to this guide. A large number of schools in all IB regions submitted their interdisciplinary units for review. A list of schools that have submitted sample work for this guide appears below. Their careful designs and imagination have enriched our thinking about the opportunities and challenges of interdisciplinary education in the MYP. School heads and MYP coordinators played a key part in gathering endless lists of materials, and in many cases warmly hosting the research team's visits. Teachers and students welcomed the team for classroom observations, participated in extensive phone and face-to-face interviews, shared carefully documented unit plans and extensive samples of student work.

Two teams of researchers at Harvard University's Project Zero contributed substantively to the content presented in this guide. The first, including Liz Dawes, Steven MacAlpine, Matthew Miller and Alison Rhodes, participated in the empirical testing and conceptualization of the interdisciplinary teaching framework in which this guide is grounded. The second, composed of Sholeh Koorjee, Yee Ping Lee, Guillermo Marini and Puay Yin Lim, worked on the documentation and analysis of MYP units and student work. Special thanks go to Flossie Chua for her analysis and endless creativity in co-designing activities, graphics and thinking tools, and her careful editing of text, and to Howard Gardner who served as an ever insightful adviser in the original research.

The group collaborated closely with a number of exemplary teachers whose work informs this guide directly in the form of examples or reflections. Among them, and cited here are Javier Bastos, Brian Dempsey, Judi Freeman, Michael Kozuk, Paul Papadonis, Larry Sheinfield, Jodi Falk, and Valerie Vasti.

List of schools that have contributed

Many MYP schools submitted strong units of instruction for analysis. In selecting units to be included, criteria such as strength of design, relevance of the topic, link to areas of interaction, and teachers' experience with the unit were considered. The units selected had to collectively illustrate various aspects of interdisciplinary work and vary in scope. These units served as inspiration for the examples developed for this guide. In many respects examples reflect the experience of teachers and students in the classroom, but these unit designs have been expanded and adjusted to illustrate particular aspects of the framework.

Units by topic	School	Year
Interdisciplinary fieldwork: Geography–Science	Chinese International School, Hong Kong	5
Perseverance and determination; Appreciating ancient civilizations	Carl Sandburg Middle School , Golden Valley, Minnesota, USA	1
Ancient civilizations	Qatar Academy, Doha, Qatar	2
Sikkus en la cultura Latinoamericana	St George's College North, Buenos Aires, Argentina	3
The sound of music	International School of Uganda, Kampala, Uganda	2
All monsters are made by people and we are responsible for the monsters we make	St Dominic's International School, Lisbon, Portugal	5

Units by topic	School	Year
Epic revolutions	International School of Belgrade, Belgrade, Serbia	4
Exile	International School of Amsterdam, Amstelveen, Netherlands	5
Metals and the recycling of used metals	International School of Uganda, Kampala, Uganda	2
Facing history and ourselves (Please note that this is a non-MYP unit.)	Boston Latin School , Boston, Massachusetts, USA	5

Appendix 2: Reading list

Purpose of education

Beane, JA. 1997. *Curriculum Integration: designing the core of democratic education*. New York. Teachers College Press.

Boix Mansilla, V and Gardner, H. 2007. "From teaching globalization to nurturing global consciousness." In Suarez Orozco, M (Ed), *Learning in the Global Era: International perspective on globalization and education*. Berkeley. University of California Press. Pp 47–66.

Gardner, H. 2006. *Five Minds for the Future*. Boston, MA. Harvard Business School Press.

Gardner, H. 2000. "How education changes." In Suarez Orozco, M and Baolian, D (Eds). *Globalization Culture and Education in the New Millennium*. Berkeley. University of California Press. Pp 235-258.

Gibbons, M et al. 1996. *The New Production of Knowledge: The dynamics of science and research in contemporary societies*. London. Sage Publications.

Hargreaves, A. 2003. *Teaching in the knowledge society: Education in the age of insecurity*. Buckingham. Open University.

Levy, F and Murnane, R. 2007. "How computerized work and globalization shape human skill demands." In Suarez Orozco, M (Ed), *Learning in the Global Era: International perspective on globalization and education*. Berkeley. University of California Press. Pp 158–174.

Levy, F and Murnane, R. 2004. *The New Division of Labor: How computers are creating the next job market*. Princeton, NJ. Princeton University Press.

Postman, N. 1995. *The End of Education: Redefining the value of school*. New York. Knopf.

Suarez Orozco, M and Satin, C. 2007. "Learning in the global era." In Suarez Orozco, M and Satin, C (Eds), *Learning in the Global Era: International perspective on globalization and education*. Berkeley. University of California Press. Pp 1–43.

Interdisciplinary work

Klein, JT. 1996. *Crossing Boundaries: Knowledge, disciplinarities, and interdisciplinarities*. Charlottesville, VA. University Press of Virginia.

Klein, JT. 2002. *Interdisciplinary Education in K-16 and college*. New York. College Board Publications.

Klein, JT. 1990. *Interdisciplinarity: History, Theory and Practice*. Detroit. Wayne State University Press.

Newell, W. 1998. *Interdisciplinarity: Essays from the Literature*. New York. College Board.

Richards, J. 2007. "Interdisciplinary Teaching: History, Theory and Interpretation." In Valarie, A (Ed), *Interdisciplinary Language Art and Science Instruction in the Elementary Classroom*. New Jersey. Lawrence Erlbaum Associates. Pp 15–28.

Building disciplinary grounding

Boix Mansilla, V. 2004. "Between reproducing and organizing the past: High school students' beliefs about the standards of acceptability of historical knowledge." In Lee, P (Ed), *International Review of Research History Education*. London. Fran Cass.

Carey, S. 2000. "Science education as conceptual change." *Journal of Applied Developmental Psychology, 21,* 1, pp 13–19.

Donovan, S and Bransford, J. 2005. *How Students Learn: History, mathematics, and science in the classroom*. Committee on How People Learn, A Targeted Report for Teachers. Washington, DC. National Academies Press.

Gardner, H and Boix Mansilla, V. 1994. "Teaching for understanding in the disciplines and beyond." *Teachers College Record* 96 (2) pp 198–218.

Grotzer, TA and Lincoln, R. 2007. "Educating for 'intelligent environmental action' in an age of global warming." In Moser, S and Dilling , L (Eds). *Creating a climate for change: Communicating climate change and facilitating social change*. Cambridge, UK. Cambridge University Press.

Hofer, B and Pintrich, P. 1997. "The development of epistemological theories: Beliefs about knowledge and knowing and their relation to learning." *Review of Educational Research*, 67, pp 88–140.

Lee, P and Ashby R. 2000. "Progression in historical understanding." In Seixas, P and Wineburg, S (Eds), *Knowing, Teaching, and Learning History: National and international perspectives*. New York. NYU Press.

Minstrell, J and Kraus, P. 2005. "Guided inquiry in the science classroom." In Bransford, J and Donovan, S (Eds). *How Students Learn: History, Mathematics, and Science in the Classroom*. Washington, DC. National Academy Press. Pp 475–514.

Perkins, D. 1994. *The intelligent eye: Learning to think by looking at art*. Santa Monica, CA. The Getty Center for Education in the Arts.

Perkins, DN and Grotzer, TA. 2005. "Dimensions of causal understanding: The role of complex causal models in students' understanding of science." *Studies in Science Education, 41,* pp 117–166.

Wineburg, S. 2000. *Historical Thinking and other Unnatural Acts: Charting the future of teaching the past*. Philadelphia. Temple University Press.

Winner et al. 2007. "Studio Thinking: How visual arts teaching can promote disciplined habits of mind." In Locher, P, Martindale, C. Dorfman L an. Leontiev D (Eds). *New Directions in Aesthetics, Creativity, and the Arts*. Amityville, New York. Baywood Publishing Company, 2006. Pp 189–205.

Integrating disciplinary perspectives

Bromme, R. 2000. "Beyond one's own perspective: The psychology of cognitive interdisciplinarity." In Weingart, P and Stehr, N (Eds). *Practising interdisciplinarity*. Toronto. Toronto University Press.

Dawes Duraisingh, L and Boix Mansilla, V. 2008. "Interdisciplinary forays within the history classroom: How the visual arts can enhance (or hinder) historical understanding." *Teaching History*. December, 2007.

Nikitina, S. 2006. "Three Strategies for Interdisciplinary Teaching: Contextualizing, Conceptualizing, and Problem-Centering." *Journal of Curriculum Studies, 38, 3*, pp 251–271.

Perkins, D, Simmons, R and Tishman, S. 1990. "Teaching cognitive and metacognitive strategies." *Journal of Structural Learning 10,* 4, pp 285–303.

Salomon, G. 1993. *Distributed cognitions: psychological and educational considerations*. Cambridge, England. Cambridge University Press.

Wiley, J and Voss, JF. 1999. "Constructing arguments from multiple sources: Tasks that promote understanding and not just memory for text." *Journal of Educational Psychology, 91*, 2, pp 301–311.

Interdisciplinary curriculum work

Beane, L. 1993. *A middle school curriculum: From rhetoric to reality.* Columbus, OH. National Middle School Association.

Boix Mansilla, V and Gardner, H. 1999. "What are the qualities of understanding?" In Wiske, MS (Ed). *Teaching for Understanding – a practical framework*. San Francisco. Jossey Bass. Pp 161–196.

Clarke, J and Agne R. 1997. *Interdisciplinary High School Teaching: Strategies for integrated learning.* Boston, MA. Allyn and Bacon.

Drake, S. 2005. "Meeting Standards through curriculum integration: A bridge to the mainstream." In Etim, J (Ed). C*urriculum integration K-12: Theory and practice*. Lanham. University Press of America.

Etim, J. 2005. *Curriculum Integration K-12: Theory and practice.* Lanham. University Press of America.

Gardner, H. 2000. *The Disciplined Mind*. New York. Penguin.

Jacobs, HH. 2004. *Getting Results with Curriculum Mapping*. Alexandria, VA. Association for Supervision and Curriculum Development. Pp 25–35.

Jacobs, HH. 1989. *Interdisciplinary Curriculum: design and implementation.* Alexandria, VA. Association for Supervision and Curriculum Development.

Jacobs, HH. 2004. *Mapping the Big Picture: Integrating curriculum and assessment K-12.* Alexandria, VA. Association for Supervision and Curriculum Development.

Perkins, D. 1992. *Smart schools: better thinking and learning for every child*. New York, NY. The Free Press.

Wineburg, S and Grossman, P. 2000. *Interdisciplinary Curriculum: Challenges of implementation.* New York. Teachers College Press.

Professional development for interdisciplinary teaching

Darling-Hammond, L. 2006. *Powerful Teacher Education, Lessons from exemplary programs*. San Francisco. Jossey-Bass. Pp 3–18.

Darling, HL et al. 2005. *Preparing Teachers for a Changing World, What teachers should know and be able to do.* San Francisco. Jossey-Bass.

Little, JW et al. 2003. "Looking at student work for teacher learning, teacher community and school reform." *Phi Delta Kappan 85* (3), pp 184–192.