

INTEGRATING CONCEPTS OF INTEGRATIVE LEARNING

Bettie Higgs, University College Cork and Brendan Hall, University of Gloucester

Introduction

In contemporary higher education, there is significant potential for students to have a fragmentary learning experience. Integrative learning, which Huber and Hutchings (2004, p. 13) describe as “connecting skills and knowledge from multiple sources and experiences”, may be one way to address this issue. Indeed, it may help students get the most out of their undergraduate experience and prepare for what lies ahead.

At University College Cork (UCC), an investigation of student engagement in a geoscience field course designed to foster integrative learning concluded that all students in the course benefited from intentional teaching for integrative learning (Higgs, 2006; 2007; and see also chapter 4 in this volume). But the study also revealed that not *all* students will go *all the way* to make meaningful connections, even when multiple opportunities are provided. These students may fall into Ritchhart’s (2002) ability–action gap. To foster integrative learning more effectively, teachers may require a deeper understanding not only of the complex opportunities students need to connect, but also of how to help them overcome the gap between their abilities and their motivation to act.

Huber and Hutchings (2004; 2005) warn, however, that unless teachers become integrative thinkers, modelling integrative learning, we are unlikely to encourage our students to be integrative learners. The work of campuses involved in the Integrative Learning Project (Association of American Colleges and Universities, 2004–07) and analysis by senior scholars at the Carnegie Foundation for the Advancement of Teaching (Gale, 2006; Huber, 2006; Hutchings, 2006; Miller, 2006), confirm this. They suggest that integrating pedagogies and integrating modes of assessment may provide new ways to encourage integrative learning. In addition, we find that the concept of integrative learning overlaps with several neighbouring concepts, and that by investigating these overlaps, and integrating concepts, we may see innovative possibilities for fostering integrative learning.

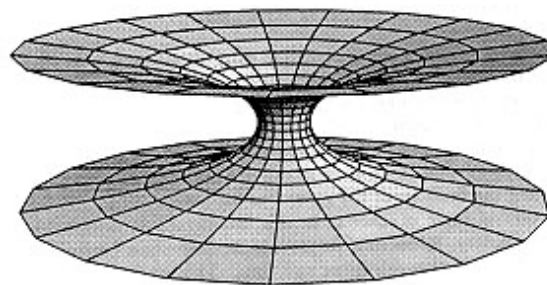
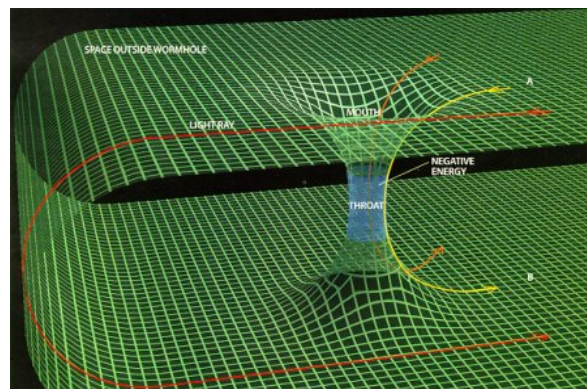
This chapter considers how attempts to promote integrative learning can be informed by an exploration of these overlapping concepts. The chapter expands on the metaphor of “wormholes”, (introduced in Chapter 4 this volume) which the authors have found particularly illuminating as a model of integrative learning and as a practical device for helping students to make connections between apparently disparate areas of knowledge. From this starting point, the chapter aims to align metaphors and conceptual models – such as “wormholes”, troublesome knowledge, threshold concepts and border crossings – and find new knowledge at the intersections. In so doing, it hopes to extend our understandings of integrative learning and inform intentional teaching for integrative learning.

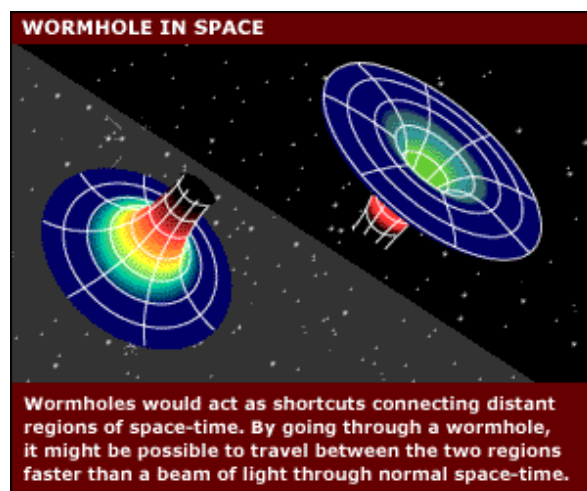
Exploring “Wormholes”

In science fiction, “wormholes” refer to pathways to parallel universes. In the redesign of a first-year geoscience field course at UCC, wormholes were used as a metaphor for activities to help students connect parallel packages of learning (Higgs, 2006; 2007; see also chapter 4 this volume).

Although mainly associated with science fiction, wormholes have attracted a considerable scholarly literature (for example, Morris and Thorne, 1988). The literature dates back to 1935, when Albert Einstein and Nathan Rosen realised that general relativity allows the existence of “bridges”, originally called Einstein-Rosen bridges but later renamed wormholes by the physicist John Wheeler. These bridges act as shortcuts between distant regions of space-time (Figure 1). By journeying through a wormhole, a person could travel between two regions faster than light traversing a path in normal curved space-time. Apart from connecting separate universes, wormholes can vary in shape, can be difficult to get through without being destroyed and can have a constriction, bottleneck or throat that necessitates a struggle to get through. A known property of wormholes is that they are highly unstable and would probably collapse instantly if anyone attempted to pass through them. Calculations suggest that an advanced civilisation might be able to navigate wormholes by using something physicists call “exotic matter” to prevent them from closing. In more recent hypotheses, wormholes can create their own exotic matter, making them big enough and able to stay open long enough for people to get through. Once in place, it would be difficult to remove a wormhole. New work suggests that wormholes can have numerous strands or connecting fibres, and may be more complex than the diagrams in Figure 1 suggest.

Figure 1: Representations of Hypothetical Wormholes (BBC website)





In metaphorical terms, normal curved space-time represents what students can do unaided; when guided by intentional teaching for integrative learning, students can connect areas of their learning just as wormholes connect different regions of space-time. The “wormhole”, in this case, is a specially designed integrative learning activity. The wormhole metaphor overlaps in interesting ways with ideas such as troublesome knowledge and threshold concepts, and it can also be extended. For example, we use the notion of “exotic matter” below as a submetaphor for the assistance that students need from tutors and peers to help them through wormholes.

Integrative Learning: Neighbouring and overlapping concepts

Previous studies have indicated that there are *levels* of integrative learning, and that the degree to which students make connections is influenced by their attitudes to learning (see Chapter 4 this volume). The evidence also shows that students do not always turn their ability into action, and so do not integrate their learning effectively – that is, they do not navigate wormholes successfully. In an attempt to understand why this occurs, here we use the concept of integrative learning as a lens to investigate the neighbouring concepts of troublesome knowledge, threshold concepts and border crossings, all of which are currently being debated in the literature. What will this exploration tell us about integrative learning itself? In particular, can we gain insights into the blockages that stop students linking theory to practice, linking laboratory and field-based experience, linking academic and work-based learning, and linking naïve to deeper understandings?

Troublesome Knowledge and Threshold Concepts

Perkins (1999) suggests that there are some concepts that are difficult for students to grasp because those ideas are counter-intuitive, alien or complex. He refers to these concepts as “troublesome knowledge”. He also proposes the concept of breakthrough thinking (Perkins, 2000), where learners struggle to make sense of messy data before a “light goes on”. Building on this work, and using examples mainly from economics, maths and science, Meyer and Land (2003; 2005; 2006a; 2006b) find that certain concepts are held to be central to the mastery of a subject. They call these threshold concepts. The idea that there are threshold concepts in each discipline emerges from a national research project in the UK, ‘Enhancing Teaching–Learning Environments in Undergraduate Courses’ and is summarised by Cousins (2006).

Several of the characteristics of threshold concepts resonate with integrative learning:

- Grasping a threshold concept is transformative, causing a significant shift in the learner's perception of the subject and allowing further learning to proceed. For example, when learning about climate change, if an understanding of the natural variability of climate through time is grasped, this is transformative.
- A threshold concept is integrative. It exposes the hidden interrelatedness of phenomena, for example when a learner grasps the concept that surface landforms are related to the geological structures beneath our feet.
- A threshold concept is often irreversible. The concept causes such a repositioning of subjectivity on the part of the learner that, once understood, the learner is unlikely to forget it, for example when the learner internalises evidence that the Earth's outer layers are made up of a series of plates that are in constant motion.
- Within a discipline, a threshold concept is likely to have borders with thresholds in new conceptual areas, for example when a learner uses the laws of physics to remotely investigate the geological subsurface. Exploration at these borders encourages integrative learning.

Meyer and Land (2005; 2006a) refer to threshold concepts as “conceptual gateways” or “portals”, leading to previously inaccessible ways of thinking about something. In this visualisation, threshold concepts can be likened to wormholes, through which learners must pass to deepen their understanding. Threshold concepts are likely to involve forms of troublesome knowledge (Perkins, 2006), just as wormholes require learners to struggle to get through the constriction or throat.

If wormhole activities are designed to focus on the connection across one of these conceptual gateways, a threshold concept can be grasped. This represents significant integrative learning. In the study carried out by Meyer and Land (2005;2006a), the act of grasping a threshold concept allowed students to attain a higher level of understanding *within the discipline*. The current analysis concludes that it is likely that *interdisciplinary* threshold concepts also exist, and once identified and negotiated, could help ensure that interdisciplinary studies are integrative and transformative. This assertion is also supported by the characteristic of threshold concepts being bounded by thresholds in other subject areas.

These ideas have implications for curriculum design and for pedagogy. According to Cousins (2006, p.4)

in contrast to transmitting vast amounts of knowledge which students must absorb and reproduce, a focus on threshold concepts enables teachers to make refined decisions about what is fundamental to a grasp of the subject they are teaching. It is a “less is more” approach to curriculum design.

Building on Cousin's statement, we can say that a focus on threshold concepts would enable teachers to make refined decisions about what is fundamental to a grasp of the interconnectedness of disciplines and domains. If we aligned this approach with a learning outcomes approach, we would associate each learning outcome with a threshold concept – that is, what the student would master as a result of taking the course or programme. Our

objective would be to help learners build a robust framework of understanding. Students could then integrate “content” into their framework of understanding by self-directed study.

Meyer and Land (2006b) indicate that it may not be easy to pass through conceptual gateways. This is consistent with the idea of struggling to navigate a wormhole. They also suggest that learning may involve the occupation of liminal space during the process of mastery of a threshold concept. This is an unstable space, where learners oscillate between old and emergent understandings. When knowledge is troublesome, this learning experience can be uncomfortable and associated with feelings of anxiety. As with Vygotsky’s (1978) Zone of Proximal Development (ZPD), what teachers do to assist learners in this space is crucial.

A learner who enters the liminal space is taking a step towards mastery of a concept “unlike the learner who remains in the pre-liminal state in which understandings are at best vague” (Cousins, 2006, p.4). This links with Ritchhart’s (2002) concept of the ability–action gap. Cousins (2006) and Higgs (2006) agree with Ritchhart that difficult learning is both cognitive and affective, and so students’ attitudes to learning are of key importance.

King (2006) reports on an attempt to uncover threshold concepts in the geosciences. When she asked participants at a conference in June 2006 about areas of difficulty encountered by their students, they highlighted geological time and visualisation in more than two dimensions. In May 2007, a two-day symposium-in-the-field on the teaching of field geology expanded on this work (Higgs, 2007). The 18 participants had, between them, 400 years of experience teaching geology. At one point, they were asked two subtly different questions about field-based learning:

1. What do students find difficult to learn?
2. What causes difficulty for students’ learning?

The responses clustered into themes and are outlined in Box 1. They give an indication of where wormhole activities could be concentrated. Unless these difficulties are negotiated, students may not be able to secure robust understandings.

Box 1: Responses to Questions Asked of Geological Field Course Leaders

“What do students find difficult to learn?”

1. **Geological time**, particularly imagining the scene “at the time”, when surroundings were different, and processes might have been occurring at a different rate from the present day.
 - **Example:** The now famous tetrapod trackway on Valentia Island, Co. Kerry, never fails to excite interest and engage students. But because the location is directly adjacent to the sea, students believe the creature walked out of this sea onto dry land and left its tracks on a beach. Examination of the evidence shows that the animal lived in a freshwater environment, far from the sea, and left its tracks on a river flood plain. Students will, however, often revert to their original understanding after a short time-lapse. The image of the present-day setting is very powerful.
2. **Visualising in three dimensions:** Geologists often work with 2D information, but must interpret the “patterns” to construct the 3D reality. Many students find this difficult. If students are told that it is easy for some people and difficult for others, they put themselves into the second category, and accept this as an innate deficiency.
 - **Discussion:** Gardner developed the theory of multiple intelligences, with spatial intelligence defined as the ability to represent the spatial world internally, both perceiving the visual as 3D and transforming it into 3D (Gardner, 2004; Viens and Kallenbach, 2004). Intentional teaching may find strategies to assist the development of spatial intelligence.

“What causes difficulty for students’ learning?”

3. **Things that teachers do that make learning difficult:** As leaders on field trips, we point out things that cannot be seen with the naked eye. We are using information that is “common knowledge” to the experienced geologist, but is still at the level of theory for students.
 - **Example:** A field tutor may say, “This rock contains no biotite and therefore formed under anhydrous conditions”. This statement makes understanding difficult on two counts. First, the tutor is sure there is no biotite in the rock because he has seen a thin section of the rock under the microscope, on a previous occasion. A student looking at the rock and listening to the tutor may think that he or she alone is the only person unsure about the presence of biotite. Second, the rock contains black minerals that may be amphibole or pyroxene. These are difficult to tell apart in the field in a hand specimen. Amphibole is a hydrous mineral. Again the leader had prior knowledge, and knows that amphibole is rare in the rock. This practice is common on field courses, and leads the student to become dependent on the teacher, to lack confidence and to consider themselves “not very good in the field”. So teachers can create troublesome knowledge.
 - **Discussion:** It was suggested that we must build student confidence by encouraging a culture of questioning. A confident student might ask, “Is it possible to tell from this hand specimen whether biotite is present, or would we need to study a thin section of the rock?” This could be followed up with “What about amphibole? Isn’t this a hydrous mineral? How can we tell amphibole and pyroxene apart in this hand specimen?” Students need to know that questioning is key to their learning.
4. **The student feels there should be a right answer:** Leaders may give lectures in the field, in which interpretations are presented as facts. This positions the leader as the only authority figure, and also means there is little opportunity for students to learn from each other. Moreover, students learn to accept and write down whatever the leader says. They do not build confidence in “doing field work”, and do not grasp the concept of provisional interpretation and uncertainty. If these concepts are not articulated, students may find knowledge troublesome and become despondent.

Drawing on the responses in Box 1, we propose that two examples of potential threshold concepts for first-year science students are:

- There may not be a right answer.
- Scientists learn from discussion with peers.

In chapter 4 of this volume, Higgs describes a wormhole activity in which students were simply asked, “What did you learn from others?” In their answers, students addressed both of these threshold concepts. The answers indicated that, for some students, there was a small identity shift, because they realised *how* they were learning. Others engaged with these threshold concepts without realising it! Their attitudes were influenced simply by observing their peers.

Cousins (2006) finds that these identity shifts can sometimes entail more troublesome, unsafe cognitive and affective journeys than the example given above. This is because grasping a threshold concept may involve leaving an old belief system behind, and can require a difficult repositioning for students. This suggests that students must take risks to make troublesome connections. As teachers, we must encourage this risk-taking, and explicitly reward it. Cousins (2006, p.5) observes that “often students construct their own conditions of safety through the practice of mimicry. In our research, we came across teachers who lamented this tendency among students to substitute mimicry for mastery”. Mimicry can take the form, for example, of echoing expert language – and can in fact help students to internalise concepts, so long as it is accompanied by a struggle to understand. There must be an inclination to resolve conflicts in knowledge, pull disparate pieces of information together, and close the ability–action gap for deeper understanding. The characteristics of intentional learning, summarised by Higgs in chapter 4 in this volume, must be encouraged, otherwise learning can be “the product of ritualised performances rather than integrated understandings” (Cousins, 2006, p.5).

The question remains: how can we design a curriculum that encourages and welcomes students to enter a wormhole, a liminal space or a ZPD? That is, how can we encourage students to turn ability into action? The concept of intentional teaching for integrative learning offers a solution to these problems. We must identify the transformative points in student understanding – that is, we must be aware of areas of troublesome knowledge, where intentional teaching is required. We must design curricula that allow students to spend some time in the liminal space, “hanging out” part way through the wormhole, while they are seeking answers to their questions. As Cousins (2006) says, this space should allow recursiveness and excursiveness – that is, it should allow students to loop back on the conceptual material, rather than trying to push them through in a simplistic, linear way. This is consistent with findings in neuroscience that multiple connections build robust learning (Greenfield, 2004) and aligns with the multiple strands and complexity in our wormhole metaphor.

It is important to highlight a final complication here, which is that common knowledge is different for each student, and may be much different from the teacher’s common knowledge (see Box 1, for example). Moreover, the threshold between common knowledge and theory moves for each individual as experience is gained. So, theoretically (and this can be observed in practice to a certain extent), thresholds are in different places for each student, and teachers should ensure that wormholes are capacious enough for many students, or that there is a range of wormholes to suit different students.

Cousins (2006) makes an important point when she challenges the assumption that it is always the threshold concept itself that is troublesome. Rather, she believes the difficulty of mastery is not separate from learners and their social and emotional contexts. This brings us to a consideration of border crossings.

Border Crossings

The concept of border crossings is different from the idea of threshold concepts, but it also adds depth to our understanding of the process of integrative learning. Jegede and Aikenhead (2004) developed the concept of border crossings to deal with the reality that students live and work in more than one domain (or culture). In their study of home culture versus university science culture, for example, they found that “for many learners conventional science seems disconnected from practical ends” (p. 167) and not all learners have the capacity to resolve conflicts between the subcultures of families, peer groups, the broader community and university science.

Their work deepens the language of integrative learning, and articulates the potential for smooth, manageable or rough border crossings between the domains that affect student learning. In this view, “troublesome knowledge” would be seen as a social or cultural phenomenon, in addition to being cognitive and affective. For example, if a student lives in several “cultures” (perhaps there are no scientific conversations in the home, or the student is discouraged from studying science), the student may experience difficult border crossings. Navigating these crossings successfully for these learners would be integrative and transformative, and can depend on the assistance they receive in making transitions. Huber and Hutchings (2004) advocate intentional teaching to assist students in developing capacities to integrate their academic and work-based or community-based learning. When integrative learning is effective, university science culture and other cultures need not be in conflict.

Jegede and Aikenhead (2004) describe a spectrum depicting degrees of interaction between domains. At one extreme, there is parallel learning where conflicting domains (on campus and off campus, for example) do not interact and are held separately. Cobern (1996) called this “cognitive apartheid”. At the other extreme, students are able to resolve any conflicts and feel comfortable with border crossings. These students are likely to be integrative learners. Students move between the two extremes, depending on the circumstances. They may need to struggle, and may need assistance, to move away from cognitive apartheid and towards integrative learning. This aligns with the findings reported in Chapter 4 of this volume that there are levels of integrative learning, with students moving back and forth between them.

Can the study of border crossings offer new insights into the ability–action gap? Jegede and Aikenhead (2004) find that, when the culture of science education generally harmonises with learners’ “life-world” culture, science will tend to support the learner’s view of the world. This process is characterised by smooth border crossings, and successful connection making. But when the culture of science education is at odds with the learner’s life-world, science instruction will tend to disrupt the world view by trying to force the learner “to abandon or marginalise his or her life-world concepts and reconstruct in their place new (scientific) ways of conceptualising” (Jegede and Aikenhead, 2004, p.155). This can make learners feel uncomfortable, and alienate them from their life-world culture – or alienate them from science. These students may be deterred from entering the liminal space, or wormhole.

Jegede and Aikenhead (2004, p.156) do throw some light on the ability action gap. They report that learners can develop “clever ways to pass their science courses without learning the content in a meaningful way” but develop coping mechanisms such as silence, evasiveness and manipulation. There may be no meaningful learning, but communicative competence (Jegede and Aikenhead, 2004). The concern is that the students may not be poor learners, but they learn how to learn sufficiently well to succeed. If there is no reward for struggling to “get through the wormhole”, students may not expend the required time and effort.

What can teachers do to help? Understanding the nature of border crossings can offer new insights into activities designed to promote integrative learning. Intentional teaching can build bridges between the world view of science and the world view of learners, and help to resolve the conflicts. For example, at LaGuardia Community College, first-year students create e-portfolios to help them to link coursework to the rest of their lives, this being considered vital for personal growth and academic success (Arcario et al, 2005). We can design assessments to reward what we value. In the study in geosciences reported in Chapter 4 this volume, first year students were given a group research project designed to help them to integrate on-campus research with field based research. In addition “wormhole” opportunities encouraged these students to link natural phenomena with the real world. With border crossings in mind, more science could be taught from the angle of community concerns, focusing, for example, on geo-hazards, resource development and exploitation, groundwater protection, coastal erosion, environmental management, and ethics. This is exactly what Huber and Hutchings (2004) call for. Teaching strategies can be chosen to help students to identify any conflicts, explore them from several angles, and move towards integrative learning.

Jegede and Aikenhead (2004) suggest that teachers make potential border crossings explicit for learners. For inexperienced learners, they advocate the “tour-guide teacher”, who gives a high degree of guidance, and has an extensive repertoire of teaching strategies. When less guidance is needed, they advocate the teacher as “travel agent”, providing incentives, topics and issues that create the need to know science. Not all teachers will be comfortable with this view of teaching science, but these ideas can help us hone existing teaching strategies, or develop additional strategies, to build capacities for integrative learning.

Conclusions and discussions

In this chapter, we have explored the metaphor of the “wormhole”, facilitating integrative learning by providing pathways between discrete packages of learning. Successful navigation may need ‘exotic matter’ (assistance from a peer or guidance from a teacher) to keep the wormhole open and allow safe passage for the learner. We have brought this metaphor together with the neighbouring concepts of troublesome knowledge, threshold concepts, and border crossings. By integrating these concepts, we have come to a new understanding of the nature and complexity of integrative learning. Insights into the blockages that can prevent connection-making have been gained.

The ideas and concepts – threshold concepts, troublesome knowledge, and border crossings – all overlap with integrative learning, but are not entirely the same. Nevertheless, they have significant implications for intentional teaching for integrative learning, and suggest a new focus for the design of opportunities to connect.

Viewed as such, they bring richness and clarity to the understanding of integrative learning itself, and situate integrative learning at the heart of what Perkins (2006) calls “practical constructivism”. They help answer the questions: What is integrative learning? What does it look like? And how can we assess it?”

This exploration of neighbouring and overlapping concepts has also highlighted another important characteristic of integrative learning. That is, integrative learning can vary in the “type” or nature of connection and the time required to make the connection. Learners might not attempt the connection, they might try and not make it through, or they might struggle long enough to pass through successfully. If a connection is important enough, learners must be allowed time to visit and revisit in multiple ways; they must feel safe that confusion is tolerated, and that even mimicry as a route to understanding is allowed. An awareness of this tolerance may encourage more students to take the plunge and turn their abilities into action.

At the beginning of this chapter, we asked, “Why are we interested in understanding and aligning models and frameworks?” As teachers, we are students of design and strategy for better learning. We need to understand how students learn, and how our actions enable or inhibit learning. This can help us to encourage closure of the ability–action gap. To do this, we need to concentrate the “opportunities to connect” in the most effective places, building an intentional framework of understanding around which the student can proceed with independent study.

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