Cognition and Instruction: Chapter4

The Role of the Teacher in Making Sense of Classroom Experiences and Effecting Better Learning (written by Jim Minstrell)

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＜内容＞

教師（物理）＋研究者である著者の経験（具体例として重力と環境要因の効果）とそれから得られた知見→よい学習環境とは何か？から始まり、教師の役割、授業デザイン、支援する道具（DIAGNOSER）について書かれている

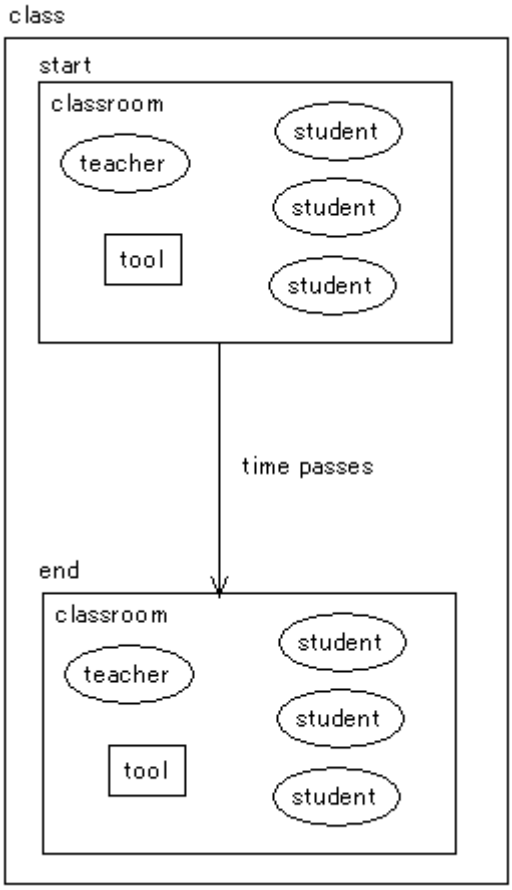
＜得られた知見＞

教えることは不良設定問題である

→目的（生徒の学習、よい概念変化）に沿って様々なアプローチが出来る

⇒「よい学習環境は生徒の初期概念からよい変化を生む」として、facet-based lerning environment を提案する（この考えは他の教育／学習の文脈に一般化できる）

＜facet-based lerning environment＞



facet-based learning environment は、生徒の facet をよい方に換える手助けをすることを目的とする、生徒個人の学習（概念変化）を中心とした環境

start

各生徒が異なる facet を持つ

end

全生徒が少なくともそれぞれの start よりよい facet を持つ

教師が出来ること

・class(cource)をデザインする

・tool を使う

教師に求められること

・生徒の考えと根拠を理解する

・教室での出来事に前向きな意味を与える

＜facet＞

facet は生徒の考え（知識の断片の構造や推論方略）を表したもの

TABLE 4.1

Facet Cluster for Separating Fluid Effects From Gravitational Effects

*310	**Pushes from above and below by a surrounding fluid medium lend a slight support (net upward pressure due to differences in depth pressure gradient).**
*310-1	The difference between the upward and downward pushes by the surrounding air results in a slight upward support or buoyancy.
*310-2	Pushes above and below an object in a liquid medium yield a buoyant upward force due to the larger pressure from below.
*311	**Archimedes Principle is correctly applied**
312	**Push up is greater than push down but no difference for difference in depth for a compressible object.**
313	**Knows that things weigh less in water and knows that there is a push up and a push down by the fluid, but not sufficiently relating the "weighing less" to difference in pushes.**
314	**Surrounding fluids don't exert any forces or pushes on objects in them**
315	**Surrounding fluids exert equal pressures all around an object in the medium**
315-1	Air pressure has no up or down influence (neutral).
315-2	Liquid presses equally from all sides regardless of depth.
316	**Which ever surface has greater amount of fluid above or below the object has the greater push by the fluid on that surface. (e.g. an object near the bottom of lake or container will experience a greater force downward because there is more water above than below the object.)**
317	**Fluids exert an upward push only.**
317-1	Air pressure is a big up influence (only direction).
317-2	Liquid presses up only.
317-3	Fluids exert bigger up forces on lighter objects.
318	**Surrounding fluid mediums exert a net downward push.**
318-1	Air pressure is a down influence (only direction).
318-2	Liquid presses (net press) down.
319	**Weight of an object is directly proportional to fluid medium pressure on it.**
319-1	Weight is proportional to air pressure.
319-2	Weight is proportional to liquid pressure.

table4.1: 単元における facet の分類例

番号の付け方！尺度は相対的であり、段階に合わせて上がっていくことが重要！

０，１：学習の目的、２～６：推論や理解の並び替え、７～９：初期に共通する facet

facet の解釈・使い方

Facet 319: Some students have suggested a correlation with no air in space and no apparent weight in space. What they haven't realized is in an earth orbiting shuttle, one would likely get a zero spring scale reading, whether in the breathable air inside the shuttle or in the airless environment outside. Also, they are thinking that gravity is the result of an interaction between the object and something else. Only they hypothesize an interaction with the surrounding air and the scientist believes the interaction is with the earth. To address Facet 319, students will need to see there is little if any change to the scale reading when the surrounding air has been removed.

Facet 318: It is true that air is light, that is, its density is low relative to most objects we put in it. Air does push downward, but it also pushes in other directions. Students will need to experience this.

Facet 317: Air does help buoy things up, but the buoyant force involves a resolution of the upward and downward forces by the fluid, and that effect is relatively small on most objects in air. (Not so for a helium balloon.) To address Facet 317, students need to see that surrounding fluids like air and water push in all directions, not only upward.

Facet 316: Squishable objects that barely float (such as a scuba diver with a weight belt) near the upper surface of the water may not float when they go deeper than say 30 feet. Thus, it seems like the fluid pushes mostly up when a lot of water is below and pushes mostly down when the object has a lot of water above it. Later in the unit, these students will see that there is no measurable change in the scale reading on a string that supports a solid cylinder whether the cylinder is totally submerged just below the upper surface or submerged to a point slightly above the bottom. (Note this first puts more water below the object and then more water above the object.)

Facet 315: Knowing that the fluid pushes all around but that typical scale readings are not affected, it seems reasonable that the pushes are the same. (This generally happens because the limits of precision of the measurement instruments are too coarse to detect the small difference.) These students will see that there is a difference in scale reading on a string supporting an object submerged in water compared to an object supported out of the water and they will have an opportunity to see that the difference in the support depends on the density of the fluid in which the object is immersed.

Facet 314: For many situations, the difference between the up and down forces by air is so little, even the physicist chooses to ignore it. Thus, there is validity to most of the facets of understanding and reasoning used by students as they attempt to understand and reason about this problem situation. The previous information provides guidance for the teacher as she reads students' answers and explanations and makes plans for instruction.

＜授業デザイン（facet-based learning environment の作り方）＞
授業の流れ：小テスト→議論→実験

教える内容を事前にテストする（小テスト＝生徒の学習を促進する道具）
- 何が生徒の学習問題になるのかの知識を教師に与える
- 生徒が示す特殊な知識を提供する
- 生徒が文脈や問題に気付く手伝いをする

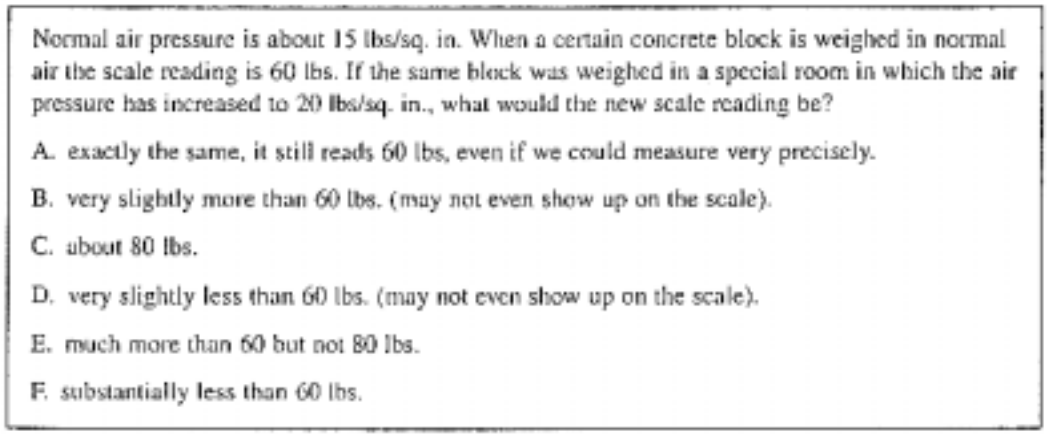
教師は生徒が書いた解答と根拠から facet を判断する、生徒は解答と根拠を共有・議論する
　！教師が解答や根拠の正しさに対する判断を示すことは避ける！
答を導く実験をする
　！使っていない facet は後で扱うので、次につながる重要な結論が分かることが重要！
　生徒がより原理的な視点（一般的な科学の概念、結論）を得られるように支援する

＜システム（DIAGNOSER）＞
生徒に理解と推測をチェックし修正する機会を与える
評価を個別化する過程、生徒の進展を記録する過程で教師を支援する
４つの画面から成る
　１．現象質問画面
　２．根拠質問画面
　３．フィードバック画面
　４．予測画面

１．現象質問画面、２．根拠質問画面について
　facet に基づく多肢選択形式
　自由記述欄を持つ
　　自由記述欄の有効性
　　生徒にとって：質問の解釈、内容の難しさを残せる

教師・研究者にとって：生徒個人を支援する材料になる、学習を改善する活動の修正
システム設計者にとって：DIAGNOSER の改良

戻る、進むボタンを持つ


Normal air pressure is about 15 lbs/sq. in. When a certain concrete block is weighed in normal air the scale reading is 60 lbs. If the same block was weighed in a special room in which the air pressure has increased to 20 lbs/sq. in., what would the new scale reading be?

A. exactly the same, it still reads 60 lbs, even if we could measure very precisely.

B. very slightly more than 60 lbs. (may not even show up on the scale).

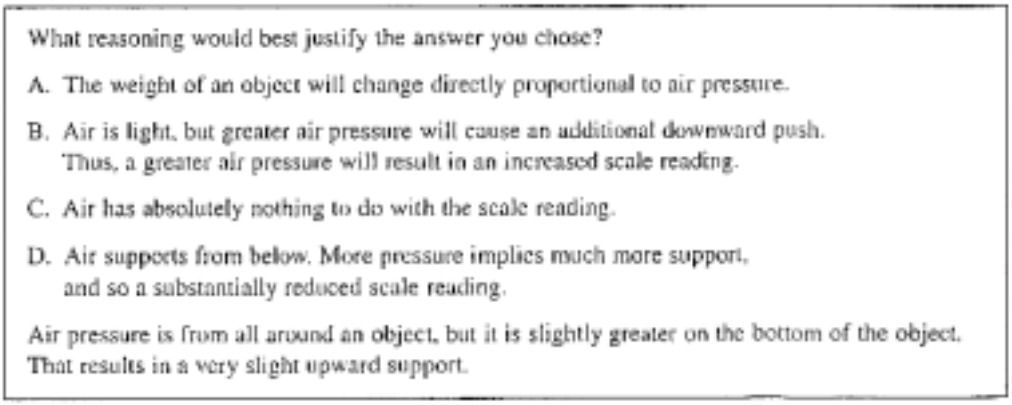
C. about 80 lbs.

D. very slightly less than 60 lbs. (may not even show up on the scale).

E. much more than 60 but not 80 lbs.

F. substantially less than 60 lbs.

FIG. 4.2. DIAGNOSER Phenomenological question screen 3100.


What reasoning would best justify the answer you chose?

A. The weight of an object will change directly proportional to air pressure.

B. Air is light, but greater air pressure will cause an additional downward push. Thus, a greater air pressure will result in an increased scale reading.

C. Air has absolutely nothing to do with the scale reading.

D. Air supports from below. More pressure implies much more support, and so a substantially reduced scale reading.

Air pressure is from all around an object, but it is slightly greater on the bottom of the object. That results in a very slight upward support.

FIG. 4.3. DIAGNOSER Reasoning question screen 3100.

３．フィードバック画面について

現象質問画面と根拠質問画面の組み合わせから５つに分けられる

１．現象的な質問と物理的な推論の両方に対して「正しい」答
　→奨励のメッセージ、一貫しているという事実の獲得

２．間違った予測と関連した推論
　→一貫しているという奨励、正しい予測を導くための議論

３．正しい予測と誤った推論

４．正しく思える推論による誤った予測
　→予測と推論の間の明らかな非一貫性の指摘、助けるための指示に従うことを奨励

５．間違った予測と一貫性のない推論

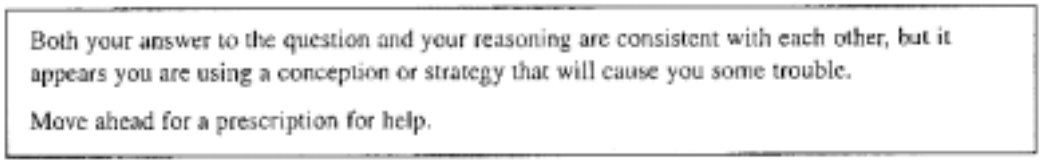


FIG. 4.4. DIAGNOSER Feedback screen for consistent answer and reasoning but indicating a conceptual difficulty.

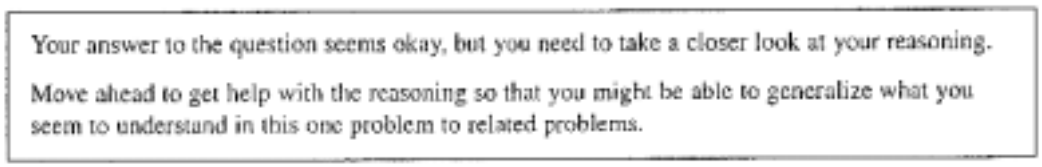


FIG. 4.5. DIAGNOSER Feedback screen for inconsistent answer and reasoning and indicating problematic reasoning.

４．予測画面について

生徒の考えが診断されたら、穏やかに称賛され他の問題を試すことを奨励される

＜評価と現状＞

平均してパフォーマンスを上げることが出来た

facet に基づく教示に似たものが物理教師のネットワークによって使われている

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