Checklisting

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A checklist is a series of statements that describe the critical attributes of either some procedure or product. It can serve as aid to the performer carrying out the procedure or producing the product, and it can provide the basis for evaluation of the performance or outcome.

This paper is a discussion of checklists and their variations (jobs aids, algorithms, heuristics, and decision tables): what they are, how they are generated, and some implications of checklisting for instruction, evaluation, and learning.

Examples. Figure 1 shows a procedural or performance checklist. It states chronologically the steps to be carried out by a technician taking a blood sample. The performer following this checklist would correctly execute the act and an observer could evaluate the performer by reference to it.

Figure 2 represents the critical attributes of a product, in this case a correctly addressed mailing envelope. Each statement refers to the outcome of an activity rather than to the performance itself.

Checklists are typically used to evaluate a performance or to guide it (in which case it is often referred to as job aid.) However, the general procedures for developing and utilizing a checklist apply equally to one which represents criteria for a product (in a sense a quality control device).

The image of an evaluator observing a learned performance and checking off accomplishments and failures suggests a static role for the checklist. Using a checklist to provide feedback to the learner on his or her performance or as a job aid are examples of more dynamic, interactive uses.

Later in this paper we will discuss several points in the instructional sequence where checklisting can be used more dynamically:

- as a way to define and delimit the curriculum, including specification of the key discriminations or concepts to be taught
- as a reference or guide to instruction being developed or on-going (e.g., to the teacher)
- as an instructional technique in which the task of the student is to generate a checklist:

But before exploring its uses, let us examine in more detail some attributes of checklists.

Criteria. Three important criteria applicable to any checklist are: relevance, observability, and reliability. A checklist is relevant when all of the items on it are critical; nothing important is omitted and nothing unnecessary is included. The criterion of observability is met when each item on a checklist refers to something an observer, either with or without training, can respond to; items refer to things overt and objective. It follows from this criterion that a good checklist will be reliable: different observers will agree on whether or not (or to what degree) an item on the checklist is present in the performance or product.

A more global application of the criterion of *relevance* can be applied to the checklist as a whole. The performance being described in the checklist should, in fact, result in the consequences it purports to produce otherwise it is merely a superstitious routine or ritual. (Relevance in this sense is analogous to the concept of validity in test construction.) When the valued product can be attained in many different ways, a process checklist is probably less desireable, and indeed, slavishly following a particular routine may distract the performer from focussing on the results or "purpose," a point described later.

Algorithms, Heuristics and Decision Charts.[1] When the checklist explicitly and comprehensively describes the only or the preferred procedure for attaining a specified result, it is termed an algorithm. If the steps in a performance algorithm are followed exactly, the desired outcome is inevitable. The step by step proofs in geometry textbooks are algorithms. Another example would be the instructions for changing an automobile tire in a well designed car owner's manual. Not all rule systems are algorithmic. For example (to use an example from Landa) the rules of chess describe how each piece on the board may be moved but they do not tell us how to play a winning game. Landa (1974) contrasts such permissive rules with the prescriptive rule systems of algorithms.

Algorithms might be termed instruction without teaching. But as we will repeatedly caution: Any checklist requires prerequisites which the successful user must bring to it. (The visitor in a foreign land soon learns that no matter how well designed the tire changing algorithm is in the driver's handbook of his rented car, he must understand the native language if that checklist is to be useful to him.)[2]

A less explicit checklist is the heuristic which provides general guidelines; carrying it out often requires that the user bring to it a sophisticated repertoire. Furthermore, the probability of producing the desired outcome by the use of the heuristic is raised but not guaranteed. A clearly defined, step by step recipe for making a particular dish would be an algorithm. An addition such as this one would be more of a heuristic: "Any tasty fruit might be substituted for the apples in this recipe. However firmer fruits are likely to produce a firmer taste."

A more sophisticated example of heuristic, offered by Landa, would be the description of a sequence to be used by a detective in attempting to solve a crime.

An example of a complex heuristic would be a description of the activities involved in carrying out a literature search in order to generate an annotated bibliography. Within the general procedure are algorithmic sequences (e.g., the procedures for carrying out a computerized search of the ERIC data base); others involve more general guidelines (e.g., determining the key words to be used in the search, abstracting relevant articles.) The attempt to develop an explicit heuristic often reveals some algorithmic components. This can be helpful in planning what and how to teach the relevant content and can demystify the complex expert performance which at first may seem unteachable or even unanalyzable.

The heuristic, unlike the algorithm, is an appropriate method when the outcome cannot by its very nature be predicted. The steps in solving new problems, developing an original short story or creating a piece of pottery can be described heuristically. The outcome of each of these activities might then be examined or judged using an attribute checklist.

A close relative of the checklist is the decision chart. Indeed, upon careful examination and after clarification, checklists often are transformed into decision charts. Figure 3 shows part of a decision chart illustrating its major characteristics. (A decision chart is a flowchart with decision points or nodes. Simpler flowcharts do not include decisions or choices; they are merely descriptions of linear processes or act as summaries or clarification of accompanying text.) A decision chart represents situations in which either of two (or more) conditions could conceivably prevail and a different response is required for each. Thus the user must discriminate the presence or absence of a particular situation and then proceed accordingly to the next node in the chart. Decision charts are often hierarchical or chronological. Typically, the discriminations and the actions which follow are complex and not fully described within the chart itself; consequently, they must be taught if it is to be useful. Branches of decision trees are in a sense algorithms or checklists.

Taxonomies in Biology and Botany are examples of well-developed decision charts. An interesting example of complex decision making is the explication of the steps used by expert readers of visual patterns such as satellite photographs.

Another example of complex procedural decision chart, explicit or implied, is medical diagnosis. Sequential discriminations are required (e.g., Temperature? Rash?). Each discrimination leads to branches (e.g., High temperature? Low temperature? Periodic cycles of temperature? Steady?) Rather than being the result of travelling through a linear path, the final decision seems to be based upon a slowly emerging pattern which pattern is compared to a standard set of patterns, as if various templates were fitted over it until a best fit is found. Diagnosis also involves circling back to earlier steps, rechecking some indicators, collecting supporting data for others, etc. Diagnostic decisions result from an accumulation of probabilities rather than a summation of straightforward, dichotomous discriminations (e.g., yes/no, on/off.) The probabilistic nature of such decision making adds complexity to its description but is a critical feature which the learner must

Part of a Checklist for a Medical Technician

Goal: Student technician will correctly take a blood sample from a patient's finger.

Medical Technology Checklist

1. Assemble equipment
2. Take patient's hand
3. Rub finger vigorously to bring blood to surface
4. Rub alcohol on finger
5. Open instrument pack without touching blade end
6. Jab finger
7. Pinch sides of finger to produce blood
8. Touch slide-face to blood
9. Place cover slip on specimen slide; slightly rub together
10. Place specimen on table
11. Rub finger with alcohol
12. Place Bandaid on finger

Figure 1. An example of a procedural checklist.

Correctly Addressing and Stamping an Envelope

1. Always write clearly enough so that the first 5 people you stop can read the address.
2. The name and address of the addressee should be written in the center of the front of the envelope as follows:
   Name on first line. Street address on second line.
   City, state and zip code on third line.
3. In the upper left hand corner of the envelope, write your name and address following the format described in #2 above.
4. Moisten and place the correct amount of postage stamps in the upper right hand corner of the envelope.
5. If special mailing procedures are used (e.g., air mail, special delivery), the appropriate notation should be added to the front of the envelope in a space away from the stamp, address, or return address. Print the words that denote the special procedure (e.g., Via Air Mail).

Figure 2. An example of product checklist.

recognize at the outset.

Troubleshooting equipment is analogous to medical diagnosis. A recent, highly readable book on troubleshooting (Mager 1982) provides examples of and procedures for developing checklists.

Many grammatical rule systems can be depicted as decision charts. However, as with other subject matters, as the rule maps are developed some arbitrary rules may emerge (e.g., "exceptions to the rule.") Not every part of a curriculum may lend itself to the checklisting approach. For sets of rules that are not intrinsically rational or ordered it is pedagogically preferable to recognize the arbitrariness rather than struggle to develop obscure formulas and generalizations with numerous exceptions.

Landa (1974) has suggested some criteria for deciding whether or not to develop and teach algorithms, criteria which apply equally well to heuristics and decision charts. The problem to be solved should be important or significant; the algorithm should not be excessively difficult or complex; the problems to be solved by means of the algorithm should be ones that re frequently encountered. He adds that exceptions to these criteria include instances in which an incorrect solution or procedure of searching for a solution (e.g., trial and error) might be dangerous or otherwise harmful.

In the following discussion we shall use the term checklist to refer generally to algorithms, heuristics, and decision charts since the comments apply to any of these variations.

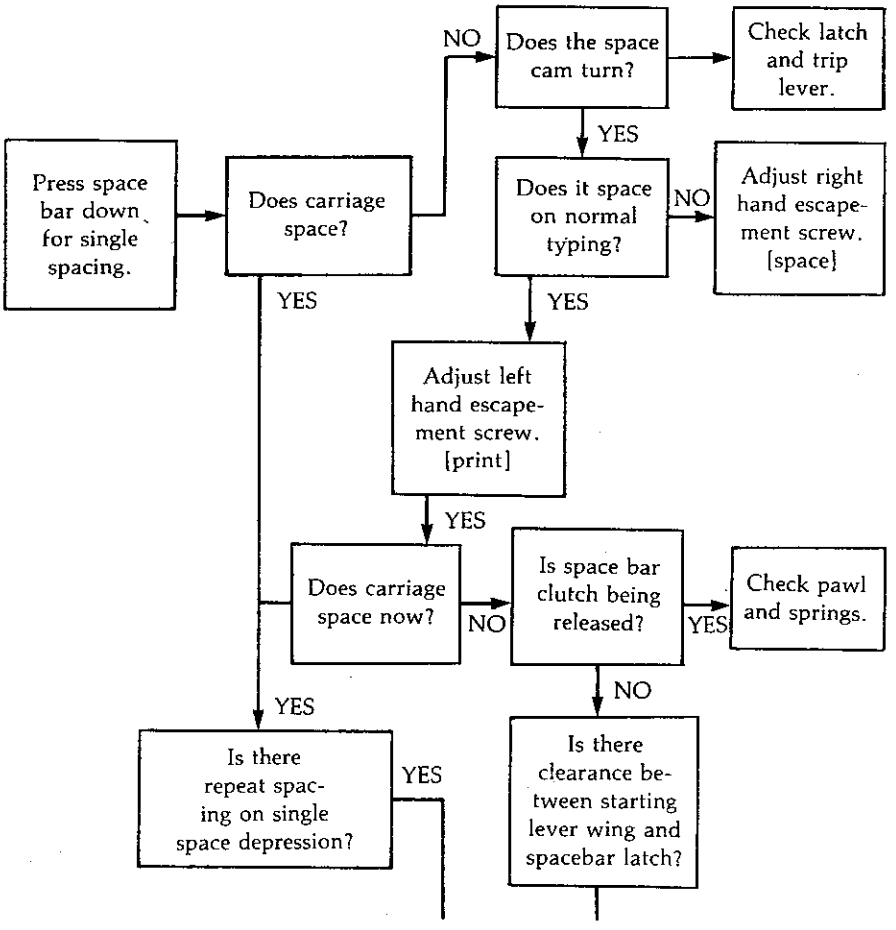
Weighting. All items on a checklist are important if the criterion of relevance is being met. however they might not be weighted equally, that is, some are more critical than others. An error or omission at some point might be dangerous, costly, preclude attaining the results, or even prevent remedial action later on.

Robert Mager (1973) provides a good example of this point illustrated in Figure 4. Obviously the inclusion of ground coffee is a *sine qua non* for the attainment of liquid coffee at the end of the sequence. While the system might tolerate some skimping or variability in other steps in the sequence, this item must be included and so it should be weighted more heavily than some others. Whether the checklist is to be used by an observer for summative evaluation purposes or by the student to provide feedback during learning, it is important to note the relative importance of the items on it.

Analogous to weighting is rating. Sometimes there is reason for the observer or user to indicate the degree to which an attribute or step is present. Figure 5 is essentially a checklist used for grading student themes in a History course at Murdoch University. The degree to which each attribute is present in a particular theme may be indicated on the partitioned scale. Such checklists are usually called Rating Forms. Student evaluations (i.e., agreement) among observers is a serious consideration when any checklist is used; obviously the problem is intensified when ratings are introduced. Fairly elaborate techniques may have to be employed to obtain good inter-judge reliability.

Clarity. Checklists are instruments of communication. We might as "Communicate to whom? and Communicate how well?" A checklist utilizing highly technical terms might communicate to the expert observer but not to the novice. Ambiguous terms (which may not meet the criterion of true observability) are likely produce variability among observers as well as users. For example a checklist for evaluating clinical performance of student nurses required that the observer rate the degree of empathy exhibited by trainees toward patients. Lack of reliability among rates (embarrassing questions by trainees about the meaning of the item) led to attempts to clarify it in terms both of observable sets of behaviour and reactions of patients.

Part of an Algorithm for Locating Faults in an Electric Typewriter



From: Horabin, Ivan, *Improving Human Performance: A Research Quarterly, 1,*(1), March 1972.

Figure 3. An algorithm.

Developing checklists. Various procedures for generating checklists have been suggested (e.g., Landa 1974). Those familiar with task analysis (e.g., see Briggs 1968, Mager 1972) will see clear similarities between procedures employed in carrying it out and those below. In fact, a checklist is a task analysis converted into a form that is more useful in teaching, evaluating and learning. The reader may also be familiar with reports of experts on how they solve problems. These include informal observations (e.g., Polya, 1957) as well as the more recent systematic work of cognitive psychologists. Clearly that literature is also relevant ot this discussion.[3] The simplified versions below provided the reader with a better sense of how checklists might come to be rather than with algorithms for constructing them.

Performance Checklists

1. The performance of an expert is observed and recorded. (Even though the author of the checklist may be a master performer, it is preferable to start by observing another performer, thus encouraging the generation of items which meet the criterion of observability.)

In some cases here may be no master performer as, for example, when a new piece of equipment is produced and no operators for it have yet been trained. Experience suggests that total reliance of the development of a training manual or checklists should not be placed upon the developers of the system, such as the designers and engineers. Alternatives include using the performance and comments of successful trainees who have probably supplemented, clarified and performed their own trouble shooting on the original instructions. (For an interesting discussion of developing training manuals to be used with new machines, see Duffy 1982).

2. After a draft checklist has been created on the basis of observing one master performer, other experts should be observed and notes made on differences among their performances with regard to apparently critical attributes, sequencing, and the like. This may help separate "style" from critical attributes and reveal alternative ways of accomplishing the same end. Differences between style and critical elements become blurred in master performers–"my way" is equated with "the way." If alternative paths are equally effective and efficient they should be noted as options. Disagreement among experts may reveal basic problems: what seemed to be a matter of fact may turn out to be a matter of opinion; agreed upon steps may be ambiguous and "clarification" of them may *reduce* the amount of agreement. Patient and lengthy discussions may be necessary to produce consensus. Sometimes consensus may not be attainable; then, as suggested above, options should be indicated.

3. The checklist is reviewed and revised after observing several master performers. Then it should be tried out on a naive subject, a person drawn from the population of potential learners. Very likely technical terms will have to be defined, discriminations explained, and skills demonstrated. This process will reveal two things: terminology in the procedure that should be simplified or clarified and, importantly, parts of the content that must be taught to any new student. (Alternatively this set of knowledge and skills may be seen as the entry repertoire for effective use of the checklist; instead of representing material to be learned, this content may be used as the basis for a *prerequisite test* on which one must show proficiency before using the checklist.) Trying out the checklist on novices offers a means of developing a lean and relevant set of teaching objectives.

4. The author of the checklist has determined that, given a specific set of prerequisites, the user can successfully carry out the procedure and achieve the final goal. Further verification and additional insights will result when the author plays the role of user and a master performer observes and comments.

5. Examination of unsuccessful performances is also useful. It points up what items on the checklist are especially critical. It suggests where and what kinds of errors are commonly made, thereby providing the teacher with further guidance in developing the appropriate curriculum and deciding upon the emphasis within it. Error frequency data pinpoints common faulty discriminations or poorly executed skill elements.

An important point being made by this somewhat lengthy discussion of the development procedure is that such a careful process suggests (1) how much universality there is among experts with regard to what is to be taught and, (2) what the critical content of the curriculum should be. Having carried out the process, the instructor has in hand the content of a well developed instrument for evaluation purposes and an explicit statement of key elements of the teaching episodes.

Almost always, this procedure of explication is time consuming and difficult. When complex decision charts are being produced, the task is even more onerous. However, the outcome is uniquely valid and valuable.

Checklist for Making a Pot of Coffee

	Norm-Referenced Scoring	Criterion-Referenced Scoring
Disconnects coffee pot	10	✓
Disassembles coffee pot	10	✓
Cleans components and pot	10	✓
Inspects components	10	✓
Fills pot with water	10	✓
Reassembles components	10	✓
Fills basket with coffee	0	×
Reconnects coffee pot	10	✓
Sets dial on coffee pot	10	✓
Reports pot is perking properly	10	✓
SCORE	90%	0%

From: Mager, R.F. *Measuring Instructional Intent.* Belmont, California: Lear Siegler Inc./Fearon Publishers, 1973.

Figure 4. A procedural checklist, illustrating the need for differential weighting of items.

Product Checklists

The same general principles described above apply to the development of a product checklist; the specific steps are somewhat different and deserve comment.

1. To begin with, one engages in a procedure that is, in fact, a version of concept formation: Good and poor exemplars of the product are gathered. For example, to generate a checklist for graders of English compositions, one would gather batches of "A" and "F" papers. Experts should verify the original selection by sorting the whole into two or more piles.

2. Attribute analysis is undertaken either during or after the sorting. The experts discuss on what basis each production is placed in the appropriate category. Critical features are revealed as well as disagreements among experts as to both the criticality of the feature and the degree to which it is present in any particular example.

This will result in a first draft of an attribute checklist for the product. The

road is unlikely to be smooth, for the experts will be revealing not only their discriminations but also their values (or, as the disagreeing expert might say, "their biases.") But this is the very stuff of which an exciting, thought-provoking curriculum can be built. What seemed like a simple checklist may turn into a complex and revealing decision chart with important and controversial modal points (e.g., "If at this point you believe that the most important function of literature is that it serves the goals of the State, then...") Careful recording of disagreements among experts is a critical part of this step.

3. Applying the checklist to a new set of exemplars tests out its comprehensiveness and validity. (Alternatively, it might be applied to the old set of exemplars by a new set of judges.) Repeated revisions and tryouts lead to the final version.

4. The use of the checklist by novices will reveal ambiguities, technical terms, higher order discriminations and the like which must be taught to students.

It is worthwhile noting again that the students may be taught long, complex performance chains and sometimes even provided with performance guides without ever acquiring the ability to discriminate the *quality* of the product they have made. An attribute checklist is the means by which such quality judgements can be learned. In fact, no performance checklist should be used without a corresponding product checklist which allows the performer to evaluate the consequences of his or her performance, a point which will be further elaborated below.

A special case. Occasionally, neither examining performance nor (in the usual meaning) product seems to allow evaluation or determination of "success." Rather one must look at the consequence of the action performed, often the impact upon other people. For example, an actor or actress is valued in terms of the degree to which an audience (perhaps a highly sophisticated audience) is moved. Elements of the performance may be analyzed by critics, but these are at some distance from what really counts. It is by the laughter the comedian produces, not by his routine, that we judge him to be successful. One could call this the "product" and we are inclined to do so, because it lends itself to the same kind of attribute analysis described above. It is sufficient to note that responses to our actions and products by other human beings deserve attention when develop-

History Programme

Assignment Attachment

(Prepared with the assistance of Educational Services & Teaching Resources Unit)

Student's name: Assignment grade

	Itemized Rating Scale (ticked when applicable)	
STRUCTURE		
Essay relevant to topic		Essay has little relevance
Topic covered in depth		Superficial treatment of topic
APPROACH AND ARGUMENT		
Independent approach / interpretation		Little evidence of originality
Logically developed argument		Essay rambles and lacks continuity
Adequate analysis of subject		Descriptive account of subject
Critical evaluation of subject		Uncritical account of subject
Accurate presentation of evidence		Much evidence inaccurate or questionable
SOURCES AND THEIR USE		
Adequate acknowledgment of sources		Inadequate acknowledgment of sources
Effective use of primary sources		Insufficient use of primary sources
Representative evidence chosen		Highly selective choice of evidence
Correct citation of references		Incorrect referencing
Effective use of figures/tables/ maps/photographs		Figures/tables/maps/photographs add little to argument
STYLE AND PRESENTATION		
Fluent piece of writing		Clumsy expression
Succinct writing		Unnecessarily repetitive
Effective paragraphs		Over/Under length paragraph
Economic use of sentences		Over/Under length sentences
Legible and well set out work		Untidy and difficult to read
Reasonable length		Over/Under length
Grammatical sentences		Ungrammatical sentences
Correct spelling throughout		Much incorrect spelling

Figure 5. An example of a rating form checklist.

ing the kinds of analyses described in this paper. Is some cases like those just described, focus on those reactions should be of primary importance.

Painting by number? It should be obvious by now that the development and use of checklists need not suggest simple automaton-like routines to be grimly executed by unthinking drones. In fact a case is being made here for the application of checklisting to the most complex and sophisticated problems and for the incorporation of checklists into teaching and curriculum analysis and design as well as their use in evaluation. The process of developing the checklist is clearly as important as the outcome. Involving students in that process is an exciting challenge to both teacher and learner, a point to be examined in more detail in a moment.

Performance checklists become more than a series of ritualistic directions when three elements are considered: antecedent conditions, the response itself and the consequence of the response.

Antecedent conditions. The responses in a series of checklist items depend upon a set of prevailing conditions. At each step a set of circumstances prevails under which that particular response is appropriate. Technically, the response involves a discrimination. Thus: "The flour should be added after the butter has melted" requires the performer to discriminate that the butter has melted. Even such a simple discrimination may require some instruction or training (e.g., "*just* melted, before it foams or starts to brown.")

Too often the checklist is focused on the action to be carried out, with little attention being paid to the discrimination which should precede and initiate the action. Consequently the performer may automatically execute successive steps in the checklist being controlled not by the real environment but, in fact, by the next command of the checklist. So he or she is chastised: "But didn't you see that it was boiling over." (An honest answer would be "How could I notice that? I was following the checklist.")

It is a bit more likely that antecedent conditions will be spelled out in a decision chart which often requires consideration of two or more possibly prevailing conditions, followed by the decision as to which one is present and then by the execution of the appropriate response.

Before leaving the topic of antecedent conditions we should note that it is important to indicate under what conditions a particular, whole algorithm may appropriately be used. In the discussion of decision charts we noted that they may consist of trees of algorithms. The nodes of the decision charts often represent discriminations of appropriate conditions for each algorithm. If this meta-level of decision-making is not addressed the learner may master a set of algorithms without understanding when each can be applied. A frequently occurring example is the student in statistics who is eminently competent in carrying out the procedures of chi-square, t-test, ANOVA, etc., but has not the foggiest idea of which test to use under which circumstance.

Consequences. Frequently, a checklist represents a chain with each response item producing the antecedent conditions for the next response. "Press Button A" results in the red light over Button B going off thereby setting up the conditions for "Press Button B."

In some checklists, then, explication of antecedent conditions results in simultaneously describing most of the consequent conditions in the chain. However, this is not true of all cases, and, in particular the terminal consequence is often neither clearly described nor placed within a larger context of "purpose." As a result, the performer may not know the "reasons" for carrying out each step, not be able to judge the quality of the outcome of the routine, and not be able to see or state the reason for doing it at all. (cf. the discussion above concerning product checklists.)

At first glance, it seems bizarre to suggest that students should grade their own final examinations. At second glance it seems ever more bizarre that they should *not*. If at the end of the course the learner (as well as being able to emit the performance itself) cannot discriminate whether his or her performance is satisfactory, we have neglected a critical component of the curriculum. Learners cannot be independent as long as they can never judge the worth of their performance or the degree to which it is successful. The study of consequences is obviously a critical element in the teaching of a performance. Neglecting it enslaves the student to an outside judge who always must be consulted before value and competency can be determined.

The response. It is obvious that responses called for in the checklist must be in the repertoire of the performer. In some cases that response is narrowly defined—for example when the nature of the machine being manipulated does not tolerate much variability. The performer must demonstrate the particular response required before one can be assured that it is in the performer's repertoire and that he or she understands how much variability is called for. The tennis instructor says, "Grasp racquet firmly," but *grasp* is a generic term for a wide variety of responses. If the instructor means that a particular grip be used, then it must be described or taught.

The problem of limiting the appropriate response becomes particularly critical in heuristics and decision charts. The writer of a heuristic for sales personnel which states, "Greet the customer" probably assumes a particular repertoire on the part of the user. "Hi. How's it going, folks?" would be an inappropriate greeting by one promoting the services of a funeral parlor. But it is a possible, even likely greeting, given the heuristic statement.

In part, the appropriate class of responses is delimited when antecedent conditions are clearly understood. It is important to realize that further shaping out of the repertoire is enhanced when the consequences are noted and understood as well.

The learner: automaton or thinker? Let us now look at some concerns related directly to the learner. First we will reexamine the common criticism raised earlier: Checklists produce compulsive

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robot-like behavior in the performer. We have all been frustrated by bureaucrats who seem immune to our pleas that our case just does not fit their formula, of salesmen prattling on through their routines insensitive to our questions, of workers who carry out the sequence of the task and ignore the shoddiness of their product.

Dental students using checklists, one dean complained, mastered the technical skills of their trade but did not emerge from their training as problem solvers. Reflection on the points made above about antecedents, responses and consequences revealed the sources of his concern. A "thinking" performer should be able to discriminate the appropriate conditions for executing the next step on the performance chain. He or she should respond not merely on the basis of the previous response but should be governed by the conditions that currently prevail.

Secondly, the recommended response should be seen as one selected from a variety of possible responses. That set of options should be known by the performer and the reasons for the choice (of the optimal response) understood. (For example, although it would work as well to use a non-silver solder to fix the joint, in time the joint would corrode and break.) The reasons for the selection of a particular response in preference to any other may presume a wide knowledge of theory and facts; they should be taught.

Lastly, the consequence of the performance can be discriminated by the "thinking" performer (e.g. "This is a well done job.") *and* the relationship of that particular outcome to the broader picture is clear and, one hopes, motivating.

Learning and checklists. All of this means that to produce a problem-solver performer—one who really understands the task and who can correctly adjust the performance to challenging circumstances—the instruction must include learning experiences focusing on antecedent conditions, response choice, and consequences.

The checklist need not be a sterile job aid or rating form. It can guide the progress of the learner by explicating what precisely is expected at the end of instruction; it can guide the teacher by reminding him or her of the minimal, critical curriculum to be taught; it can guide the evaluator by describing in detail the performance criteria.

But it is also in the *development* of the checklist that pedagogical benefits can be reaped.

The checklist technique places several demands on instructors. They must make explicit the performance routines, key decisions, alternative routes, critical discriminations, criteria for acceptable outcomes and response choices. Furthermore these all must be justified in terms of and related to, theory, principles, facts and real world resources and constraints. The curriculum is the body to be built around the skeleton of the checklist.

Furthermore, the checklist implies a lean approach to teaching with the teaching/learning episodes clearly related to the outcome. Does this mean a march along a barren asphalt road rather than a meandering stroll through the garden? Not necessarily. It merely means that the strollers have in mind some rather well defined purposes. While that constraint may bridle those who have a very different model of education, it should serve those who are attempting to develop in a systematic way certain performances and certain criteria for products of the performers.

> opment of the students' ability to think creatively."
>
> (Landa 1976, p. 101).

So far we have been emphasizing the generation of checklists by experts, instructional designers and teachers. But the reader may have detected in this paper a slow movement toward another, direct pedagogical use of checklisting. Students can be involved in producing checklists. (In fact, some students' notes reduce lectures and texts to a checklist-like format.) Usually, students are not skilled at doing so; learning how to produce and actually producing effective checklists can be an explicit part of the curriculum. In the process of generating checklist students explore why certain conditions are appropriate for certain responses, what the criteria are for a well-done performance or product and how the particular task fits into a larger context. Suppose for example, we built a course in English Composition around developing criteria for "good" writing, resulting in a checklist which would be used to judge all student products.

The involvement of the learner in the creation of the checklist offers an exciting challenge to both learner and teacher.

Students using the checklist as a guide might be encouraged to ask the questions raised above concerning antecedents, response choice, and consequences. "Why am I doing this?" "How will I know if I've succeeded?" These are questions at a higher level than "What do I do next?" The way we have been looking at checklists encourages such probing.

Learners as Developers

But other possibilities suggest themselves.

> "It would be wrong to suppose, of course that it is necessary to present algorithms in completed form. Correctly structured teaching of algorithms presupposes that students will learn to discover them and the general methods for devising them independently. These skills are of great importance in the devel-

"Grammatically correct" might be one item. It would likely lead to the generation of several algorithms. Another candidate for the checklist—"shows originality"—could open the door to an interesting exploration of invention and originality. In short, as a checklist is developed, the content of the "course" involves developing understanding and proficiency in all the areas to which it refers.

Using the generation of checklists as the motive force of curriculum development and teaching poses many problems, several of which have already been indicated. Another one is the possible threat to us, the teachers. We may not be able to generate a good checklist, or the ones we generate reveal ambiguity between personal values and agreed upon judgements or truths. Like the master performer discussed earlier, we may not have realized the extent to

which the curriculum is *our* curriculum. This is not to suggest that the teacher's values, special insights, unique viewpoints are unimportant—indeed, they may be a major contribution that only teachers can make to education. The point is simply that the confrontation of *my* curriculum and *the* curriculum may prove uncomfortable. On the other hand, it offers special opportunities for exciting high level class interactions—discussions of absolute versus normative standards, of fads and taste versus external verities, etc.

Too often teaching, even good teaching, is focused upon internalizing and using rules. There never seems to be enough time to develop in students techniques of searching for, selecting, generating, and choosing novel procedures and solutions. The particular solutions or rules that are taught to students are the results of such higher order problem-solving by the teacher and other experts; this higher order activity ought to involve the students. The teacher might share with students his or her own heuristic processes rather than the resultant algorithms. Perhaps not every academic really wants to encourage that kind of discussion, but those that do will find that building a course around checklisting will be the ideal catalyst—not only producing discussion but always directing students toward a real practical goal.

The involvement of the learner in the creation of the checklist offers an exciting challenge to both learner and teacher. Carried out to its fullest, it offers new roles for both and a chance for dynamic, higher level interaction even in subject areas that traditionally have been tiresomely taught and learned by rote.

Finally, it may not be too much to suggest that repeated excursions into checklisting may have global effects on students. Most analyses of problem solving as a general ability suggest procedures analogous to those which are involved in the development of a checklist. Students faced with the task of generating a checklist will engage in many problem-solving behaviors (steps such as analyzing the task, considering resources and constraints, ordering a sequence of activities.) It may be, as Landa suggested in the quotation earlier, that repeated guided exercises in developing checklists will result in the internalization and generalization of many problem-solving skills.

Conclusion

Checklists (algorithms, heuristics and decision charts) provide not only a means of evaluation but also an operational definition of teaching objectives, a guide to learning, and an outline for curriculum development. Generating checklists can offer new insights into the subject matter and teaching strategies. If students are involved, the process can become an exciting and powerful teaching and learning experience.

Checklists are instruments of communication. We might ask Communicate to whom? and Communicate how well?

Footnotes

1. The outstanding contributor to the analysis and application of algorithms and heuristics to education is L. N. Landa. His detailed and extensive work (e.g., 1974, 1976) is highly recommended.

2. The basic properties of algorithms typically cited bear a close resemblance to the previously discussed criteria for checklists. They are *specificity* (unambiguous, uniformally understood instructions,) *generality* (applicability to an entire class of problems rather than only one,) and *resultivity* (always produces intended results.) See Landa 1976, p. 108.

3. It is beyond the scope and intent of this paper to explore adjacent areas in the literature. However we should at least note the exciting literature which reports on observations of subjects solving problems. Early studies (e.g., Newell and Simon, 1972, Bruner et al., 1956) have been elaborated by recent research in cognitive psychology.

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