Problem and Solution Ratings

One important issue that we encountered is that it was unclear how problem parameters should be defined to identify problem difficulty. Two major areas of research provide information regarding problem parameters and problem difficulty – specifically, the creativity literature and problem solving literature. We utilized research in those two areas to identify problem parameters and develop guidelines for evaluating these parameters that can be given to subject matter experts.

We started with a review of literature from problem solving and creativity that focused on the concepts of ill-defined vs. well defined problems and open vs. closed problems. Based on the creativity literature, defining and constructing the problem are important first steps to the process of problem-solving. Unlike highly-structured situations, ambiguous problems have many possible solutions, and problem solving must follow a less-uniform path to the solution state (Mumford, Mobley, Uhlman, Reiter-Palmon, & Doares, 1991). Because of this ambiguity, more emphasis is placed in defining the problem because this process guides individuals towards better solutions. To completely define the problem, individuals undergo a cognitive process called problem construction, which is concerned with identifying the goals, objectives, and parameters of the situation they are presented with (Mumford, Reiter-Palmon, & Redmond, 1994). This process includes two components, 1) drawing from domain specific knowledge to outline different components of the problem, and 2) organizing facts and principles relevant to the problem and eventual solution. Individuals categorize these components into problem representations, which capture the central features of the situation (Gick & Holyoak, 1980). These ad hoc representations contain essential information including possible goals and

outcomes, objects and procedures required in solving the problem, and any constraints placed on the problem solution (Holyoak, 1984).

The ability to solve problems depends on more than just domain specific knowledge, one of the most important constraints is the problem's structure. With a problem that is considered well-defined, there is a single, guaranteed solution. There are two constraints that bound the problem; the first being only one correct solution that can be determined with total certainty, and second, there is a guaranteed procedure available in which to reach that solution. On the other hand, ill-defined problems are those with multiple, non-guaranteed solutions. In ill-defined problems there exists conflicting assumptions, evidence, and opinions which can lead to different solutions, or the possibility of no solution. Unlike well-defined problems, the key defining feature for ill-defined problems is that there is no guaranteed procedure to reaching the solution (Schraw, Dunkle, & Bendixen, 1995). The application of this research in the current curriculum lies here in ill-defined problems – those that are ambiguous in nature and have many possible solutions.

Another classification for problems exists creating a continuum in which a problem can be placed of open vs. closed problem. An open problem is one that is not clearly defined, meaning the situation is ambiguous in describing all components to the problem. In approaching an open problem, first identify and structure the situation by looking at the goal, and think of the many obstacles that stand in the way of reaching this goal. The other end of the continuum includes closed problems, where the problem is highly defined and evaluated on an agreed upon standard, which means solving the problem is straightforward. This does not mean the problem is simple, but unidimensional, meaning there is common practice in which the goal can be reached (Wakefield, 1992). These classifications of both ill-defined problems and whether they are open

or closed informed the rubric that was created to guide subject matter experts to accurately characterize problems.

To further detail the final rubric presented to the subject matter experts and expand upon the problem representation literature that led to the rating scale items, one of the first considerations is identifying the goal state, which directs problem solving. We concluded that by having subject matter experts first identify the goals of the problem, an ill-defined problem would become clearer. Further, problems with multiple goals are more ill-defined or open. When searching for the goal or goals, a few questions must be addressed. Is there one goal or could there be multiple? Are there goals that must be reached before the final goal? Do the goals need to be achieved concurrently (Mumford et al., 1991)? These questions were developed into the multiple rating scales within the goals subsection of the rubric.

After identifying the goal state, another step in the creative thought process and problem solving is to identify any constraints. Constraints are anything that places a limit or boundary on the solution, meaning they must be considered when problem solving in order to reach a solution that is plausible and achievable (Mumford, Reiter-Palmon, & Redmond, 1994). In the rubric created, subject matter experts first identify if any constraints or limitations exist, and then the extent to which these limitations prevent solution implementation. This was chosen as the second domain on which subject matter experts would rate the problems, as they provide further detail into the degree to which the problem is ambiguous.

The final product includes a rubric in which the goals and constraints of the problem are explicitly quantified, creating boundaries in which the problem is now clearly defined. By using creativity and problem-solving literature, we were able to create a rubric in which a highly ambiguous problem can be accurately assessed using parameters that frame the problem into

more understandable terms. Having this information is necessary, as our objective is to create more creative problems on exams in this domain. Drawing from creativity literature was the best source of knowledge in how to accurately characterize problems, particularly problems that are ill-defined and ambiguous in nature. The best procedure, our final product, assesses goals and constraints of problems and solutions for this application of problem construction and representation, as the phrasing was most understandable and relevant to the cybersecurity domain. Once the problem is represented using these parameters, problems can easily be identified on the basis of how ambiguous, conflicting, compatible, or restrictive they are. By identifying goals and constraints, an ill-defined problem becomes clear and succinct, which in turn increases the possibility for creative solutions.

Goals

First, identify the goals of the problem-solving effort. These goals will direct how and in what way you will try to solve the problem. When thinking about the goal or goals that you are trying to solve for, a few questions must be addressed in order to identify the best goal/s:

First, identify the number of goals. Approximately how many goals are there to this problem?

Rating	1	2	3	4	5+
Choice					

If you selected 1 goal above, skip to the Constraints Subsection. Otherwise, answer the next two questions about the multiple goals.

If there is more than one goal, do the goals need to be completed in a specific order or is there no order?

Rating	1 No order for goal completion	2	3 Some goals must be completed in order	4	5 All goals must be completed in order
Choice					

Next, assess if the goals are compatible with each other.

Rating	1 Not compatible goals	2	3 Somewhat compatible goals	4	5 All compatible goals
Choice					

If you selected 1 (not compatible) above, skip to the Constraints Subsection. Otherwise, assess if the goals conflict at all. Conflicting goals mean that completing one goal (impedes) you from completing another.

Rating	1 Not conflicting goals	2	3 Somewhat conflicting goals	4	5 All conflicting goals
Choice					

Constraints

First, identify number of constraints. Approximately how many limitations are there to this solution?

Rating	0	1	2	3	4	5+
Choice						

If no constraints were identified, then skip to the Conditional Knowledge Section. Otherwise, are there solutions you cannot implement because of any limitations?

Rating	1 All solutions can be implemented, no limitations	2	3 Some solutions can be implemented	4	5 No solution can be implemented because of limitation
Choice					

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