Work-In-Progress:Tools for Creating Variable Parameter Homework Problems

Dr. John Eric Wagner, Trine University

John Wagner is a Professor in the McKetta Department of Chemical and Bioprocess Engineering at Trine University. He has degrees in chemical engineering from the University of Colorado and Rice University and has worked for Shell Oil.

Dr. Amanda Portis Malefyt, Trine University

Amanda Malefyt is currently Chair and Assistant Professor in the McKetta Department of Chemical & Bioprocess Engineering at Trine University. Her research interests include engineering education and nucleic acid therapeutics.

Dr. Jon D Koch, Trine University

Introduction

Numerical problems and exercises are foundational to the education of students in natural science, technology, engineering and mathematics (STEM) and have been a central feature in the curriculum of those majors. The effort that students put forth in solving these problems is a prerequisite for the students understanding and problem solving ability. Learners can mislead themselves in thinking they have mastered a topic, if they look at the solution to a problem before they expend sufficient effort in solving that problem. This self-deception can have a negative impact on student learning[4]. The temptation to look at the solution is almost irresistible with over 90% of students using textbook solution manuals[1,2,3]. These factors, combined with the availability of these manuals have made for a degradation of the homework system traditionally used in the STEM subjects[1]. While solutions manuals may be used effectively[5], it is not hard to find examples of students turning in homework solutions that are direct copies of the solutions manual, even when the published solution has an obvious error.

Professors in the STEM areas have responded in several ways[6]. Some professors make up problems or use problems that have not been published. This is a time intensive process where mistakes in setting up the problems are easily made. Some have used electronic homework systems developed by textbook publishers. The cost of these systems is usually passed on to the students who may resent having to pay an additional fee to have their homework graded. These publisher systems are also not available for all courses and tend to tie the course to a specific book.

Free or low cost electronic homework systems are available such as LON CAPA[7,8], or WeBWorK[9,10]. While these systems are well established and have many users, they do have a significant learning curve, require a commitment by both the faculty member and the college IT department and require integrating with or replacing the current university learning management system (LMS). Sontoro and Bilisoly[11] have developed their own electronic variable parameter problems for a statistics course using Mathematica. These questions had the advantage of working with their current LMS, but the authors did note a high level of effort required to independently develop the questions.

To address some of the issues associated with each of the above systems, the authors propose a centralized crowd sourced problem repository that is freely available to educators at ExcelProblemPedia.org. The repository will provide both computer-based variable parameter problems and computer generated static problems for quantitative subjects. Instructors will be able to select problems from the repository, modify them if they choose, and distribute them to their students through any learning management system.

The computer-based problems will provide learners with immediate feedback on their numerical work, and encourage them to think about what they are learning through instructor graded metacognitive and reflection questions. These metacognitive questions are normally absent in other systems.

The time investment to use the problems from the repository is minimal, and these problems can be used in any desired quantity to supplement or replace the instructor's current homework problems. For the instructors using the computer-based option, the numerical parts of the problems are "machine graded" thus saving the grader time and allowing the grader to spend a larger percentage of their time assessing the students' higher level thinking skills demonstrated in the reflection questions. In addition, student rating of the problems gives the instructor feedback and allows consideration of the quality, difficulty and value of the problem as perceived by the students.

Because the problem repository is envisioned as crowd-sourced, it is critical to have an easy-to-use, widely accepted, and standardized problem creation template. A macro-enabled Microsoft Excel template was chosen because Excel is:

- widely available
- flexible and can be modified with the use of macros and forms
- familiar to all students, practitioners and educators in the STEM areas
- expandable, in the form of well-developed Add-ins that assist in solutions creation and documentation. These include APEx[12], FormulaDesk[13], Process Utilities[14], Polymath[15], MATLAB, and process simulators.

The information flow to and from the repository is shown in Figure 1. Problems can be developed based on examples and textbook problems or screencasts such as LearnChemE[16]. The Governing Board will encourage problem contribution from a diverse group, including student groups, working professionals, and educators including teaching assistants. This encouragement could take the form of problem contests or a "problem of the week" where a specific concept would be featured and working professionals could contribute problems from their workplace that test that concept.

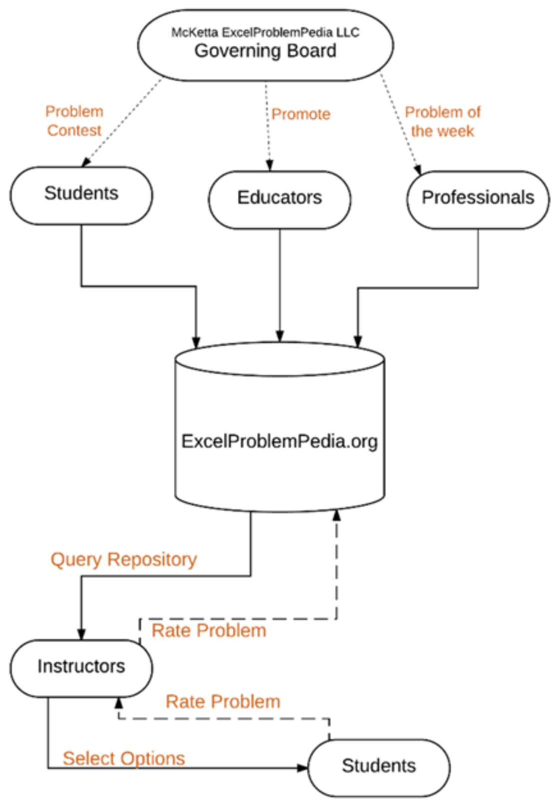


Figure 1 Overview of the system. The structure of the system hosted at www.ExcelProblemPedia.org is represented above. This homework repository is crowd sourced and is freely available for educators. The Governing Board encourages problem contribution by promoting the repository to educators, students and working professionals. The repository can be queried by instructors who may select problems by author, reference, subject area or difficulty and eventually student or instructor rating. The instructors can then distribute selected problems to students via an LMS or even e-mail.

The problem creation template allows for diverse groups to create problems for the repository and encourages those submitted problems to have consistent form and have educationally sound components. The template allows:

- Different versions of a problem that have differences in difficulty. Easier versions can ask for intermediate values that will lead the student through the solution process.

- Qualitative reflective and metacognitive questions that ask the student to reflect broadly on the concepts they are learning and how these concepts interrelate.
- Pre-problem questions to get students thinking about the strategy needed to solve the problem and to estimate the solution. These questions have the added benefit of encouraging students to start earlier, giving them more incubation time and time for questions.
- Answers to a Base Case problem with references for a worked solution as a safety net
- A standardized file naming scheme - based on educational concepts
- Growth mindset quotes to provide a source of inspiration or motivation to the students

Instructions, including video tutorials, on how to use and develop these features will be included on the web site. In addition, surveys will be available on the site so that both contributors and repository users will be able to assess the tools available and provide feedback for further repository and template development.

Repository file creation

Well-suited variable parameter problems should be quantitative in nature and have multiple parts that can be calculated to lead the student through the process. Multiple versions of this problem can then be made where the instructor-users of these problems have the option of eliminating the intermediate parts of the problem and require the students to think through the steps of the problem more independently. The process of creating a problem involves three steps.

1) **Create the Base-Case Problem**. The Base-Case problem provides the text of the problem and contains one set of quantitative data and the corresponding answers to the requested quantities. These could come from existing problems in the educator's files.

2) **Use the template to convert the Base-Case problem to a variable parameter problem**.

3) **Upload the files generated by the template to the repository**. This file uploading process can be done through the web-site, although currently, password protection is used to protect users of the site from malicious intent.

What follows emphasizes the second step in the above process. While this is not meant to be a tutorial, the example below should provide the reader with a sense of how the template is used. Detailed instructions and the latest template can be found at www.ExcelProblemPedia.org

It should be noted, the website repository is in its infancy and it, along with the templates and instructional material, are works in progress. While over 100 different problems, primarily in Material and Energy Balances, have been developed using some version of the template, most are not yet available on the web site. In this stage, template development is much easier if a limited number of questions are developed for the templates current version. It is planned that the beta version of the template will be available in the summer of 2017. At that time, all existing problems will be updated to this template version.

Example 1 – filling a weigh tank

We outline the variable parameter problem creation process with an example from an introductory course in Chemical Engineering. The original example problem, with highlighted regions of the values that will become variable parameters, is shown in Figure 2.

A mass of 1500 pounds of liquid having a specific gravity of 1.2 and molecular weight of 150 is pumped into an empty weigh tank over the course of 25 seconds. The tank is cylindrical with a diameter of 3 ft. Determine the:

a) average mass flow rate (lb/s)
b) average volumetric flow rate (gal/min)
c) average molar flow rate (lbmole/s)
d) total volume of liquid transferred (ft^3)
e) height (ft) of liquid in the tank after the transfer

Figure 2- Example 1 Original Problem Statement – all numerical values in this example will be turned into variables. The values highlighted will be replaced by variables so that each student will have different values and therefore different answers.

To clarify the objective, the final product as the student would see it, is shown in Figure 3. While the final user interface will likely change in future years, possibly to a web-based platform, the current version has students opening a macro-free Excel file. The students could receive this file via email or through the university LMS. When the students first download, open the file, and initialize the sheet (F9), the sheet displays the problem as shown in Figure 3. The problem is individualized with a set of parameters for the variables selected randomly from a set of two hundred numerical variations.

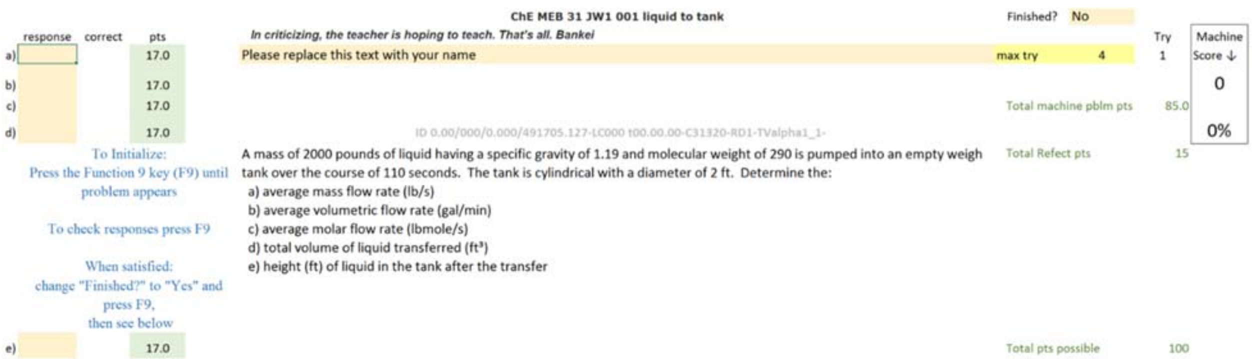
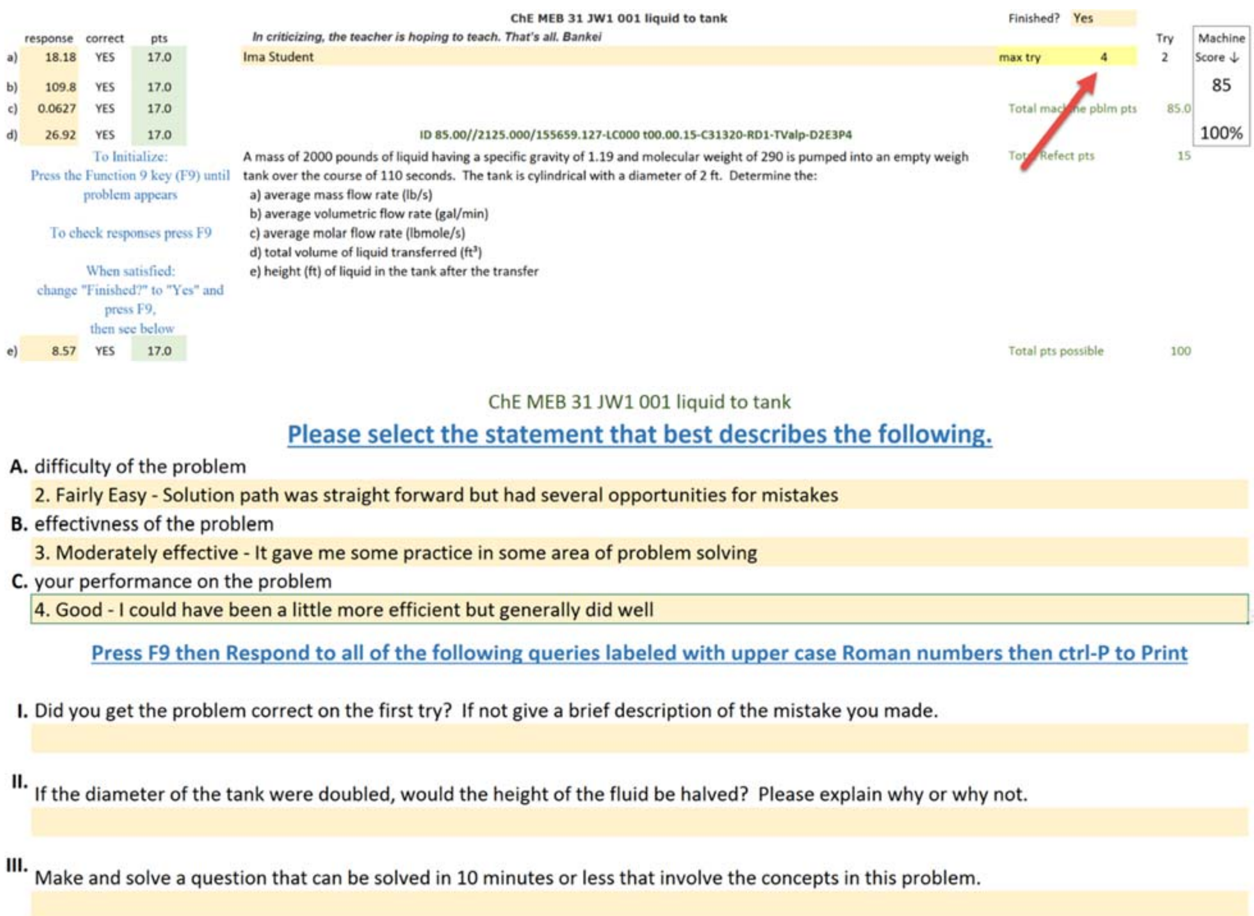


Figure 3- Example problem as it would first appear to a student. The tan boxes are for student input. After responding to all parts of the problem, students would refresh (F9) to see if they got each part of the problem correct.

The student fills in their name and after responding to all parts of the problem, updates the worksheet with the F9 key. If their responses were correct they would see something like the sheet shown in the upper portion of Figure 4. If the student missed one or more parts, the sheet would indicate this and they would have another opportunity to correct their responses, up to the instructor-selected value of "max try" shown in yellow and indicated with the red arrow in Figure 4.

When the student is satisfied with their responses they would change the "finished?" box to "yes" and update (F9) the sheet to reveal the rating section where the student would rate the problem difficulty, effectiveness and their performance. After completing the rating section and recalculating, the reflection portion would appear. This reflection portion asks the students higher level qualitative questions about the concepts involved in solving the problem or metacognitive questions. These reflective or metacognitive questions are optionally selected by the instructor. Our initial results agree with those that have found that while students are very positive on having immediate feedback, the reflective/metacognitive questions, while important to student learning, tend to be less popular[17,18,19].



ChE MEB 31 JW1 001 liquid to tank

In criticizing, the teacher is hoping to teach. That's all. Bankei

Finished? Yes

Ima Student — max try 4 — Try 2

Machine Score ↓ 85 — 100%

Total machine pblm pts 85.0

Total Refect pts 15

Total pts possible 100

	response	correct	pts
a)	18.18	YES	17.0
b)	109.8	YES	17.0
c)	0.0627	YES	17.0
d)	26.92	YES	17.0
e)	8.57	YES	17.0

To Initialize:
Press the Function 9 key (F9) until problem appears

To check responses press F9

When satisfied:
change "Finished?" to "Yes" and press F9,
then see below

ID 85.00//2125.000/155659.127-LC000 t00.00.15-C31320-RD1-TValp-D2E3P4

A mass of 2000 pounds of liquid having a specific gravity of 1.19 and molecular weight of 290 is pumped into an empty weigh tank over the course of 110 seconds. The tank is cylindrical with a diameter of 2 ft. Determine the:

a) average mass flow rate (lb/s)
b) average volumetric flow rate (gal/min)
c) average molar flow rate (lbmole/s)
d) total volume of liquid transferred (ft^3)
e) height (ft) of liquid in the tank after the transfer

ChE MEB 31 JW1 001 liquid to tank

Please select the statement that best describes the following.

A. difficulty of the problem

2. Fairly Easy - Solution path was straight forward but had several opportunities for mistakes

B. effectivness of the problem

3. Moderately effective - It gave me some practice in some area of problem solving

C. your performance on the problem

4. Good - I could have been a little more efficient but generally did well

Press F9 then Respond to all of the following queries labeled with upper case Roman numbers then ctrl-P to Print

I. Did you get the problem correct on the first try? If not give a brief description of the mistake you made.

II. If the diameter of the tank were doubled, would the height of the fluid be halved? Please explain why or why not.

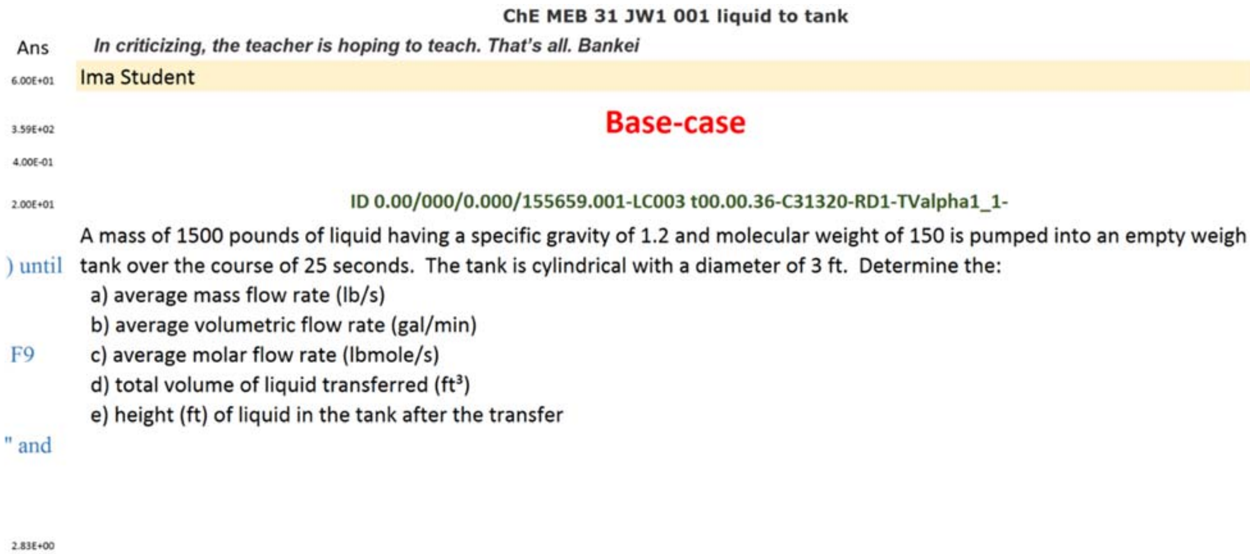
III. Make and solve a question that can be solved in 10 minutes or less that involve the concepts in this problem.

Figure 4- Student response including the "rating" and "reflection" portion of the problem. The reflection portion is hand-graded by the instructor or teaching assistant.

Student responses to this section would either be typed directly in the space provided or included on a separate document and optionally uploaded to a service such as Turnitin[20]. After completion, the student would print the spreadsheet and include their documented solution with the printout. Of course, the printout could also be a pdf file and the entire submission handled electronically within the LMS. The instructor must grade the responses and make sure that the documentation is adequate to award the appropriate points. However, since the quantitative parts are computer graded, and students will correct their mistakes to get these parts correct, the grading process typically takes a fraction of the time of a normal hand graded homework problem.

It should be noted that an ID number becomes more visible above the problem statement (see Figure 5) after the student finishes the rating section of the problem. This number contains potentially useful information about the problem including a unique identifier, the index number of the data selected by the spreadsheet for this particular student, and how long the student had the sheet open. The unique identifier embedded in the ID number, may discourage students from printing multiple copies of the same problem for different student submissions.

If the student has trouble with the problem and runs out of tries – the problem reverts to the Base Case. The instructor can choose to give the students the answer to the Base Case problem (as shown in Figure 5), the solution to the Base Case or both.



ChE MEB 31 JW1 001 liquid to tank

Ans *In criticizing, the teacher is hoping to teach. That's all. Bankei*

6.00E+01 Ima Student

3.59E+02 **Base-case**

4.00E-01

2.00E+01 ID 0.00/000/0.000/155659.001-LC003 t00.00.36-C31320-RD1-TValpha1_1-

A mass of 1500 pounds of liquid having a specific gravity of 1.2 and molecular weight of 150 is pumped into an empty weigh

) until tank over the course of 25 seconds. The tank is cylindrical with a diameter of 3 ft. Determine the:

a) average mass flow rate (lb/s)

b) average volumetric flow rate (gal/min)

F9 c) average molar flow rate (lbmole/s)

d) total volume of liquid transferred (ft^3)

e) height (ft) of liquid in the tank after the transfer

" and

2.83E+00

Figure 5- Base Case is Presented to the Student. Everyone gets the same Base Case but students do not receive points for solving the base case. In this case, the instructor decided to show the students the answers to the base case (just left of the problem statement).

After working through the Base Case, students can then reset the problem and get a fresh set of tries by simply updating the spreadsheet. The Base Case then gives an important safety net for confused students and provides a common set of parameters for problem discussion.

As mentioned briefly, there are other options the instructor has when using the variable parameter problems such as a pre-problem or making different versions of the problem that vary in difficulty. These options will not be presented here but will be on the web site.

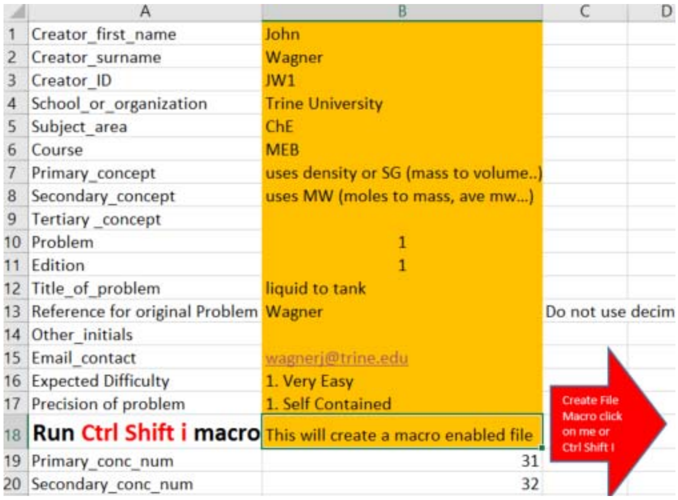
Creating Example 1 using the template

This section is concerned with taking the original tank filling example problem and using the template to create the problem given to the student. This basic process can be subdivided into five steps:

1. Input information about the problem (the problem meta-data)
2. Enter the problem statement, identifying the variable parameters
3. Set the range of each of the parameters
4. Solve the problem using Excel or an auxiliary program
5. Run macros to generate files that can be uploaded to the repository

These steps will be detailed below:

The **first step** in problem creation is to open the Excel template (Alpha 1_2_2.xltm in this case) and fill in the meta-data (information about the problem) in the "info" sheet as shown in Figure 9. For the entire creation process, the user input boxes are color coded in dark yellow.



	A	B	C	D
1	Creator_first_name	John		
2	Creator_surname	Wagner		
3	Creator_ID	JW1		
4	School_or_organization	Trine University		
5	Subject_area	ChE		
6	Course	MEB		
7	Primary_concept	uses density or SG (mass to volume..)		
8	Secondary_concept	uses MW (moles to mass, ave mw...)		
9	Tertiary _concept			
10	Problem	1		
11	Edition	1		
12	Title_of_problem	liquid to tank		
13	Reference for original Problem	Wagner	Do not use decim	
14	Other_initials			
15	Email_contact	wagnerj@trine.edu		
16	Expected Difficulty	1. Very Easy		
17	Precision of problem	1. Self Contained		
18	Run Ctrl Shift i macro	This will create a macro enabled file		
19	Primary_conc_num	31		
20	Secondary_conc_num	32		

Figure 6- Problem Meta Data - Many of the fields have drop down lists to assist in Meta Data creation. This data will help ensure that problems are properly classified in the repository. After the data is input, a Macro is run that will create a file with a suggested name associated with the problem.

After the meta-data are input a macro is run that creates a macro enabled Excel "Create" file by clicking on the big red arrow. The macro suggests a file name that has some of the meta-data included in the file name. At this point, the creator is no longer working on the template but with the "Create" file. Some of the entered meta-data is also used in the setup of the problem. For instance, the data field denoted with the label "precision of problem" helps to determine how close the students' answers should be to that calculated by the spreadsheet to be counted as correct.

In the **second step** the problem statement is typed or copied into the macro enabled spreadsheet as shown in Figure 7. Parameters that are variables are put in {braces}.

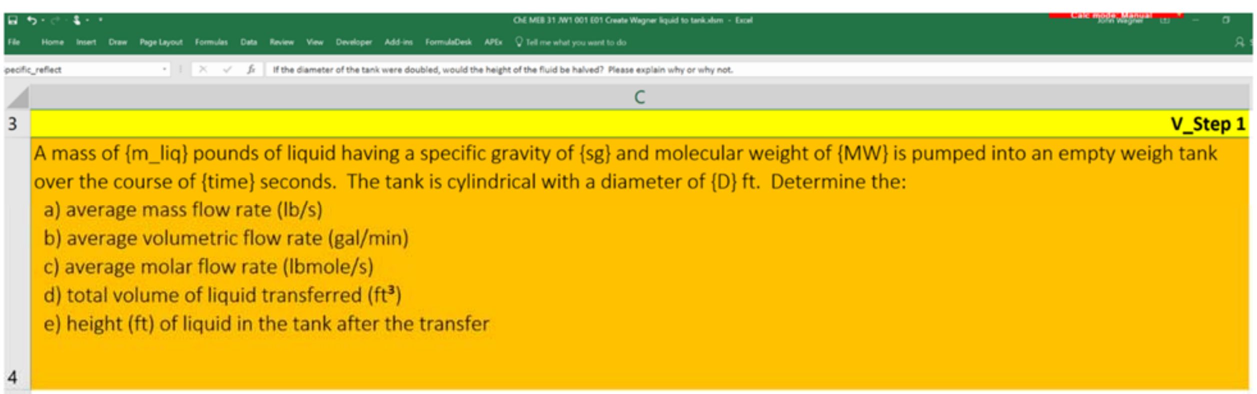


Figure 7- Example Problem copied in the spreadsheet- the values are replaced with variables enclosed in braces. Dark yellow is used for input and light yellow for the steps to be followed.

The range of each variable is input into the sheet along with the Base Case values in the **third step** as shown in Figure 8.

variable	m_liq	sg	MW	time	D
Increment	100	0.01	5	5	0.1
upper limit	2000	1.5	300	200	4
lower limit	1000	0.8	90	20	2
basecase	1500	1.2	150	25	3

Figure 8- Limits and Base Values for the variables are set. Two hundred sets of data for the input variables are created. Again, dark yellow is used for user input.

Using the column headings, the creator solves the problem in the **fourth step** as shown in the Figure 9. Solving the problem, in this case, just involves standard Excel functionality. For solution documentation, the spreadsheet automatically displays the formulas that are being used and these are displayed on the right of the table as shown in the Figure 9.

	BE	BF	BG	BH	BI	BJ	BK	CB	CC	CD	CE	CF
11												
12												
13				V_Step 4	Calculations - you can solve the problem any way you want. replace the variable names in the							
14						again you can hide the unused columns to the right that are not used.						
15						This will be a table (from the previous step) - the use of tables to solve the probl						
16						Can use the RunSolv macro						
17		Calculations are on the RHS of the table. Comments on the formulas could be provided for be							Variable		Formula	
18	----->	mdot	Rho	Vdot_GPM	ndot	V_ft3	H_ft		mdot	=[@[m_liq]]/[@time]		
19	1	60	74.916	359.466603	0.4	20.0224251	2.83259372		Rho	=[@sg]*62.43		
20	2	35	73.6674	213.2429	0.15909091	19.0043357	1.97527116		Vdot_GPM	=[@mdot]*448.83/[@Rho]		
21	3	11.1764706	49.944	100.439198	0.04064171	38.0426077	3.53815577		ndot	=[@mdot]/[@MW]		
22	4	29.2307692	51.1926	256.280129	0.1043956	37.1147392	4.91737291		V_ft3	=[@[m_liq]]/[@Rho]		
23	5	28	79.2861	158.504959	0.10181818	17.6575718	1.73474681		H_ft	=4*[@[V_ft3]]/(PI()*[@D]^2)		

Figure 9 - Solution to example problem

After final setup, a final check is made and a Macro is run in the **fifth and final step** that automatically generates a set of files as shown in Figure 10.

Name	Type
ChE MEB 31 JW1 001 E01 BC_state Wagner liquid to tank.csv	Microsoft Excel Comma Separated Values File
ChE MEB 31 JW1 001 E01 BC_state Wagner liquid to tank.pdf	Adobe Acrobat Document
ChE MEB 31 JW1 001 E01 BC_state Wagner liquid to tank.png	PNG File
ChE MEB 31 JW1 001 E01 Create Wagner liquid to tank.xlsm	Microsoft Excel Macro-Enabled Worksheet
ChE MEB 31 JW1 001 E01 Setup Wagner liquid to tank.xlsm	Microsoft Excel Macro-Enabled Worksheet
ChE MEB 31 JW1 001 liquid to tank.xlsx	Microsoft Excel Worksheet
ChE MEB 31 JW1 liquid to a tank solution.pdf	Adobe Acrobat Document

Figure 10- List of files created for the problem. Highlighted areas are referred to in the text below.

The csv file is an input/output data file that can be used by other web based student interface programs in the future. A png image and pdf file are created so other educators may preview the problem in the repository. The “Create” file contains the solved problem.

The “Setup” file is a macro-enabled excel file that could be used by other educators to change some of the options in the problem. For instance, the “Setup” file is used to change the number of points that students receive for each portion of the problem, which parts of the questions are included, selection of reflection problems, if the answers to the base case are given or how many tries a student would get for each data set. This file contains the two hundred solution data sets but not the solution itself.

In addition, an example macro-free excel file, "ChE MEB 31 JW1 001 liquid to a tank.xlsx", is also produced that could be distributed to the students, if the educator chooses not to alter the default problem setup parameters. This file was the one shown previously as an example of the student interface.

While converting numerical examples into variable parameter problems using the template is a multistep process, it is not a difficult one. Undergraduate students, even freshmen, have successfully used the template and instructional material on the website without additional instruction to successfully create variable parameter problems.

Creating More Sophisticated Examples

Example 2 – Modifying example 1 to add a categorical variable and a drawing.

Adding a categorical variable is also straightforward. Categorical values tend to make the solutions more difficult for students to "share" computer generated solution files that some students will create. This is done with an integer index variable, a table of the values of the categorical variable, and Excel's Vlookup function. In this example, the type of liquid is the categorical variable. For instance, one student may receive a problem statement where the compound is methanol where for another student it is isopropyl alcohol as shown in Figure 11. In this case, the APEx[12] Excel add-in's SG and MW function were used in the solution of the problem so that these values are automatically generated for each of the included compounds.

Drawings, tables and graphs are also easily added to the problem as pictures. The student interface after the categorical variables and an image is added is shown in Figure 11.

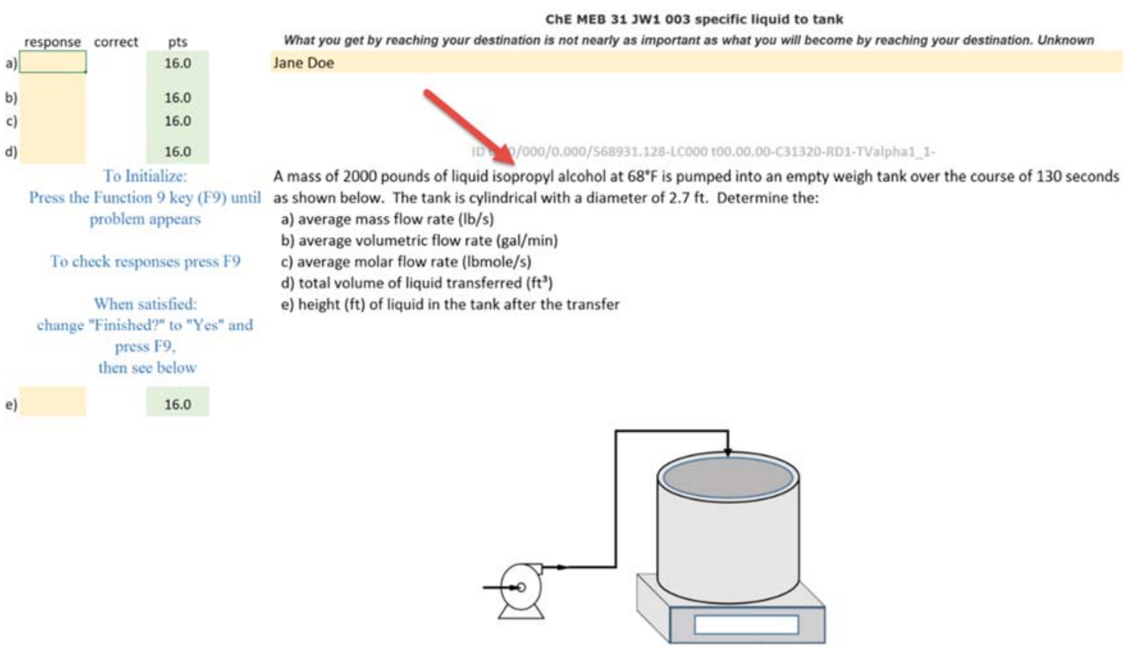


Figure 11 – Student Interface showing a drawing and the categorical variable liquid type.

Using a trial and error solution with and without MATLAB.

Many engineering problems involve iterative numerical solution techniques, and some instructors may have existing databases of single problems that are solved using other software packages. Variable parameter problems can accommodate iterative solutions within Excel, and because of its ubiquity, Excel can work with these other packages. For Excel-based problems, a multiple trial and error macro included in the template that utilizes Excel's solver add-in can be employed. Alternatively, Excel or can be used to generate the variables and the data can be read by a program such as MATLAB to generate the solution set. A heat exchanger example taken from a Mechanical Engineering Heat Transfer course was solved using both methods and is available on the website. In this case, the iterative solution from the problem had already been programmed utilizing several functions within MATLAB. The MATLAB-based solution was modified so that the input data set was read from the Excel "Create" file. The solution set was calculated in MATLAB and written back into the Excel file. This is an example of the creator using the problem-solving application most comfortable and appropriate for the problem. Instructions on integrating the creation process with different applications will be included on the website.

Additional Thoughts

In addition to creating the quantitative part of the problems presented above, the authors feel that it is important for the problem creator to suggest some thought provoking metacognitive and reflective questions to promote higher order thinking skills. The structure of the variable parameter setup files is designed to make it easy for the educators to include these important questions as part of the assignment. Instructions on adding these types of questions are included on the web site.

The standardized problem creation template allows features such as the metacognitive questions to be systematically tested by educational researchers. The repository could then eventually represent a central place for educators to systematically test learning elements on students from many universities and collaborate on improving our collective homework system.

Conclusion

A crowd-sourced problem repository has been initiated. This repository will be freely available for instructors to query and use as well as submit numerical problems. An Excel template and associated macros make it relatively easy for educators, students and practitioners to create and contribute problems to the repository. The goal of this repository is to help educators in the STEM areas deliver quality, thoughtful problems to students with minimal additional effort on the part of the instructor. Various forms of the template have been used to create over seventy-five variable parameter problems within Chemical Engineering.

References

1. Herold J., Stahovich T.,& Rawson K., (2013) Using Educational Data Mining to Identify Correlations Between Homework Effort and Performance. Proceedings of the 2013 *American Society for Engineering Education Annual Conference & Exposition*. Paper ID 7074

2. Widmann, J., Shollenberger, K., & Kennedy, J. (2007) Student Use of Author's Solution Manuals: Effect on Student Learning of Mechanics Fundamentals. Proceedings of the 2007 *American Society for Engineering Education Annual Conference & Exposition.*

3. Walberg, H. J., Paschal, R. A.,& Weinstein, T., (1985) "Homework's Powerful Effects on Learning," *Educational Leadership*, 85 (42):76-79.

4. Lee S., & Klein, H., (2002) Relationship Between Conscientiousness, Self-Efficacy, Self-Deception, and Learning Over Time. Journal of Applied Psychology Dec; 87(6):1175-82

5 Georgieva B., (2002) New Approach to the use of Solution Manuals in the Teaching of Higher Mathematics, Proceedings of the 2nd International *Conference on the Teaching of Mathematics at the Undergraduate Level*, Crete, Greece

6. Gehringer E., & Peddycord B., (2013) Teaching Strategies when Students have Access to Solution Manuals. Proceedings of the 2013 *American Society for Engineering Education Annual Conference & Exposition.* Paper ID 6828

7. https://loncapa.msu.edu

8. Balascio C.C. (2015) A Dozen years of Asynchronous Learning: Using LON-CAPA for Online Problem Sets Proceedings of the 2015 *American Society for Engineering Education Annual Conference & Exposition.* Paper ID 11338

9. http://webwork.maa.org

10. Swanbom M. K. Moller D. W., Evans K., (2016) Open-Source, Online Homework for Statics and Mechanics of Materials Using WeBWorK: Assessment of Student Learning. Proceedings of the 2016 *American Society for Engineering Education Annual Conference & Exposition.* Paper ID 16092

11. Santoro K., Bilisoly R., Creating, Automating and Assessing Online Homework in Introductory Statistics and Mathematics Classes, JSM 2014 Section on Statistical Education (p1787 – 1798)

12. http://www.engr.uky.edu/~silverdl/apex.html

13. https://www.formuladesk.com

14. http://www.processutilities.com

15. http://www.polymath-software.com

16. http://www.learncheme.com

17. Wynne, R., Student Perception of Reflective Learning Activities (2010) Proceedings of the 2010 *American Society for Engineering Education Annual Conference & Exposition – Mid-Atlantic*

18. Turns, J., Sattler, B., Yasuhara, K., Borgford-Parnell, J. L., & Atman, C. J. (2014). Integrating reflection into engineering education. Proceedings of the 2014 *American Society for Engineering Education Annual Conference & Exposition.* Paper ID 9330

19. Chew, K., Chen, H., Rieken, B., Turpin, A., & Sheppard, S., (2016) Improving Students' Learning in Statics Skills: Using Homework and Exam Wrappers to Strengthen Self-Regulated Learning. Proceedings of the 2016 *American Society for Engineering Education Annual Conference & Exposition.* Paper ID 15770

20. http://turnitin.com