

# Education and business style innovation by COMSOL Apps

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**Abstract:** This paper investigates how to construct Apps via COMSOL Application Builder with simplest steps. We show some Apps constructed based on the procedure proposed here. It was shown that the present procedure can make effective Apps very easily and innovate lecture style and the relating business style.

**Keywords:** Web simulation, COMSOL Multiphysics, Application Builder.

## 1. Introduction

Computer science has become significant tool for design, research and development in many industries and universities. In high-level simulation area such as multiphysics simulation where many physics are coupled, in general, only professionals could handle such state-of-the-art simulation. In order to shorten the period spent for design and R&D or education, it is strongly desired to innovate the style of these activities. COMSOL application (abbreviated by Apps)[1] can be considered as a reliable tool for this innovation. Indeed, Apps can provide a simplified GUI for non-professional people. This means we can assign non-professional people to computation activity even if they do not know how to use multiphysics analysis tools. Professor Takano, Keio University, applied Apps for a simple FSI analysis in an undergraduate course on computational mechanics successfully[2]. However it seems that procedures by which developers of multiphysics simulation can tailor their Apps very easily, is not clear and therefore strongly desired.

In this research, we propose some prototype of COMSOL Apps and applied them to in-company training and assist educations in classroom of universities. It was shown that proposed prototype is well organized and very useful for making Apps. We believe Apps will innovate education/training, and R&D as well as our business.

## 2. Proposed procedure for designing Apps

Since we have assisted lecture in universities many times, we thought that the lecture should be more effective if Apps were introduced. However, it was too difficult for a lecturer to learn how to make Apps with reading the manuals. So, we decided to advocate the aim to propose the simplest procedure for designing the prototype of Apps. The guidelines we should proceed along are as followings.

- (i) Apps should be operated intuitively just by reading the screen of Apps.
- (ii) Design of the screen of Apps should be simple and compact.
- (iii) What if-analysis part could be included into Apps.
- (iv) Computed results can be extracted for reporting.
- (v) Basic procedure making Apps should be constructed only with GUI.

First, we will discuss on the realization of the item (v). After several try and error process, we decided to limit our procedure within simplest one, which are proposed here as shown in Table 1.

Table 1. Procedure for designing Apps based on Forms.

Step1	Forms > New Form > OK to make form_1.
Step2	Duplicate form_1 to get form_n (n=2~N). The case of N=5 is explained here.
Step3	Edit form_1 and select Form Collection
Step4	Select form_2 to form_5 as Panes.
Step5	Edit form_n (n=2,3,4,5) and attach objects etc.

Detailed illustrative explanation of the procedure is shown in Fig.1. (see page 3) This procedure completes Apps with several tabs, for which user can follow step by step.

This procedure is simple and clear and is constructed with minimum steps which can be considered as a sufficient tool for education/training and rapid circulation of R&D.

Through this procedure the realization of the item (ii) is achieved automatically.

What if-analysis is very important for both education and R&D. For the realization of item (iii), new tabs for What if -analysis can be added easily along the above mentioned procedure. What if-analysis frequently changes input parameters and boundary conditions. Application builder can handle the change of input parameters with input field and the change of boundary selection with data access and selection list. User can easily include the input fields necessary for What if-analysis into Apps. The procedure steps are shown in Table 2. The detail illustration of explanation on this topic is shown in Fig.2. (see page 3)

For the realization of item (i), manual-less usage of Apps should be recommended. Insertion of Text is available via Insert Object function of Application Builder. Illustration by images sampled from experiment, power point or discussion on the whiteboard, is very useful and should be included into Apps. This also can be done in Apps with png images and the following simple steps.

Table 2. Inclusion of png images.

Step1	Prepare png-type file
Step2	Libraries > Images > +(add) your png
Step3	Edit form_i > Insert Object > Image > Select your png in Step 2

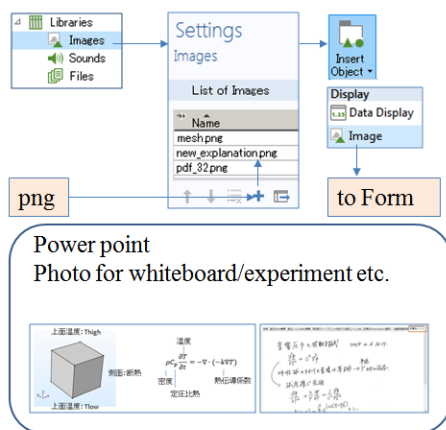


Figure 3. How to include images into Apps

For the realization of item (iv), when inserting Graphics via Insert Object function, Application Builder attaches image snapshot function and printer function with the corresponding icon as default settings as shown in Fig.4. Therefore the item (iv) is done automatically.



Figure 4. Controls added automatically for extracting results from Apps.

### 3. Application and discussion

Some fundamental examples[3] will be introduced in this section to show proposed concept for designing these Apps. First, an example for university is introduced. For non-professional or first-met-computation people, explanation of the job sequence of CAE is very important. When clicking tabs on the tabs one by one, they automatically learn the standard job sequence from preprocessing, solving and postprocessing of CAE.

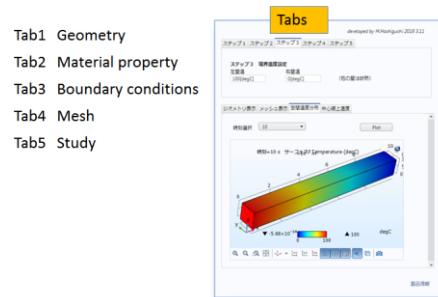


Figure 5. Explanation of work flow of CAE.

We have offered our procedure for making Apps to university people and they have started to introduce Apps for active learning. Active learning means the student can get their hands on the material of education prior to the class. This also means the lecturer can spend/focus more time in classroom to essential part which he/her should carry out. Figure 6 shows an example of heat transfer Apps. As a preparation of the class, for example, students can use this Apps to examine what the heat transfer equation is. Furthermore, student can observe how the time-dependent temperature distribution is affected by changing the input parameters or boundary selection. Also, changes of heat flux vectors, can be easily visualized when adding heat

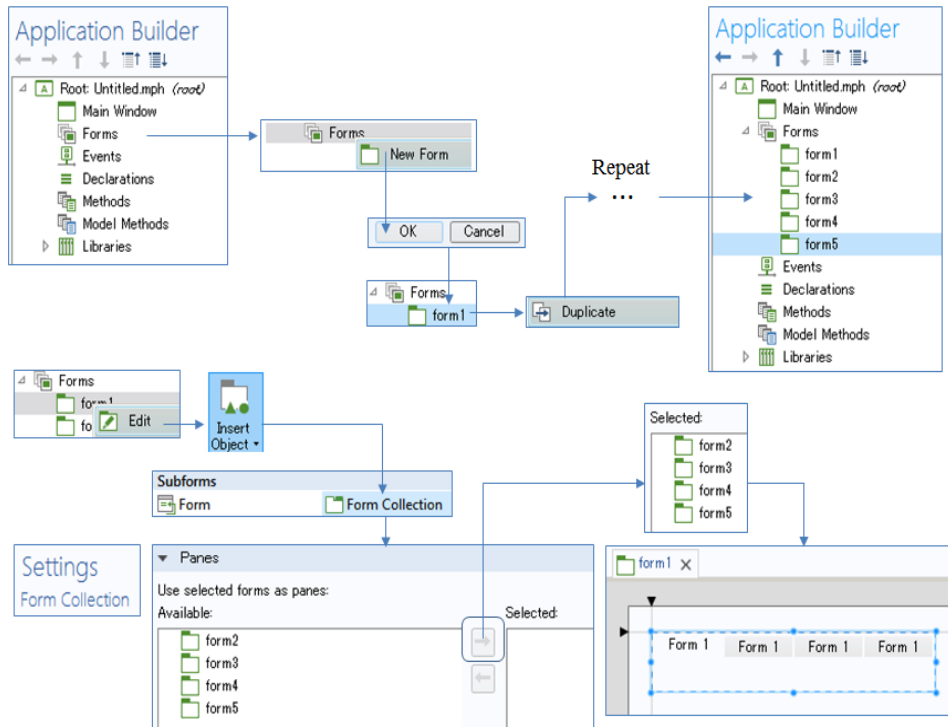


Figure 1. How to construct the simplest and effective Apps.

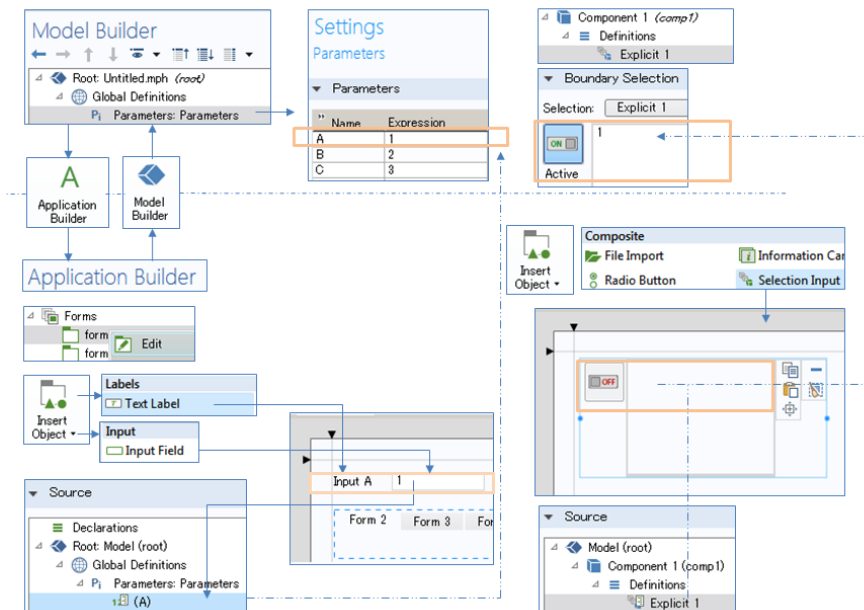


Figure 2 How to change input parameters and boundary selections

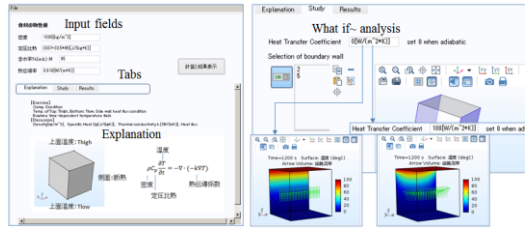


Figure 6. Example of Apps for active learning for heat transfer.

transfer wall condition via boundary selection and corresponding input as shown in Fig.6.

Understanding of Heat flux vector field is very significant when discussing heat transfer problem.

Second example shows that we can use Apps for non-professional people belong to sales division as in-company education tool.

The first thing need to be taught is V & V - Verification and Validation-, which is very important for sales people as well as engineer.

When we apply computer simulation, we have to verify the software prior to actual application. Figure 7 shows an Apps we developed for verification. This is acoustic sound emitted from a pulsating small sphere which has exact solution. The numerical solution of COMSOL Multiphysics coincides with the exact solution.

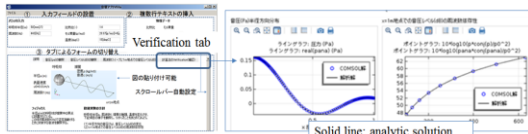


Figure 7 Example of Apps for verification .

For the validation example, we treat a practical problem. In tunnel excavation, TNT is used to tunnel mountain. The blast of TNT causes acoustic sound emission from the entrance of tunnel under construction and harms neighborhood with low frequency vibration although the sound noise barrier set within the tunnel. Acoustic resonance tube shown

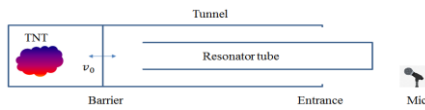
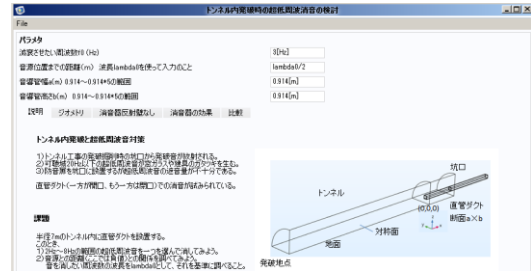
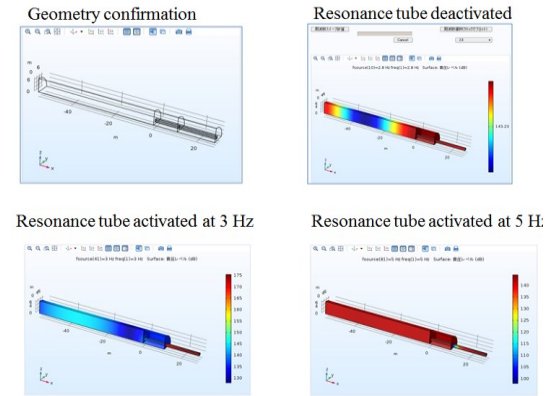


Figure 8. Resonator tube used to reduce acoustic sound noise due to excavation of tunnel.

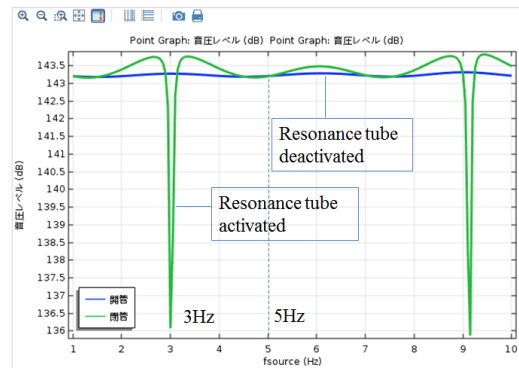
in Fig.8 is useful to remove the specified component of acoustic noise emitted from the entrance of tunnel[4]. The physics is very simple and significant from the point of view of



(a) Main Form



(b) Geometry confirmation and effect of resonance tube.



(c) Sound pressure level v.s. noise source frequency.

Figure 9. Developed Apps for discussing acoustic noise reduction for tunnel excavation using TNT.

environmental assessment. We developed an Apps for observing the physics included in this problem and explore the way to remove the noise component as desired, shown in Fig.9. The behavior of the solution is plausible. First the user of this Apps set (Fig.9(a)) and confirm geometry configuration in geometry tab as shown in Fig.9(b). Secondly the user can see the sound pressure level v.s. noise source frequency shown in Fig.9(c) and he/she will notice that there is a big difference between with/without resonance tube. Then the user can visualize three-dimensional sound pressure field as shown in Fig.9 (b) and understand the reason of such big discrepancy. In actual application, many resonance tubes of different geometrical sizes are used for the reduction of noise of various noise source frequency.

Furthermore we constructed the system consists of COMSOL server within our KESCO's seminar room as shown in Fig. 10.

It was shown that non-professional people can use Apps easily and we can save the time for education. Furthermore they eager to feed back to the lecturer about the Apps. In fact, we could improve the contents of Apps, e.g., with addition tab for explanation of professional terms and tab for the explanation of fundamental equations. We discussed the formulation of the physics using the whiteboard, and then took the photo and convert it to png in order to attach it to the Apps. For education in the universities, it was



Figure 10. In-KESCO training for sales people by using Apps and COMSOL Server.

found that Apps can save time for the explanation of software GUI and students could try to tackle real computational science problem.

## 4. Conclusions

In this paper, we proposed the simplest procedure for making Apps and exemplified some Apps based on the procedure proposed here.

It was found that the Apps developed here proved the effectiveness of our procedure when making Apps and we can innovate the style in both education and relating business when coupling Apps and COMSOL Server, in particular, R&D could be assisted, accelerated and solidified based on feedback from various people who use Apps, including sales people as well as engineers.

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