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Research Article

Regression Analysis Approach for Mathematical Model Development in Dynamic System.

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Abstract:

We proposed an approach using multiple regression analysis to develop a mathematical model that represents a dynamic manufacturing system. Simulation data are specifically analyzed using this multiple regression analysis approach to obtain a data pattern. The aim of the approach is to reduce the gap between theory and real-time data of the system. To evaluate the effectiveness of the proposed mathematical mode, simulation model was first validated using real-time data. The applicability of the proposed mathematical model was evaluated by testing with real-time data. The outcome +positively demonstrated that the develop mathematical model based on multiple regression analysis approach can be used to make predictions in the dynamic manufacturing environment with an acceptable error percentage range. The mathematical development in this field will enhance the future establishment of a decision-making model using a spreadsheet in the management field.

Key words: Multiple regression analysis; Dynamic manufacturing system; Mathematical model; Decision making model.

Introduction

Mathematical modelling in dynamic producing system needs a good approach to slim the gap between theory and observe of the model's application (Mule et al., 2006). A survey of connected literature has indicated the likelihood of employing an information pattern, like fault pattern variable, to formulate a mathematical equation to represent a dynamic producing surroundings system (Li, 2007). In general, the most objective of this approach is to spot a possible methodology to link information pattern to a mathematical equation for application. variety of methodologies for developing mathematical model within the system are obtainable, and one in every of these methodologies is that the application of multiple correlation analysis within the model. Associate in Nursing example of such work is out there in (Li, 2007), and this previous work showed that it's doable to develop mathematical model victimisation practical regression approach.

The challenge of making a mathematical model with a little error comparison victimisation simulation and period information has been addressed (Chinchilla et al., 2004; Muhammad Marisa et al., 2009). Mathematical model development and simulation are used at the same time in analysis papers. In distinction to simulation, mathematical model still plays a very important role during a dynamic producing system. Mathematical model applications in numerical analysis and programme models are a typical observe within the field (Boudin teal., 1992; Jennifer Robinson et al., 2003; Susan Cole and Jennifer Rowley, 1996). within the work of (Al-Zuberi et al., 2012), the realm of dynamic producing surroundings study is on walking employee line. The authors worked on rising the decision-making method by employing a mathematical model and simulation.

The authors (Al-Zuberi et al., 2012) compared the anticipated results from simulation model and mathematical model together with the error price between the model's victimisation root-mean sq. (RMS). alternative researchers (Cao, Z et al., 2012; Cathay et al., 2003; Zhang et al., 2014) have explicit that semiconductor method is that the most complex producing system concerned during a dynamic system. during a previous study (Cao et al., 2012), a bottleneck prediction mathematical model that's supported Associate in Nursing improved adaptation network-based fuzzy reasoning system (ANFIS) has been planned. The prediction accuracies from simulation and mathematical models were analysed (Cao et al., 2012). (Cathay, B et. al., 2003) given a mathematical model for multipored tool capability coming up with in semiconductor producing.

The planned model is valid victimisation process experiments victimisation Lag range a based heuristic answer procedure, that is coded in C-programming language (Cathay et. al., 2003). (Jaconine et al., 2014) given 2 production coming up with approaches victimisation mixed-integer programming and heuristics ways to appreciate a step toward the event of capability coming up with at a finite capability in semiconductor producing. No validation activity has been given for the planned models within the study (Jaconine et al., 2014). (Jaconine et al., 2014) used CAPACE and ILOG CPLEX thinker software package to produce and analyse the result from the developed models. Mathematical model formulation victimisation information pattern analysis has been conducted antecedental (Li, 2007). (Li, 2007) given that a model-based reception and estimation approach may be applied, and therefore the method may be described by an appropriate dynamics model (either within the type of state space or transfer function).

The author (Li, 2007) studied the information pattern and developed the mathematical model as a regression model that may be accustomed build predictions by employing a practical regression methodology. (Faraway, 1997) noted

that the practical regression approach is appropriate once the response variable for prediction is practical. The author (Li, 2007) failed to perform validation on the regression model Associate in Nursing incontestable the planned model victimisation an example from the resistance spot attachment method mentioned in previous studies. An antecedental revealed review (Zhang et al., 2014) indicates that the variable regression approach tends to be a lot of convenient once input file are noise or once the complicated relationship among the input variables isn't totally understood. (Zhang et al., 2014) cited the work of (Wang and Mallacoota, 1992) and (Malhotra et al., 1999) as a result of this approach is wide employed in analysis strategy and is evidenced to be effective and adaptation. during this paper, we have a tendency to any extended the work of another research worker (Li, 2007) on totally different dynamic producing environments.

The approach we have a tendency to adopted was to use an information pattern from a simulation model to formulate a mathematical model via regression methodology. Our definition of dynamic producing system is product movement from the primary method to the last method in Associate in Nursing assembly semiconductor. a groundwork during a literature info indicated the shortage of data associated with the event of mathematical model during this outlined dynamic system. Hence, we have a tendency to are the primary to figure during this space to produce extra info by extending the results of the same study (Li, 2007). The organization of this paper is delineating as follows. Section a pair of discusses Associate in Nursing approach that uses multiple correlation analysis to formulate the mathematical equation of the system. Section three develops the paper's downside formulation. the small print of the planned model and its validation are given in Section four. In Section five, period case study from the information assortment time-frame is tested within the planned model, and results are mentioned and analysed. Conclusion and suggestions for any work are given in Section half-dozen.

An approach using multiple regression analysis:

Fig. 1 illustrates the process flow chart of the approach using multiple regression analysis to develop a mathematical model.

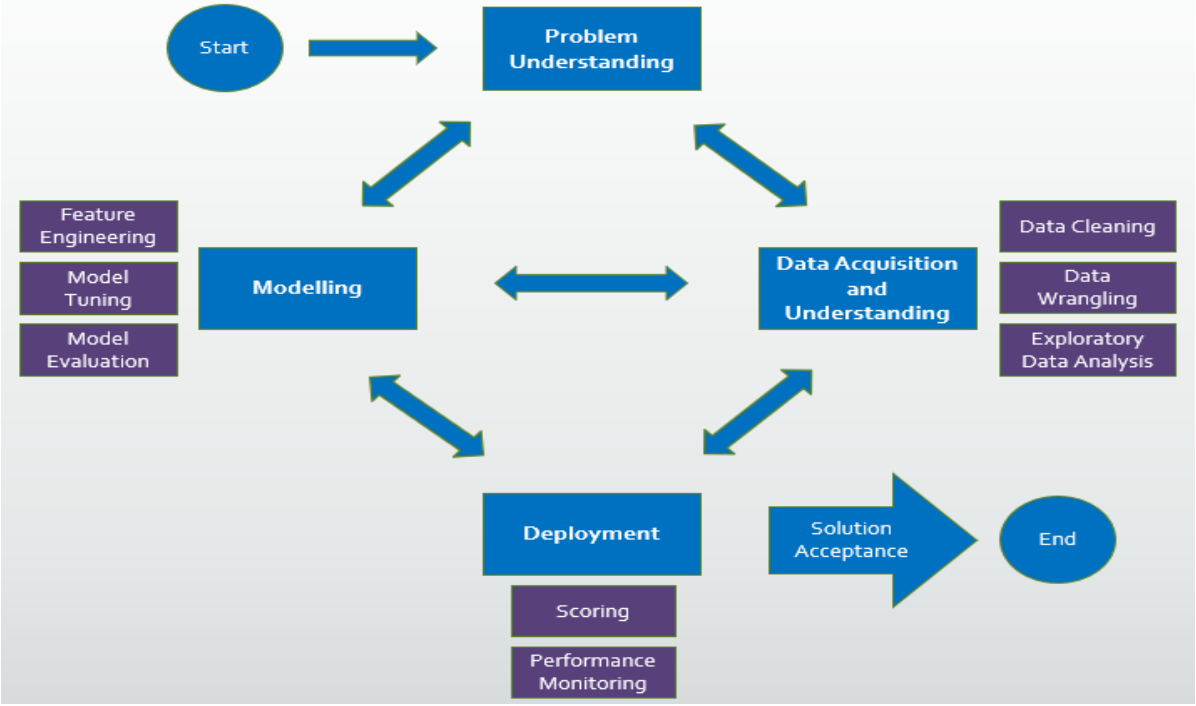

Fig. 1: Approach using multiple regression analysis to develop a mathematical model.

The paper began with period information assortment for input variables. the information was analysed exploitation JMP computer code to suit into most fitted data distribution on two level issues for nine input variables supported ninety fifth confidence interval and one three level factor for batch amount. A simulation model was designed exploitation Pro-Model, and input variable information square measure inserted into the model. Model validation activity had to be addressed to confirm its accuracy as an illustration of a true system (Martens, J et al., 2006). This paper's simulation model validation was performed by exploitation historical information technique. (Sargent, 2011) represented this system to check whether or not simulation model behaves because the system will.

An applied math t-test was wont to validate the model with period information on individual processes. once the simulation model was valid, a sample of completion time of thirty batches for every run was collected. there's total of one536 runs within the style of experiment table exploitation full factorial with 1 replication run. one replication run one full issue study is even as every factor of every level square measure coated within the style of experiment

table for the information assortment of completion time. the total factorial style is applied within the table as this can be the primary study to develop mathematical model exploitation multiple correlation approach on a producing system and check it with period information exploitation this approach. for every run, a median of total thirty batches are calculated and inserted into JMP computer code. Then, the constant and constant of every input variable were obtained exploitation JMP analysis. once the equation was established, the equation was tested by activity a comparison between prediction analysis and real time information (case study).

Problem formulation:

We examined associate example from semiconductor producing as a case study in Fig. 2. The configuration of the method is as follows: three die attach machines, one continuous accessible kitchen appliance cure machine, nine wire bond machines, and three pre-cap scrutiny machines.

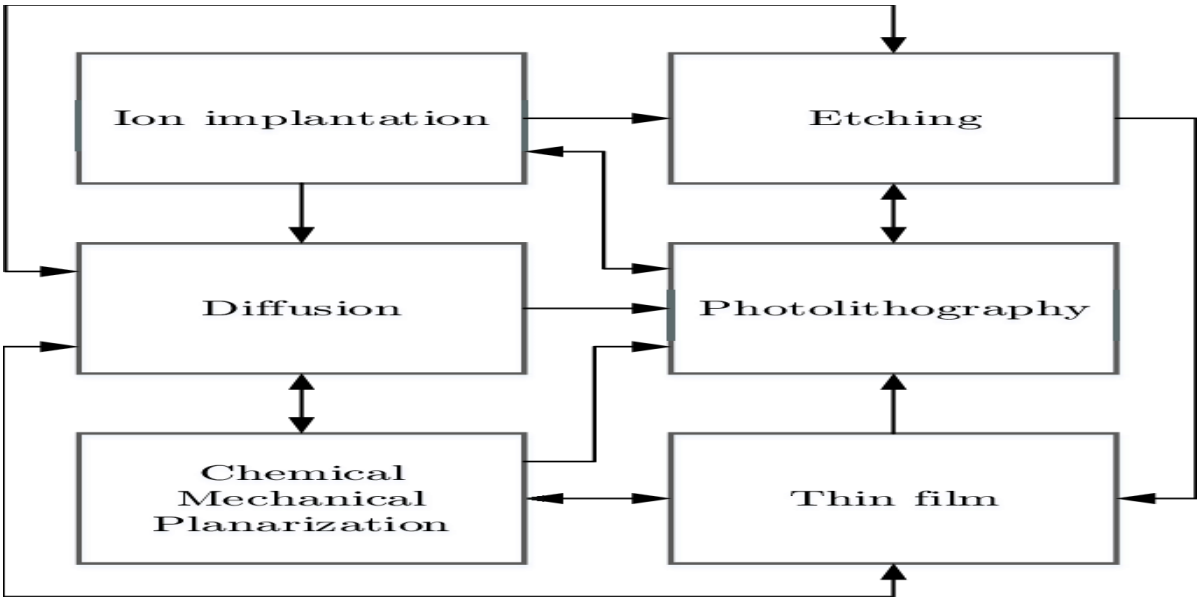

Fig. 2: Semiconductor manufacturing process flow.

The response variable is completion time with eleven input variables as follows: cycle time per unit (Die Attach), cycle time per unit (Wire Bond), cycle time per unit (Pre-Cap Inspection), machine period of time period (Die Attach), machine period of time period (Wire Bond), machine period of time frequency (Die Attach), machine period of time frequency (Wire Bond), setup time period (Die Attach), setup time period (Wire Bond), batch amount, and cycle time per batch (oven cure). The task was to perform multivariate analysis on the info pattern of completion by employing a combination of two and three level factors of input variables. a complete of 1536 runs from a full factorial style of associate degree experiment table exploitation (29 x 31) were performed exploitation professional Model package to gather completion time knowledge. 3 level factors for batch amount consisted of 2200, 3080, and 11264 units per batch, that were obtained from the assembly.

In multivariate analysis, the completion time may well be drawn as a perform of input variables as per equivalent. 1, and decibel may well be drawn because the distinction between Tb and Tb-1 in equivalent. 2. The annotation accustomed justify the regression model is represented below: Tb = average completion time per batch, b decibel = totally different between completion time per batch current minus completion time per batch previous (flow time of batch b) CTDA = cycle time per unit (Die Attach) / unit = seconds CTWB = cycle time per unit (Wire Bond) / unit = seconds CTPC = cycle time per unit (Pre Cap Inspection) / unit = seconds DDDA = machine period of time period (Die Attach) / unit = seconds DDWB = machine period of time period (Wire Bond) / unit = seconds DFDA = machine period of time frequency (Die Attach) / unit = minutes DFWB = machine period of time frequency (Wire Bond) / unit = minutes STDA = setup time period (Die Attach) / unit = seconds STWB = setup time period (Wire Bond) / unit = seconds BQ = batch amount / unit = amount CTOC = cycle time per batch (Oven Cure) / unit = seconds a1 = constant of CTDA a2 = constant of CTWB a3 = constant of CTPC a4 = constant of DDDA a5 = constant of DDWB a6 = constant of DFDA a7 = constant of DFWB a8 = constant of STDA a9 = constant of STWB a10 = constant of BQ a11 = constant of CTOC k = constant within the equivalent. 1. Tb = k + a1CTDA + a2CTWB + a3CTPC + a4DDDA + a5DDWB + a6DFDA + a7DFWB + a8STDA + a9STWB + a10BQ + a11CToc (1) decibel = Tb – Tb-1 (2)

R-squared tends to reward you for together with too several freelance variables in an exceedingly regression model, and it doesn't offer any incentive to prevent adding additional. Adjusted R-squared and foretold R-squared use completely different approaches to assist you fight that impulse to feature too several. The protection that adjusted

R-squared and foretold R-squared offer is crucial as a result of too several terms in an exceedingly model will manufacture results that you simply can't trust. These statistics assist you embody the right variety of freelance variables in your regression model.

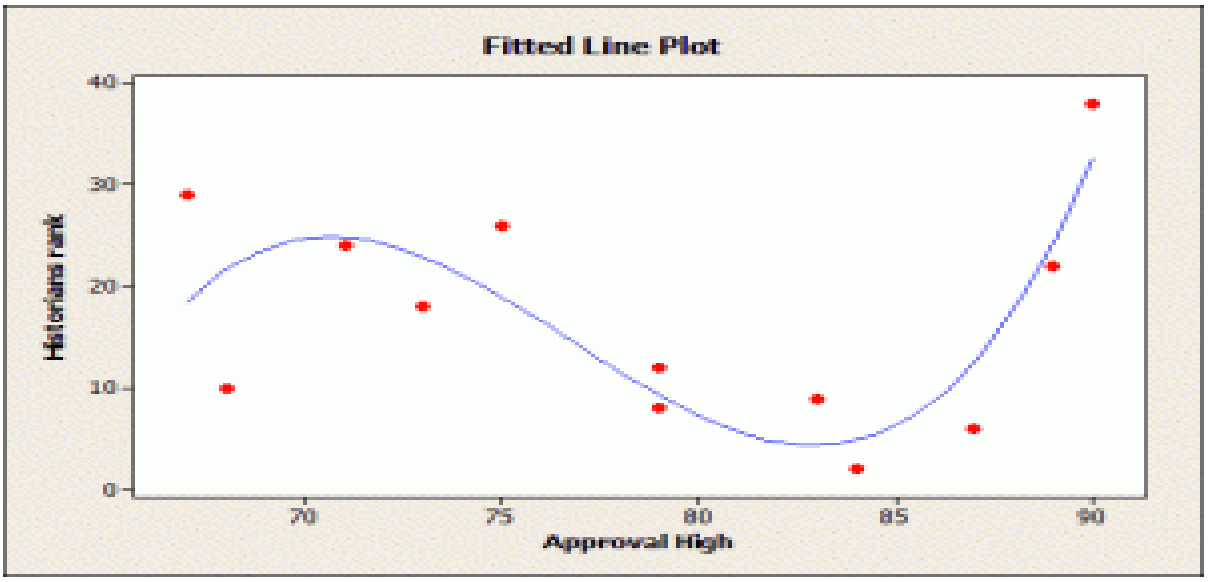

FIG.3: will this graph show associate degree actual relationship or is its associate degree overfit model? This web log post shows you ways to create this determination.

Multiple regression analysis will seduce you! Yep, you scan it here initial. It's associates improbably tempting applied mathematics analysis that much begs you to incorporate extra freelance variables in your model. on every occasion you add a variable, the R-squared will increase, that tempts you to feature additional. a number of the freelance variables are going to be statistically vital. maybe there's associate actual relationship? Or, is it simply an opportunity correlation?

You just pop the variables into the model as they occur to you or simply as a result of the information are promptly on the market. Higher-order polynomials curve your regression curve any that manner you would like. But, are you fitting real relationships or simply taking part in connect the dots? in the meantime, the R-squared will increase, naughtily convincing you to incorporate however additional variables!

Adjusted R-squared

1. Use adjusted R-squared to compare the goodness-of-fit for regression models that contain differing numbers of independent variables.
2. Let's say your scrutiny a model with 5 freelance variables to a model with one variable and therefore the 5 variable model encompasses a higher R-squared. is that the model with 5 variables truly a higher model, or will it simply have a lot of variables? to work out this, simply compare the adjusted R-squared values!
3. The adjusted R-squared adjusts for the number of terms within the model. significantly, it's worth will increase only the new term improves the model match over expected inadvertently alone. The adjusted R-squared worth truly decreases once the term doesn't improve the model match by a comfortable quantity.
4. the instance below shows however the adjusted R-squared will increase up to a degree so decreases. On the opposite hand, R-squared merrily will increase with every and each further experimental variable.

Vars	R-Sq	R-Sq(adj)
1	72.1	71.0
2	85.9	84.8
3	87.4	85.9
4	89.1	82.3
5	89.9	80.7

5.
6. during this example, the researchers would possibly wish to incorporate solely 3 freelance variables in their regression model. My R-squared journal post shows however associate degree under-specified model (too few terms) will manufacture biased estimates. However, associate degree over specified model (too several terms) will cut back the model's preciseness. In alternative words, each the constant estimates and expected values will have

larger margins of error around them. That's why you don't wish to incorporate too several terms within the regression model!

The Eq. three indicates the flow time of a producing system. Simulation activity results showed that the dB worth is zero within the long haul as a result of tb and tb-1 were nearly constant. This pattern of the simulation result was most likely thanks to the configuration setting of the method during this study. The multivariate analysis approach was found within the literature, and this paper used further variables, like setup and machine time period with validation method mistreatment completely different producing environments. The extension work mistreatment this approach includes the event of a strategy that uses simulation, style of experiment conception, and applied mathematics tool analysis to derive a mathematical model. This approach is an alternate possible means of finding a mathematical model within the setting of a configuration method. though the approach isn't new, the methodology isn't usually applied to producing observe. The novelty of this paper is to indicate the approach that uses multiple correlation analysis to develop a mathematical model to represent dynamic producing surroundings. Our work contributes towards introduction of a possible methodology to formulate a mathematical equation in dynamic producing surroundings. Our results can profit the long run model work by different researchers, and that we list benefits within the following statements. the primary advantage is to modify the model to perform prediction in an exceedingly time period system with an appropriate error margin. The second advantage is that the development of a possible approach to create a model mistreatment multiple correlation analysis technique while not moving configuration.

Mathematical Modelling of Dynamic Systems:

Energy systems convert and store energy from a range of physical domains, like mechanical (e.g., flywheel), electrical (e.g., ultracapacitor), hydraulic (e.g., accumulator), chemical (e.g., gasoline), thermal (e.g., ice storage), (strong) nuclear (e.g., the energy binding a U nucleus), economic (e.g., bank account) and additional. As such, engineers and scientists need a typical framework for describing and analysing energy systems. This common framework is arithmetic, and that we check with our description of the dynamic energy systems as a mathematical model. One should perceive that a mathematical model is, at best, a surrogate for the physical system, whose exactitude is subject to the assumptions and needs created by the energy systems engineer. To quote eminent statistician Rd. George E. P. Box (1919 – 2013): "Essentially, all models square measure wrong, however some square measure helpful."

Method:

This study used development analysis ways developed by Akker, et al. [14] consisted of three stages, particularly analysis, style and analysis. within the analysis step, student analysis, programme and mathematical modelling are applied. The second step designed and created (Mathematical modelling). the ultimate step used a formative analysis style (Figure 1) consisting of self-evaluation, one-to-one, professional review, tiny cluster, and field tests [15, 16]. This study was solely conducted till the little cluster part. The success criteria of this study used the shape of Mathematical modelling for learning modelling that was valid and sensible for college students.

The validity was obtained from the validation of specialists and also the usefulness was obtained from the students' opinions and observations of the little cluster and onto-one. usefulness means that straightforward to use, explainable, and unambiguous. the themes of this study were students of SMP Negeri vi Kaya gum, Organ Homering Ilia District, South Island. The techniques of collection the info was (1) rehearse supported the professional review to induce a sound mathematical modelling downside in content, construct and language aspects. (2) interview derived from one to 1 and little cluster to search out the usefulness of the matter. The collected information was analysed victimisation descriptive analysis method: (1) rehearse sheet analysis supported the expect comments in professional review to induce valid mathematical modelling problem; (2) analyse the results of the review in one to 1 and little cluster to induce usefulness.

The Traditional Approach to teaching arithmetic isn't sufficient for strengthening student problem-solving skills and so cannot facilitate students to develop ability in maths and application [17, 18, 19]. within the ancient approach of learning there have been a lot of emphases on the mechanistic and con solutions and operations of arithmetic. as an example, consistent with Bahmaei [20] in elementary faculties normally, early arithmetic teaching cantered on process skills. Further, it's conjointly supported by the assertion that the results of ancient approaches in arithmetic square measure mechanistic or reminding of solutions to story drawbacks/word problem [21, 22]. moreover, consistent with Kulkarni [23] in ancient programs, objectives square measure classified as low-level goals supported the abilities of formulas, straightforward algorithms, and definitions. Busting [24] state that learning method not solely takes place at intervals people themselves, however it conjointly involves the social interactions among them. moreover, within the ancient approach, students solve while not understanding the matter [25], additionally as in ancient dominant learning ways the dominantly determination issues rummage around for keyword interpretation instead of thinking deeply regarding the matter [17, 26].

The supported this it's necessary to own a brand-new learning approach. supported the study conducted by Mousselines [27] it recommends that the event of a lot of specific drawback determination ways (modelling process) is required. moreover, Kulkarni [28] states that their square measure four steps of doing arithmetic or the employment of arithmetic in standard of living square measure distinctive wherever maths is applied, dynamical the sensible drawback into a drag or mathematical model, determination maths issues, and decoding and evaluating the obtained results. moreover, Sulked [28] states that in the main focus of arithmetic education is in step three it will all be done by a laptop. Thus, the main focus of arithmetic education is very important to manoeuvre on to the opposite 3 steps.

It conjointly implies that their square measure wants for innovation in arithmetic learning in faculties so as to attain ability or skills within the digital community. this is often in accordance with Kulkarni's [28] statement that mathematical ability is thought in arithmetic education because the ability needed for the digital community: application or modelling, understanding and checking. In alternative words it's vital to use the modelling ability in arithmetic education in faculties. moreover, walking on air [5] states that modelling in pre-kindergarten up to grade eight could be a thanks to float and maintain the mathematical disposition of scholars to arithmetic. this is often in line with Grave Meijer [29] assertion that there's a bent to shift mathematical learning approaches in arithmetic education in primary faculties from "knowledge transfer" to "construction of knowledge" and conjointly this definitely happens in junior high school faculties.

This fits absolutely with learning by modelling. this is often conjointly supported by walking on air [5] that mathematical modelling ought to be instructed in each level of student math education. Mathematical modelling (the method of translating between the important world {and arithmetic and arithmetic} in each directions) could be a topic in mathematics education that's most mentioned and developed over the previous few decades [1]. Every day the teaching of arithmetic in several countries is incredibly few with modelling, and this is often thanks to the very fact that the modelling is tough for lecturers [1]. conjointly Suharto [30] states that it's difficult for an educator to facilitate all the students' wants by giving a personal coach for each student within the category. Then, historically.

students were not introduced Mathematical modeling through junior high schools [10]. Furthermore, Mathematical modeling is not formally introduced at the school level in Indonesia [13]. In fact, Mathematical modeling should be and could be started early, when students already have basic competencies then modeling can be developed [11, 12]. It is also supported by Bliss [5] that Mathematical modelling should be taught in every level of mathematics education. On the Competency Standards of the 2013 Curriculum students must have 21st Century Skills [31].

The 21st century skills are creativity and innovation, critical thinking and problem solving, communication and collaboration which are all accessible via modeling [5, 32-34]. This study conducted the designing process of mathematical modelling problem in Realistic Mathematics Education which was valid and practical, i.e., on linear equation material and system of linear equation of two variables which were recommended to be done in small group and field test further. With small groups and field tests it can be obtained mathematical modelling problem that has a potential effect [23, 35]. In this case researchers conducted the small groups and field tests further to obtain valid and practical mathematical modelling problems, had potential effects, and could prepare students having 21st century skills and improve their high-order thinking skill (HOTS) according to the hope of revised edition of 2013 curriculum. This study as a continuation of the study Mouselides [27] that study about to develop a smaller and more focused theoretical model and modeling as problem -solving activities for teaching, learning and development in Elementary and junior high school. This study about how to design mathematical modeling in realistic mathematics education in junior high school. Moreover, this study also relates to Kulkarni [23]

Conclusion and future work:

In this paper, an approach that involved the use of multiple regression analysis was proposed for the mathematical development in a dynamic manufacturing system. The main goal of this mathematical model was to introduce a method for model development to narrow the gap between theory and practice in a dynamic manufacturing environment. The effectiveness of the proposed mathematical model was evaluated using real-time data. The result between proposed mathematical model and real-time data showed positive effects when considering data from previous literature. Results showed that the model is satisfactory and acceptable and can be used to make predictions. Future studies need to focus on improving the error percentage between the mathematical model and real-time data and on enhancing the methodology for mathematical development in this field. Our results can be used to continuously enhance the proposed model and to apply the model to real-time dynamic manufacturing systems in the future.

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