



## Proposed model and strategy for Indonesian higher education facing technological disruption and Industrial Revolution 4.0 using Newton's Laws analogy



Erkata Yandri<sup>1\*</sup>, Sparisoma Viridi<sup>2</sup>, Rizal F. Hariadi<sup>3</sup>

<sup>1</sup>Graduate School of Renewable Energy, Darma Persada University, Indonesia

<sup>2</sup>Department of Physics, Faculty of Mathematics and Natural Sciences, Institut Teknologi Bandung, Indonesia

<sup>3</sup>Department of Physics, Arizona State University, US

### Abstract

All economic sectors in the world cannot be separated from the challenges of facing an era of technological disruption and the Industrial Revolution 4.0 (TD4IR). As centers of higher education, campuses also cannot escape from this difficult situation. Many studies have discussed the impact of TD4IR on higher education, unfortunately, without a detailed strategy for dealing with it. The global issues were analyzed using a physical approach, such as Newton's laws. Our study's purpose is to evaluate a strategic principle that Indonesian colleges can use to prepare for TD4IR. We applied Newton's analogy system to strategic management, then modeled with the derivation of the formula, followed by modeling with the simulation, to determine the changes that higher education would need to make in response to Industrial Revolution 4.0. Acceleration and deceleration scenarios are implemented with a square or cube increase or reduction. From the modeling, the parameters of Newton's laws, such as mass, friction (barriers to change), force (internal assets as a driving force), etc., must be properly matched to the idea of strategic management of higher education to give a clear picture of the problems. From the simulation, higher education needs to know the minimum value of its organizational system so it can figure out what needs to be done right away. The organization doesn't suddenly slow down or stop; higher education needs to speed up as much as possible.

This is an open access article under the [CC BY-SA](https://creativecommons.org/licenses/by-sa/4.0/) license



### Keywords:

Driving forces;  
Education management;  
Higher education;  
Scientific collaborations;  
Strategic management;

### Article History:

Received: May 2, 2019

Revised: May 29, 2019

Accepted: June 2, 2019

Published: June 2, 2019

### Corresponding Author:

Erkata Yandri

Graduate School of Renewable Energy, Darma Persada University, Indonesia

Email:

[erkata@pasca.unsada.ac.id](mailto:erkata@pasca.unsada.ac.id)

### INTRODUCTION

All sectors in the world are currently experiencing great shocks and challenges as they enter the era of technological disruption and industrial revolution 4.0 (TD4IR) [1][2]. To better understand this situation, let's discuss what TD4IR means. Technological disruption is defined as a fast change in technology as a result of the Internet of Things (IoT), autonomous devices, artificial intelligence (AI), rich media (virtual and augmented reality), producing smart environments, and revolutionizing industry structures, and processes [3]. While, the industrial revolution 4.0 is defined by the creation

of new products, procedures, and services, as well as the widespread use of intelligent networked systems. [4]. The scale and intensity of the problems faced by each organization in each sector are certainly relatively different. However, in general, they have the same goal, to survive and get through this difficult situation. The right strategy is required to win against TD4IR,

Higher education institution, cannot be separated from facing this situation [5][6]. The higher education sector in the ASEAN region has anticipated the situation, but questions remain concerning the institutions' management and financial preparedness [7]. The competition

among campuses in getting and preparing the younger generation, especially in Indonesia, will certainly be tighter [8].

Researchers from all over the world have been drawn to the issue of higher education in dealing with TD4IR. Publications on this issue are increasing from year to year. In general, three topics are discussed. First, give an overview with an impact analysis [9]–[11]. Bonfiel et al. [9] examined the digital revolution's effects on higher education and the future of curriculum delivery. Nugraha et al. [10] put forward higher education students that study management, including empathy, compassion, and other humane qualities. Abad-Segura et al. [11] looked at how digital transformation affects the education sector and how sustainable management can adapt to new technologies.

Second, analyzing readiness and modeling [12]–[17]. According to Teng et al. [12], the university curriculum enhances student soft skills and supports the relationship between soft skills and student job readiness. Maria et al. [13] showed that the Malaysian government is aware of and preparing for TD4IR and education 4.0. The lecturer competencies that must be achieved right away were highlighted by Sitepu et al. [14] including educational competence, research, technology commercialization, future strategy, counseling, globalization, and collaboration. Lack of knowledge utilization, information, quality of knowledge sharing, and network distribution are four new criteria discovered by Sardjono and Firdaus [15] that influence the readiness for the deployment of the knowledge management system. Hartati et al. [16] offered a formulation to examine the university's preparedness for the TD4IR era using the Cobit 5 Framework, which combines a descriptive and qualitative approach. Nurhasan et al. [17] assessed a university's readiness for TD4IR and advised integrating higher education strategy to industry demand.

Finally how the strategy should handle the TD4IR [18, 19, 20–27, 28, 29]. Lee et al. [18] suggested expanding the open innovation culture and the feedback loop of an open platform business model. Based on the facts of Indonesia's education system, Lukita et al. [19] proposed the competencies required in the integration of education management and the TD4IR to be presented in a comprehensive curriculum. Jackson [28] examined the historical processes in higher education, found three reoccurring faults, and related them to absorptive capacity. Li et al. [29] created a digital learning ecosystem model to comprehend the requirement for a digitally resilient higher education system and produce graduates who

can handle upheaval and uncertainty. Miranda et al. [20] offered new educational paradigms, teaching tools, learning processes, and infrastructures to shape Education 4.0. Supriyanto et al. [21] suggested Kaizen as a continuous improvement approach to improve the quality and productivity of education. To improve the standard of education, Prestiadi et al. [22] envisioned the crucial role played by visionary leadership in Total Quality Management 4.0. to create a road map for the modernization of higher institutions, Alzahrani et al. [23] utilized the Quality 4.0 tools and methodologies along several different axes. To address the 4IR, Ramirez-Montoya et al. [24] characterized a professor as a specialist with skills in creativity, problem-solving, teamwork, entrepreneurship, an international viewpoint, leadership, and societal demands. Kipper et al. [25] proposed the key competencies required by professional education, such as knowledge of current fields, leadership, strategic vision, self-organization, giving and receiving feedback, proactivity, creativity, problem-solving, interdisciplinarity, teamwork, collaborative work, and communication skills (information and communication technology, algorithms, automation, software development, and security, data analysis, general systems, and sustainable development). According to Mulyani and Koencoro [26], Indonesia's education policy framework focused on access to education, quality of education, synergies between government, industry, and higher education, industrial linkages, and incentives. Mian et al. [27] stated that good financial planning, qualified staff, increasing industrial relationships, sophisticated infrastructure, redesigned curricula, and insightful workshops are important prerequisites for higher education in TD4IR.

There have been many studies on various topics discussing the impact of TD4IR, which has an impact on the world's higher education sector, including Indonesia. However, how they are caused or detailed strategies for dealing with them have not been discussed. This is an important thing for higher education to master to successfully face TD4IR. The global issues, including TD4IR, can be analyzed using a physical approach such as Newton's laws [30]. Based on what has been reviewed, this paper aims to explain strategic concepts in higher education in Indonesia facing technological disruption and the industrial revolution 4.0 using Newton's laws as an analogy. Newton's laws analogy could give a clearer picture and strategy for higher education in dealing with TD4IR.

**METHOD**

**Concept Analogy**

Figure 1 illustrates the challenges of higher education in the TD4IR era using the analogy of Newton's laws. As shown, a vehicle considered a higher education or university is moving uphill with a certain driving force from the point of departure towards a challenging height on the Y-axis with a certain achievement on the X-axis. An object moving on an inclination plane enforces all the parameters in Newton's laws. It applies all the forces in Newton's laws, such as; forward force, frictional force, normal force, and gravity. Here, the Y-axis is called the level of disruption, and the X-axis is called the level of achievement. The inclination angle is formed by the Y-axis as the challenging height and the X-axis as the level of achievement.

The level of disruption is a change required by higher education in facing the TD4IR era, as shown in Table 1. The points of change in Table 1 are not hierarchical, although they are seen as such in Figure 1. They can be overlapping, sequential, or semi-parallel. To show differences, they become hierarchical. For simplification of calculations and further analysis, the level of disruption is given a scale of 0-10, as is the level of achievement. Table 1 summarizes the key points of higher education's immediate response to the TD4IR era [9, 10, 11, 12-18, 19-28, 29, 31, 32]. As shown, there are 10 points of change,  $h_1$  to  $h_{10}$ , which consist of 2 inputs, 6 processes, and 2 outputs. All items of change, as shown in Table 1, were developed from the literature with placement and adjustment according to the context of the discussion.

Change occurs in a system. Thus, comprehensive changes must be made starting from the input, process, and output (IPO). Input is something entered into the system. The process is an activity in a system. While the output is the result of a system.

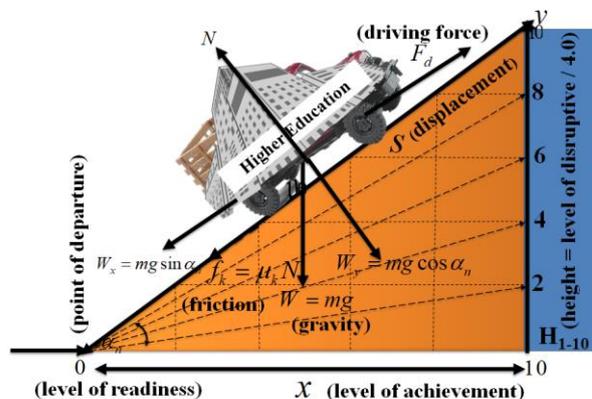


Figure 1. Newton's laws model for TD4IR

Table 1. Changes required due to TD4IR

No	Changes Required	Section	Weight
1	Changes in selection criteria for students, lectures, and management. $h_1$ , [24, 26, 27]	Input	1
2	Changes in visionary and financial resources to sustain the management and operation, $h_2$ , [16, 18, 22, 26, 27, 32]	Input	1
3	Changes in roles of students, lecturers, management, and principals in terms of quality, creativity, etc. $h_3$ , [10, 16 18, 26, 27]	Process	1
4	Changes in the method of teaching, the competence of lecturers, learning organizations in technology, $h_4$ , [1, 4, 17, 20, 23, 24, 26, 27, 33]	Process	1
5	Changes in the content of the curriculum to drive disruption and the industrial revolution 4.0, $h_5$ , [18, 19, 24-24, 32, 34]	Process	1
6	Changes in the way to control the quality of operations, research, management, etc. $h_6$ , [19, 21-23, 26]	Process	1
7	Changes in the collaboration activity nationally and internationally, etc. $h_7$ , [18, 26, 27, 35]	Process	1
8	Changes in the support and involvement of stakeholders, etc. $h_8$ , [26, 32]	Process	1
9	Changes in the output of research, $h_9$ , [18, 24, 26]	Output	1
10	Changes in graduates' qualification & competence, $h_{10}$ [15, 24-24, 32, 35]	Output	1
<b>Total</b>			<b>10</b>

The reason for more processes than input or output is to show the importance of a process in a system with proper inputs and optimal results. For simplification, each item of change is given a weighted value of 1. In this case, changes do not have to occur sequentially but can occur simultaneously, even irregularly. This is due to the opportunity, readiness, and interest of an organization.

To apply Newton's laws, several other related parameters must be involved. Table 2 explains the analogy of Newton's laws with the management description to describe the challenges of higher education in the TD4IR. The level of disruption  $Y_n$  is determined by the number of the  $i$ -th disruptive criteria with  $h_i$ , relate (1) to Table 1.

Table 2. Analogy system of Newton laws with strategic management for higher education

No.	Newton Laws	Management description
1.	Mass, $m$	Overall organizational burden (professors, lecturers, researchers, students, staff, lecture programs, etc.)
2.	Acceleration, $a$	Acceleration of the system to move forward
3.	Time, $t$	Time of work to make certain changes
4.	Velocity, $v$	Speed of work to make certain changes
5.	Gravity, $g$	Natural factors against system/institution to change
6.	Displacement, $s$	Change achieved with work and time
7.	Inclination angle, $\alpha_n$	Challenges to making changes
8.	Driving force, $F_d$	Positive force, the internal driving force of the system/institution (money, asset, intellectual property, donor/sponsor, etc.)
9.	Static & kinetic friction force, $f_s, f_k$	Negative force, system / institutional barriers to change (mindset, vision, self-learning, teamwork,
10.	Static & kinetic friction coef. $\mu_s, \mu_k$	Factors such as barriers to change (level of teamwork, level of vision, level of willingness to learn, level of maturity organization, level of technology, etc.
11.	Work, $W$	Energy is converted to or from an object along a displacement to make changes
12.	Energy, $E_k$	The quantitative property that is transferred to a system to make changes
13.	Power, $P$	The amount of energy converted per unit of time to make changes

$$y_n = \sum_{i=1}^n h_i \tag{1}$$

The level of difficulty of each criterion does not have to be the same.  $h_i \neq h_j$ , then; The inclination angle of the plane is considered as a ratio (target – current state) to the distance reached  $s_i$ . If there are  $n$  criteria and  $m$  items have been achieved. With,  $1 \leq i \leq m$ , then the angle on the inclination plane  $\alpha$  is described trigonometrically, as;

$$\sin \alpha = \frac{y_n}{s_n} = \frac{y_n}{\sqrt{(x_n)^2 + (y_n)^2}} \tag{2}$$

$$\cos \alpha = \frac{x_n}{s_n} = \frac{x}{\sqrt{(x_n)^2 + (y_n)^2}} \tag{3}$$

$$\tan \alpha_n = \frac{\sum_{i=1}^n h_i - \sum_{i=1}^{m < n} h_i}{s_i} \tag{4}$$

where;  $\sin \alpha$  is the ratio of the level of disruption  $y$  to the displacement  $s$ .  $\cos \alpha$  is the ratio of the level of achievement to the displacement  $s$ .  $\tan \alpha$  is the ratio of the level of disruption  $y$  to the displacement  $s$ .

**System Modelling**

The 2<sup>nd</sup> Newton law is expressed as;

$$\sum F = ma \tag{5}$$

where,  $F$  is the forces acting on the object in a plane [N],  $m$  is the mass [kg], and  $a$  is the acceleration [m/s<sup>2</sup>]. For no displacement, the projection of all forces onto the Y axis is given by  $a_y = 0$ , then;

$$N - W_y = 0 \tag{6}$$

$$N = W_y = mg \cos \alpha_n \tag{7}$$

where,  $g$  is gravity (m/s<sup>2</sup>) and  $\alpha_n$  is the inclination angle of the plane from normal to industrial revolution 4.0 and disruptive. For displacement, the projection of the forces to the X axis is given by  $a_x = a$ , then,

$$F_d - W_x - f = ma \tag{8}$$

where,  $F_d$  is the driving force on the object [N],  $W_x$  is the weight of the object on the X axis, and  $f$  is the frictional force on the object [N], consisting of static  $f_s$  and kinetic  $f_k$  friction forces as expressed;

$$f_s = \mu_k N \tag{9}$$

$$f_k = \mu_k N \tag{10}$$

where,  $\mu_x$  and  $\mu_k$  are the static and kinetic friction coefficient. To remain stable in place,  $\sum F = 0$ ,

$$-mg \sin \alpha_n + \mu_s N = 0 \tag{11}$$

$$-mg \sin \alpha_n + \mu_s mg \cos \alpha_n = 0 \tag{12}$$

$$\mu_s = \sin \alpha_n / \cos \alpha_n \tag{13}$$

$$\mu_s = \tan \alpha_n \tag{14}$$

If there is no  $F_d$ , then  $\mu_s > \tan \alpha_n$  so that the system is stable. If there is  $F_d$  for the object to move up,  $\sum F = ma > 0$ , then,

$$F_d - W_x - \mu_k N = ma > 0 \tag{15}$$

$$F_d - mg \sin \alpha_n - \mu_k mg \cos \alpha_n > ma \tag{16}$$

where,  $F_d - mg \sin \alpha_n > \mu_k mg \cos \alpha_n$  for initial conditions. After moving, the friction will be smaller with  $\mu_k < \mu_s$ . To move up, the object must resist the static friction force  $f_s$ .

$$F_d - mg \sin \alpha_n > \mu_s mg \cos \alpha_n \quad (17)$$

$$F_d - mg(\sin \alpha_n + \mu_s \cos \alpha_n) > 0 \quad (18)$$

$$F_d > mg(\sin \alpha_n - \mu_s \cos \alpha_n) \quad (19)$$

After these conditions are met, the acceleration is expressed by using (17) and (5);

$$F_d - mg \sin \alpha_n - \mu_k mg \cos \alpha_n = ma \quad (20)$$

$$F_d - mg(\sin \alpha_n - \mu_k \cos \alpha_n) = ma \quad (21)$$

$$a = \frac{F_d - mg(\sin \alpha_n - \mu_k \cos \alpha_n)}{m} \quad (22)$$

$$a = -g(\sin \alpha_n + \mu_k \cos \alpha_n) + F_d/m \quad (23)$$

Substituting (10) and (7) to  $\mu_k$  (22);

$$a = -g(\sin \alpha + f_k/mg) + F_d/m \quad (24)$$

$$a = -g \sin \alpha + (F_d - f_k)/m \quad (25)$$

From (25) can be understood that: the system will move forward if the acceleration  $a > 0$ , means  $(F_d - f_k)/m > g \sin \alpha_n$ , or vice versa move backward if acceleration  $a < 0$ , means  $(F_d - f_k)/m < g \sin \alpha_n$  and  $\mu_k = 0.5$ . The system is not stationary, but moves straight line and changes uniformly with the velocity  $v_t$ ;

$$v_t = v_o + at \quad (26)$$

For initial conditions,  $v_o = 0$ ,  $v_t = at$  (27)

Then, the relation among  $v_o$ ,  $v_t$ ,  $a$  dan  $s_t$  and  $t$  are;

$$v_t^2 = v_o^2 + 2as_t \quad (28)$$

$$v_t^2 = 2as_t \quad (29)$$

$$s_t = v_t^2/2a \quad (30)$$

$$s_t = v_o t + \frac{1}{2} at^2 \quad (31)$$

$$2s_t = at^2 \quad (32)$$

$$a^2 t^2 = 2as_t \quad (33)$$

$$t = \sqrt{2s_t/a} \quad (34)$$

The kinetic energy system  $E_k$  is expressed as;

$$E_k = \frac{1}{2} mv_t^2 \quad (35)$$

$$\frac{1}{2} mv_t^2 = mas_t \quad (36)$$

$$t = 1/a \sqrt{2E_k/m} \quad (37)$$

Substitute (35) with (18), the energy required to carry an object along  $s_t$  is;

$$E_k = F_d s_t - mgs_t(\sin \alpha + \mu_k \cos \alpha) \quad (38)$$

$$s_t = \frac{E_k}{F_d - mg(\sin \alpha + \mu_k \cos \alpha)} \quad (39)$$

Substitute (39) into (2), then,

$$x = s_t \cos \alpha = \frac{E_k}{F_d - mg(\sin \alpha - \mu_k \cos \alpha)} \cos \alpha \quad (40)$$

$$y = s_t \sin \alpha = \frac{E_k}{F_d - (\sin \alpha - \mu_k \cos \alpha)} \sin \alpha \quad (41)$$

From (32), the time  $t$  required to move along  $s_t$  is;

$$t = \frac{m}{F_d - mg(\sin \alpha + \mu_k \cos \alpha)} \sqrt{\frac{2E_k}{m}} \quad (42)$$

$$t = \frac{\sqrt{2mE_k}}{F_d - mg(\sin \alpha + \mu_k \cos \alpha)} \sqrt{\frac{2E_k}{m}} \quad (43)$$

Then, Power  $P$  is expressed as;

$$P = E_k s_t / t \quad (44)$$

and work  $W_n$

$$W_n = \sum F s_t \quad (45)$$

$$W_n = (F_d - f_k) s_t \quad (46)$$

With minimum  $a > 0$  from (24), then;

$$W_n / m = g \sin \alpha_n s_t \quad (47)$$

To summarize,  $s_t$ ,  $a_o$ ,  $v_t$ ,  $t$ , are standard parameters to determine the initial state, while Power intensity and Work intensity are KPIs to measure the performance of an ongoing system. To adjust to the actual situation, acceleration and deceleration scenarios are applied with an increase or decrease in squares or cubes as shown in (48);

$$a = a_o (1 \pm x_n(c))^p \quad (48)$$

where; the  $s_t$  is the minimum forward acceleration from (24) and (25); the  $x_n$  is the level of achievement; the  $c$  is constant of 0.05; the  $p$  is the power with 2 (squared) and 3 (cubed). Then, operator ( $\pm$ ) means (+) for acceleration and (-) for deceleration.

**RESULTS AND DISCUSSION**

Figure 2 shows the relationship between the minimum distance-to-move  $s_t$  to the level of achievement  $x$ . Using polynomial 2 variables, the relationship between  $t$  and  $x$  is strong with almost perfect  $R^2 = 0.99$ . That is, if the level of achievement  $x$  increase, then the minimum time to move required by the system will also increase gradually. The regression equation illustrates that for the lower  $x = 0$ , the system still required the minimum distance to move  $s_t = 9.89$ . At  $x \leq 4$ , the distance to move is relatively smaller when compared to the displacement distance at  $x \geq 5$ .

Figure 3 shows the relationship between forward acceleration  $a$  to the level of achievement  $x$ . Using polynomial 2 variables, the relationship between  $a$  and  $x$  is strong with the perfect  $R^2 = 1$ . That is, if the level of achievement  $x$  will be greater, then the acceleration required by the system will increase gradually. The regression equation illustrates that if the minimum  $a_0$  is not reached, then the system will move backward. The effect of squared and cubed acceleration will make the acceleration graph farther away from the minimum forward acceleration graph, and vice versa for deceleration. As shown, squared and cubed acceleration gives a significant difference, while deceleration gives almost the same results.

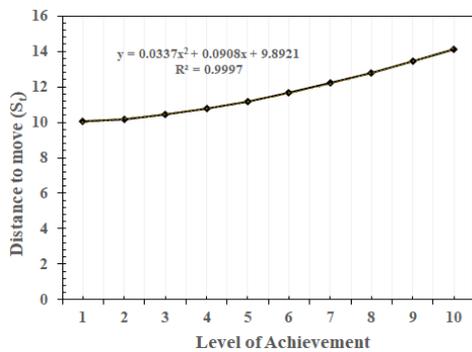


Figure 2. Distance to move to the level of achievement

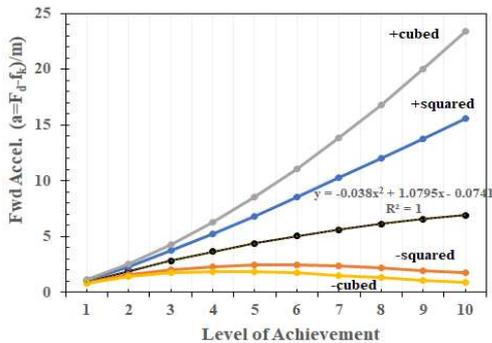


Figure 3. Forward acceleration to move vs level of achievement

Figure 4 shows the relationship between the minimum time to move  $t$  to the level of achievement. Using polynomial 2 variables, the relationship between  $t$  and  $x$  is strong with  $R^2 = 0.93$ . If the level of achievement  $x$  will be greater, then the minimum time to move required by the system will be smaller.

The regression equation illustrates that for the lower  $x \leq 4$ , the system still required time to move. After  $x \geq 5$ ,  $t$  gets smaller and tends to be constant. The effect of squared or cubed acceleration makes the time to move further away from the minimum time to move, and vice versa for deceleration. During acceleration, the time needed to make changes becomes longer. As shown, the effect of squared and cubed acceleration gives a significant difference in time to move, while deceleration gives almost the same time to move.

Figure 5 shows the relationship between minimum velocity-to-move  $v$  to the level of achievement. Using polynomial 2 variables, the relationship between  $v$  and  $x$  is strong with  $R^2 = 0.99$ . That is, if the level of achievement  $x$  will be greater, then the minimum velocity-to-move required by the system will increase gradually. The regression equation illustrates that the minimum  $v = 3.04$  should be maintained for the system to move forwards. The effect of squared or cubed acceleration will make the velocity-to-move graph move further away from the minimum velocity-to-move, and vice versa for deceleration. This means, during acceleration, the time needed to make changes becomes longer. As shown, the effect of squared and cubed acceleration gives a significant difference in velocity-to-move, while deceleration gives almost the same velocity-to-move.

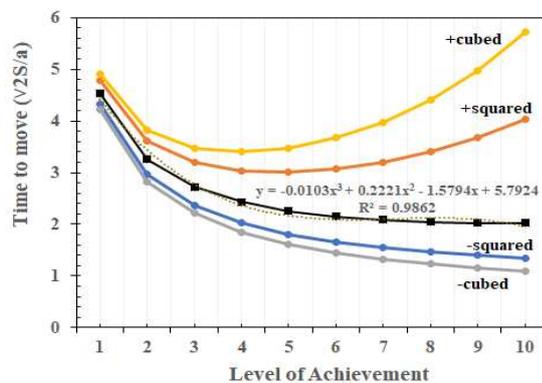


Figure 4. Time to move vs level of achievement

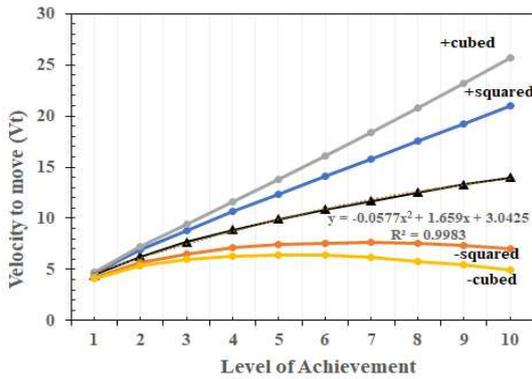


Figure 5. Velocity to move vs level of achievement

Figure 6 shows the relationship between minimum power-to-move  $P/m$  to the level of achievement  $x$ . Using polynomial 2 variables, the relationship between  $P/m$  and  $x$  is strong with  $R^2 = 0.99$ . If the level of achievement  $x$  increase, then the minimum power-to-move required by the system  $P/m$  also increases gradually. The regression equation illustrates that for the lower  $x=0$ , the system still losses power-to-move  $P/m = -20.08$ , and increases even more for  $x > 0$ . The effect of squared or cubed acceleration makes the power-to-move graph move further away from the graph of minimum power-to-move, and vice versa for deceleration. During acceleration, the power-to-move needed to make changes becomes bigger. As shown, the effect of squared and cubed acceleration gives a significant difference in power-to-move, while deceleration gives almost the same power-to-move.

Figure 7 shows the relationship between minimum work intensity to move  $W/m$  to the level of achievement  $x$ . Using polynomial 2 variables, the relationship between  $W/m$  and  $x$  is strong with  $R^2 = 1$ .

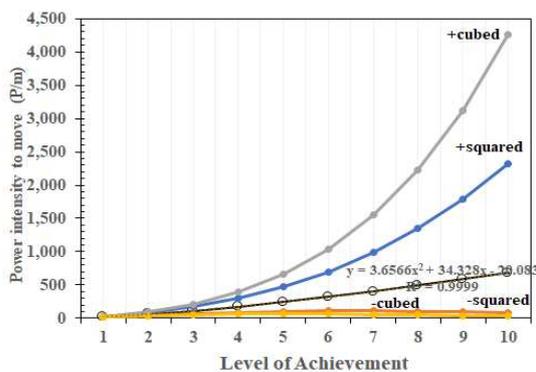


Figure 6. Power to move

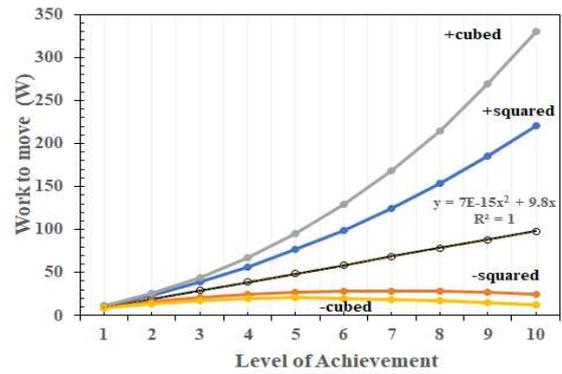


Figure 7. Work to move vs level of achievement

That is, if the level of achievement  $x$  increase, then the minimum power-to-move required by the system  $W/m$  will also increase gradually. The regression equation illustrates that for the lower  $x=0$ , the system still losses work-to-move  $W/m = -66.49$ , and will increase even more for  $x > 0$ . The effect of squared or cubed acceleration will make the work-to-move graph move further away from the graph of minimum power to move, and vice versa for deceleration. It means, during acceleration, the work-to-move needed to make changes becomes bigger. As shown, the effect of squared and cubed acceleration gives a significant difference in work-to-move, while deceleration gives almost the same power to move.

Based on the results described above, there are three things to discuss;

*First*, basic parameters: such as; minimum forward acceleration  $a$ , minimum time to move  $t$ , minimum velocity to move  $v$ , and minimum distance to move  $s_t$ , as shown in Figure 2-5. Based on individual graph simulations, it turns out that these four parameters can provide an overview of a system in the TD4IR era. In general, the simulation of these parameters can provide an understanding of higher education management and what should be done when preparing a strategic plan in dealing with TD4IR. In this strategic planning, higher education's management must focus on several things, such as; what to prepare in the early stages, what actions to take when just starting and reaching some milestones, and how to secure achievements when at the peak of the challenge.

*Second*, regarding power intensity  $P/m$  and work intensity  $W/m$  as shown in Figure 6-7. These two parameters illustrate that certain power and energy reserves must be owned by higher education when running the program. Losing a certain amount of power and energy will cause the campus to move backward or collapse.

For this reason, campus management has to find sources providing power and energy to move forward in facing the challenges of TD4IR.

*Third*, higher education in Indonesia have to understand its current position in the TD4IR era. This is an important point in accelerating understanding of what should be done. Or, act immediately after understanding the organizational system in a state of deceleration. With applied engineering in management and information systems, the proposed model can be developed through a mobile application integrated with a centralized data processing system. The system receives information manually and automatically, then processes and displays the results as the campus movement status in the TD4IR era [36][37]. Thus, all stakeholders can monitor the progress of their campus at anytime from anywhere.

Based on what has been discussed, Newton's laws analogy can provide practical application to higher education in making a management decision related to TD4IR. The results of Newton's law analogy study further complement the results of previous research, which has provided an overview of impact analysis [9, 10, 11], analyzed readiness and modeling [12, 13, 14, 15, 16, 17], and how the strategy should handle the TD4IR [18, 19, 28, 29], thereby providing a clearer picture of how higher education in Indonesia should succeed in dealing with technological disruption and Industrial Revolution 4.0. Apart from being a tool for decision-making, this study also contributes to the development of advanced strategic management science. For future research, this study needs to be developed further and in detail related to management science, and information systems.

## CONCLUSION

We have discussed the proposed model and strategy of Indonesian higher education in dealing with TD4IR using Newton's Law analogy. Some important results can be concluded as follows;

- A simple Newton's laws analogy can be used to explain the challenges of higher education in the TD4IR era.
- Higher education in Indonesia must immediately understand the 10 points required of change in facing the TD4IR era.
- The parameters such as; mass (organizational burden), friction (barriers to change), force (internal assets as a driving force), etc, must be appropriately analogized to the concept of strategic management of

higher education to provide a clear picture of the problems faced in the TD4IR era.

- From the simulation, higher education must understand the minimum value of its organizational system to understand what action must be taken immediately.
- Higher education must accelerate as much as possible so that the organization does not slow down or stop suddenly in facing the challenges of TD4IR.

Newton's Law analogy already provides an overview of practical applications in strategic management, but needs to be further developed a real-time monitoring system concerning management science and information systems.

## REFERENCES

- [1] A. Oke and F. A. P. Fernandes, "Innovations in teaching and learning: Exploring the perceptions of the education sector on the 4th industrial revolution (4IR)," *J. Open Innov. Technol. Mark. Complex.*, vol. 6, no. 2, 2020, doi: 10.3390/JOITMC6020031.
- [2] J. Rymarczyk, "Technologies, opportunities and challenges of the industrial revolution 4.0: Theoretical considerations," *Entrep. Bus. Econ. Rev.*, vol. 8, no. 1, pp. 185–198, 2020, doi: 10.15678/EBER.2020.080110.
- [3] D. Buhalis, T. Harwood, V. Bogicevic, G. Viglia, S. Beldona, and C. Hofacker, "Technological disruptions in services: lessons from tourism and hospitality," *J. Serv. Manag.*, vol. 30, no. 4, pp. 484–506, 2019, doi: 10.1108/JOSM-12-2018-0398.
- [4] S. H. Halili, S. Sulaiman, H. Sulaiman, and R. Razak, "Embracing industrial revolution 4.0 in universities," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 1088, no. 1, p. 012111, 2021, doi: 10.1088/1757-899x/1088/1/012111.
- [5] K. Yadav, "Disruptive Innovative Technologies in Higher," *Int. J. Adv. Educ. Res. Int.*, vol. 4, no. 2, pp. 43–54, 2019.
- [6] L. M. C. Benavides, J. A. T. Arias, M. D. A. Serna, J. W. B. Bedoya, and D. Burgos, "Digital transformation in higher education institutions: A systematic literature review," *Sensors (Switzerland)*, vol. 20, no. 11, pp. 1–23, 2020, doi: 10.3390/s20113291.
- [7] R. Jamaludin, E. McKAY, and S. Ledger, "Are we ready for Education 4.0 within ASEAN higher education institutions? Thriving for knowledge, industry and humanity in a dynamic higher education ecosystem?," *J. Appl. Res. High. Educ.*, vol. 12, no. 5, pp. 1161–1173, 2020, doi: 10.1108/JARHE-06-2019-0144.
- [8] U. M. Ishaq, "The Impact of Disruptive Technologies on Higher Education in

- Indonesia," *IJIE (Indonesian J. Informatics Educ.*, vol. 5, no. 1, p. 22, 2021, doi: 10.20961/ijie.v5i1.42310.
- [9] C. A. Bonfield, M. Salter, A. Longmuir, M. Benson, and C. Adachi, "Transformation or evolution?: Education 4.0, teaching and learning in the digital age," *High. Educ. Pedagog.*, vol. 5, no. 1, pp. 223–246, 2020, doi: 10.1080/23752696.2020.1816847.
- [10] Y. D. Nugraha, "the Role of Higher Education Policy and the Development of Management Science in the Industrial Revolution 4.0: a Perspective From Indonesia," *Acad. Educ. J.*, vol. 12, no. 1, pp. 1–14, 2021, doi: 10.47200/aoej.v12i1.411.
- [11] E. Abad-Segura, M. D. González-Zamar, J. C. Infante-Moro, and G. R. García, "Sustainable management of digital transformation in higher education: Global research trends," *Sustain.*, vol. 12, no. 5, 2020, doi: 10.3390/su12052107.
- [12] W. Teng, C. Ma, S. Pahlevansharif, and J. J. Turner, "Graduate readiness for the employment market of the 4th industrial revolution: The development of soft employability skills," *Educ. Train.*, vol. 61, no. 5, pp. 590–604, 2019, doi: 10.1108/ET-07-2018-0154.
- [13] M. Maria, F. Shahbodin, and N. C. Pee, "Malaysian higher education system towards industry 4.0 - Current trends overview," *AIP Conf. Proc.*, vol. 2016, no. September 2018, pp. 0–7, 2018, doi: 10.1063/1.5055483.
- [14] R. Br Sitepu, A. Eliyana, A. Raza, and M. Rosalina, "The Readiness of Educational Competency in Higher Education in Connecting the Era of Industrial Revolution 4.0," *SHS Web Conf.*, vol. 76, p. 01045, 2020, doi: 10.1051/shsconf/20207601045.
- [15] W. Sardjono and F. Firdaus, "Readiness model of knowledge management systems implementation at the higher education," *ICIC Express Lett.*, vol. 14, no. 5, pp. 477–487, 2020, doi: 10.24507/icicel.14.05.477.
- [16] S. Hartati, A. Syamsuadi, and D. Arisandi, "University Level Management Toward Industrial Revolution 4.0 using COBIT 5 Framework," *J. Phys. Conf. Ser.*, vol. 1783, no. 1, pp. 0–6, 2021, doi: 10.1088/1742-6596/1783/1/012021.
- [17] N. Nurhasan, M. Pramono, M. Martadi, E. Ert, and H. S. C. Puspita Dewi, "The Strategic Plan of University in Facing Challenges of Industrial Revolution 4.0 (Case Study at Universitas Negeri Surabaya)," *Kelola J. Manaj. Pendidik.*, vol. 7, no. 1, pp. 1–13, 2020, doi: 10.24246/j.jk.2020.v7.i1.p1-13.
- [18] M. H. Lee *et al.*, "How to respond to the Fourth Industrial Revolution, or the second information technology revolution? Dynamic new combinations between technology, market, and society through open innovation," *J. Open Innov. Technol. Mark. Complex.*, vol. 4, no. 3, 2018, doi: 10.3390/joitmc4030021.
- [19] C. Lukita, Suwandi, E. P. Harahap, U. Rahardja, and C. Nas, "Curriculum 4.0 Adoption of Industry Era 4.0 as Assessment of Higher Education Quality.pdf," *Indones. J. Comput. Cybern. Syst.*, vol. 14, no. 3, pp. 297–308, 2020.
- [20] J. Miranda *et al.*, "The core components of education 4.0 in higher education: Three case studies in engineering education," *Comput. Electr. Eng.*, vol. 93, no. June, 2021, doi: 10.1016/j.compeleceng.2021.107278.
- [21] A. Supriyanto, Rochmawati, and D. Djum Noor Benty, "Kaizen: Quality Improvement Innovation Higher Education in the Industrial Revolution 4.0," vol. 381, no. CoEMA, pp. 108–113, 2020, doi: 10.2991/coema-19.2019.23.
- [22] D. Prestiadi, W. Zulkarnain, and R. Bambang Sumarsono, "Visionary Leadership in Total Quality Management: Efforts to Improve the Quality of Education in the Industrial Revolution 4.0," vol. 381, no. CoEMA, pp. 202–206, 2020, doi: 10.2991/coema-19.2019.40.
- [23] B. Alzahrani, H. Bahaitham, M. Andejany, and A. Elshennawy, "How Ready Is Higher Education for Quality 4.0 Transformation According To the Lns Research Framework?," *Sustain.*, vol. 13, no. 9, pp. 1–29, 2021, doi: 10.3390/su13095169.
- [24] M. S. Ramírez-Montoya, M. I. Loaiza-Aguirre, A. Zúñiga-Ojeda, and M. Portuguese-Castro, "Characterization of the teaching profile within the framework of education 4.0," *Futur. Internet*, vol. 13, no. 4, pp. 1–17, 2021, doi: 10.3390/fi13040091.
- [25] L. M. Kipper *et al.*, "Scientific mapping to identify competencies required by industry 4.0," *Technol. Soc.*, vol. 64, no. November 2019, 2021, doi: 10.1016/j.techsoc.2020.101454.
- [26] S. M. Indrawati and A. Kuncoro, "Improving Competitiveness Through Vocational and Higher Education: Indonesia's Vision For Human Capital Development In 2019–2024," *Bull. Indones. Econ. Stud.*, vol. 57, no. 1, pp. 29–59, 2021, doi: 10.1080/00074918.2021.1909692.

- [27] S. H. Mian, B. Salah, W. Ameen, K. Moiduddin, and H. Alkhalefah, "Adapting universities for sustainability education in industry 4.0: Channel of challenges and opportunities," *Sustain.*, vol. 12, no. 15, 2020, doi: 10.3390/su12156100.
- [28] N. C. Jackson, "Managing for competency with innovation change in higher education: Examining the pitfalls and pivots of digital transformation," *Bus. Horiz.*, vol. 62, no. 6, pp. 761–772, 2019, doi: 10.1016/j.bushor.2019.08.002.
- [29] N. Li, H. Huijser, Y. Xi, M. Limniou, X. Zhang, and M. Y. C. A. Kek, "Disrupting the Disruption: A Digital Learning HeXie Ecology Model," *Educ. Sci.*, vol. 12, no. 2, 2022, doi: 10.3390/educsci12020063.
- [30] G. B. Dragan, G. Bleoju, A. Capatina, and A. Woodside, "European tech startups' responses to the COVID-19 pandemic: integrating McKinsey's 5R's paradigm and the Newtonian gravitational field," *Manag. Decis.*, vol. 60, no. 9, pp. 2615–2636, 2022, doi: 10.1108/MD-11-2021-1428
- [31] I. Fathurrochman, S. Danim, A. Syaiful Anwar, and N. Kurniah, "The School Principals' Role in Education Management at the Regional Level: An Analysis of Educational Policy in the Industrial Revolution 4.0," *Proc. Int. Conf. Educ. Sci. Teach. Prof. (ICETeP 2020)*, vol. 532, no. 532, pp. 237–242, 2021, doi: 10.2991/assehr.k.210227.042.
- [32] M. Novita, A. H. Ritonga, and J. Jalaludin, "The Role of University-Based Entrepreneurship Ecosystems in Facing the Challenges of the Industrial Revolution 4.0," vol. 438, no. Aes 2019, pp. 220–223, 2020, doi: 10.2991/assehr.k.200513.049.
- [33] Darmaji, D. A. Kurniawan, Astalini, A. Lumbantoruan, and S. C. Samosir, "Mobile learning in higher education for the industrial revolution 4.0: Perception and response of physics practicum," *Int. J. Interact. Mob. Technol.*, vol. 13, no. 9, pp. 4–20, 2019, doi: 10.3991/ijim.v13i09.10948.
- [34] M. Baygin, H. Yetis, M. Karakose, and E. Akin, "An effect analysis of industry 4.0 to higher education," *2016 15th Int. Conf. Inf. Technol. Based High. Educ. Training, ITHET 2016*, 2016, doi: 10.1109/ITHET.2016.7760744.
- [35] D. Permitasari, I. D. A. Nurhaeni, and R. H. Haryati, "Sustainability of Internationalization of Higher Education in Industrial Revolution 4.0 Era: A systematic literature review," vol. 343, no. Icas, pp. 88–92, 2019, doi: 10.2991/icas-19.2019.19.
- [36] O. Okfalisa, H. Rusnedy, D. U. Iswavigra, B. Pranggono, E. H. Haerani, and S. Saktioto, "Decision Support System for Smartphone Recommendation: the Comparison of Fuzzy Ahp and Fuzzy Anp in Multi-Attribute Decision Making," *SINERGI*, vol. 25, no. 1, p. 101, 2020, doi: 10.22441/sinergi.2021.1.013.
- [37] H. Pranoto, A. M. Leman, D. Feriyanto, A. Adriansyah, and A. Wahab, "The innovative design of automatic speed limiter device for trucks and buses based on road location analysis," *SINERGI*, vol. 26, no. 1, p. 15, 2022, doi: 10.22441/sinergi.2022.1.003.